GOCE DELCEV UNIVERSITY, STIP, NORTH MACEDONIA

FACULTY OF ELECTRICAL ENGINEERING

ETIMA 2023

SECOND INTERNATIONAL CONFERENCE

27-29 SEPTEMBER, 2023

TECHNICAL SCIENCES APPLIED IN ECONOMY, EDUCATION AND INDUSTRY

УНИВЕРЗИТЕТ
ГОЦЕ ДЕЛЧЕВ
ЕЛЕКТРОТЕХНИЧКИ
ФАКУЛТЕТ

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УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ”, ШТИП, СЕВЕРНА МАКЕДОНИЈА

FACULTY OF ELECTRICAL ENGINEERING,
GOCE DELCEV UNIVERSITY, STIP, NORTH MACEDONIA

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PREFACE

The Faculty of Electrical Engineering at University Goce Delcev (UGD), has organized the Second International Conference ***Electrical Engineering, Informatics, Machinery and Automation - Technical Sciences applied in Economy, Education and Industry-ETIMA.***
ETIMA has a goal to gather the scientists, professors, experts, and professionals from the field of technical sciences in one place as a forum for exchanging the ideas, strengthening the multidisciplinary research and cooperation, and promoting the achievements of technology and its impact on every aspect of living. We hope that this conference will continue to be a venue for presenting the latest research results and developments on the field of technology.
Conference ETIMA was held as online conference. More than sixty colleagues contributed to this event, from five different countries with more than thirty papers.
We would like to express our gratitude to all the colleagues, who contributed to the success of ETIMA'23 by presenting the results of their current research and by launching the new ideas through many fruitful discussions.
We invite you and your colleague to attend ETIMA Conference in the future as well. One should believe that next time we will have opportunity to meet each other and exchange ideas, scientific knowledge and useful information as well as to involve as much as possible the young researchers into this scientific event.

The Organizing Committee of the Conference

ПРЕДГОВОР

Меѓународната конференција ***Електротехника, Технологија, Информатика, Машинство и Автоматика-технички науки во служба на економија, образование и индустрија-ЕТИМА*** е организирана од страна на Електротехничкиот факултет при Универзитетот „Гоце Делчев".
ЕТИМА има за цел да ги собере на едно место научниците, професорите, експертите и професионалците од полето на техничките науки и да претставува форум за размена на идеи, да го зајканува мултидисциплинарното истражување и соработка и да ги промовира технолошките достигнувања и нивното влијание врз секој аспект од живеењето. Се надеваме дека оваа конференција ќе продолжи да биде настан на кој ќе се презентираат најновите резултати од истражувањата и развојот на полето на технологијата.
Конференцијата ЕТИМА се одржа online и на неа дадоа свој придонес повеќе од шеесет автори од пет различни земји со повеќе од триесет труда.
Сакаме да ја искажеме нашата благодарност до сите колеги кои придонесоа за успехот на ЕТИМА'23 со презентирање на резултати од нивните тековни истражувања и со лансирање на нови идеи преку многу плодни дискусии.

Организационен одбор на конференцијата

СОДРЖИНА / TABLE OF CONTENTS:

ANALYTICAL ESTIMATION OF OPTIMAL PV PANEL TILT BASED ON CLEAR-SKY IRRADIANCE MODEL

Elena Golubovska[1], Biljana Citkuseva Dimitrovska[2], Roman Golubovski[3]
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Abstract

PV panel tilt and sun tracking are crucial aspect for PV conversion efficiency. We propose an analytical methodology for estimation of optimal PV panel tilt based on calculation of the sun position and application of a clear-sky solar irradiance model. Our model outputs three angles referencing a geolocation and the moment of interest: the incidence angle θ, the sun altitude α and the sun azimuth z. The irradiance model estimates the solar irradiation at a geolocation that can be used for PV conversion estimation based on specified tilt β. The moment PV power is used for calculation of the daily energy production, and the optimal β is identified in the tilt range of $0°$ to $90°$. Seasonal division of the year is performed, and optimal seasonal tilt is estimated based on the maximal produced seasonal energy tested with every corresponding β. The methodology is tested on four typical seasonal models - 12 months, 4 three-month quarters, 2 half-year seasons and single optimal annual fixed β. Preliminary simulations produce promising results consistent with the practical engineering implementations.

Key words

PV panel tilt, optimal PV panel inclination, PV conversion efficiency, sun position model, clear-sky solar irradiance model.

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ENVIRONMENTAL AND ENERGY UTILIZATION OF MUNICIPLE WASTE – ONE PRODUCT, TWO SOLUTIONS

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Abstract

The world is facing an increasing need for energy which leads toward escalated exploitation of natural resources, mostly fossil fuels resulting with environmental pollution and global warming. Hence, the problem of finding and using alternative and clean energy sources is self-imposed. The environmental pollution problem increased the interest in allocating more funds for scientific and research work on the use of biodegradable waste, thus in many countries increased number of new power plants which utilize biomass and/or biogas increased.

Biogas is an interesting and important source of energy, especially when is generated from organic waste with an anaerobic digestion procedure. By digesting biodegradable waste originating from various organic sources such as mowing grass, cutting branches, biomass waste from farms and agricultural by-products, etc., in anaerobic conditions, the waste is fermented, and biogas is obtained as an energy source. Simultaneously, parasites and pathogenic bacteria are significantly reduced by more than 90%, which protects the groundwater, the disposal of waste in landfills, which causes water and land pollution, is reduced, and quality fertilizer is obtained for agriculture and other needs.

North Macedonia as primary agricultural country has large quantities of this type of waste which is a good prerequisite for their rational economical use to obtain both, electricity and heat. Production and utilization of biogas additionally opens opportunities for establishing a free market of electricity produced from renewable energy sources. Finally, produced biogas could find its utilization value as renewable energy source for various final customers starting from the largest, up to individual households or business users, as well as for utility companies for gasification of cities or gas stations.

Introduction

The rapid development of society as a result of the technical-technological revolution is mostly based on the possibilities of meeting the ever-increasing need for energy. Due to the inconsistency of energy needs and the possibilities for its provision, energy crises are happening, and as a result, there is an increased interest for improved and more rational use of existing and new renewable energy sources. Encouraging the use of renewable energy sources is a strategic goal of the EU, because it is in line with the Sustainable Development Strategy and enables the achievement of the goals of the Kyoto and Paris Protocols in terms of reducing greenhouse gas emissions, environmental protection, and reduction of global warming.

Several renewable or alternative energy sources are already in use. Some are in the development stage, and some are only in the research and analysis stage for their potential commercial utilization. In parallel with the energy crises, another important environmental crisis is happening, the so-called global ecological crisis, which was created because of the problems with increase amount of waste and its uncontrolled and irresponsible disposal which threatens the health of the people and the environment. Therefore, within the global economic policy, the issue of energy production from biomass using organic waste is also raised.

As there is growing concern about the excessive release of greenhouse gases into the atmosphere and their impact on ozone depletion, and the negative impact that inappropriate

waste disposal could have on human health and global warming, the well-known technologies for biogas production from waste have been re-examined. It is known that through processes of anaerobic fermentation of biodegradable waste, biogas could be obtained, which mostly contains methane as an energy resource, then carbon dioxide, and less hydrogen, oxygen, ammonia, etc. Various technologies have already been proven on a large scale for the use of biomass as a renewable energy source for obtaining electrical and thermal energy, as well as fuel for vehicles. In the EU, several hundred larger installations have already been installed for biogas production and utilization as renewable fuel in power plants for obtaining electricity, processing heat and steam, or fuel for transportation sector.

The energy potential of biomass in our country is significant to the extent that it should not be ignored as a potential energy source. Thus, an adequate energy strategy for energy utilization of biogas should be proposed. In this paper, the authors want to contribute to better understanding the process of production of biogas from organic waste using one pilot project. In this pilot project, the city Radovish and its public company responsible for municipality waste disposal is put in the center of the analysis. The aim of this paper is to provide an insight to the problem of waste disposal in our communities on a larger scale and in an environmentally sound way, and to put in focus the use of municipality waste as renewable resource for generation of biogas. In such way, with one positive action two solutions could be achieved: firstly, environmentally friendly disposal of the municipal waste, and secondary generation of biogas as renewable energy resource that could be used either for electric and/or heat energy generation or as a fuel for local transportation sector, individual cars or trucks.

Main sources for biomass production

After coal and oil, on a global scale, biomass is the largest classical primary energy source as a renewable and widespread raw material, unlike fossil fuels, whose quantities are limited and exhaustible. Biomass can be considered a strategic resource because it is not only renewable, but also available everywhere and from it one can obtain products important for human progress, which will improve the socio-economic status of the people and land. What makes biomass competitive is that it does not belong to the group of environmental pollutants. Biomass does not contain sulfur, and its processing does not release sulfur dioxide, enabling residual waste after the biomass production process to be used as a particularly good mineral fertilizer.

Biomass is defined as biodegradable materials obtained from agriculture, livestock farming and related industries and activities, as well as the biologically degradable part of the industrial and communal city waste [1], [2]. Biomass, in fact, is an organic material that originates from living organisms such as plants, animals, humans and microorganisms, which contain stored energy from the Sun, where they bind solar energy through photosynthesis. By its characteristics, biomass is a high-quality fuel. However, utilization of biomass as a fuel on a larger scale requires several actions to be taken ahead, mostly the collection, transportation, storage and bio-chemical treatment before biodegradable materials become usable biomass.

According to the EU Directive 2008/98/EC, biodegradable waste is any waste that can be decomposed anaerobically (without the presence of oxygen) or aerobic (with the presence of oxygen) decomposition processes, such as food waste, garden waste, paper and cardboard [3]. Numerous scientific and practical investigations are focused on the possibility of using biomass to obtain biogas, as a potential energy source. In general, all organic materials are susceptible to fermentation, from which processes biogas is obtained. The waste generated in agriculture, forestry, food and wood industry stands for a quantitatively significant part of the total generated waste. Additionally, biodegradable waste from households, green waste from city green areas and separately collected biowaste also represent a significant part of the total generated waste. Substantial amounts of residues (fluids and urine) are created in livestock

farming, which, together with bedding, create manure and biomass that can be further used. Apart from the desired products (milk, meat), intensive livestock farming also generates side products with limited applicability, such as feces, fluids, which should be removed and adequately used.

The largest producers of raw material for biogas production installations are animal farms, slaughterhouses, restaurants, hospitals and all other entities that produce organic waste. Growing plants to obtain more biomass will soon become a sought-after business, agriculture will revive, farmland will be protected, watercourses will be preserved. Plants with a high content of starch and oily substances are potential choice for biomass, and genetically modified woody plants and the cultivation of fast-growing special species of willows and apple trees are being investigated. Significant animal waste is also created in slaughterhouses, facilities for processing meat, fish, eggs, milk, cold stores, warehouses, markets, meat shops, fishmongers, catering, facilities for fattening and keeping animals, and everywhere else where animals are kept animal products are grown and produced. These types of waste represent vast amounts of raw material for anaerobic fermentation installations and obtaining biogas as energy and compost as quality fertilizer.

If we make more defined categorization of the most important organic materials for obtaining biomass, we should consider the following:

- Municipal waste:
  - Municipal wastewater, sewage water,
  - Septic tanks waste,
  - Sediment from fecal sewage,
  - Accumulated sediment from wastewater treatment plants,
  - Municipal solid waste, especially organic part disposed in a landfill,
  - Municipal solid waste, newly created,
  - Park and garden maintenance waste, etc.
- Agricultural waste:
  - Greenhouses waste,
  - Animal manure, stable waste,
  - Poultry,
  - Waste from growing flowers, wood or fruits,
  - Waste from growing vegetables
  - Agricultural residues such as straw, corn, husks, stalks, bones, etc.,
  - Plantation cultivation of plants specially intended for biomass production.
- The industrial organic waste:
  - Wood industry, forest maintenance, wood processing, construction wood residues,
  - Chemical industry residues,
  - Brewing industry,
  - Pharmaceutical industry,
  - Paper industry.
- Waste from slaughterhouses, carcasses,
- Kitchen waste, restaurants,
- Medical waste,
- Other types of biodegradable waste.

Table 1: Biomass and Biogas Data

Municipal waste	Energy value 6 – 15 MJ/kg
Domestic waste 1 [t]	60 m^3 – 150 m^3 biogas (50 % – 60 % methane) Equivalent to 35 – 70 litres of liquid fuel
Organic waste 1 [t]	Up to 100 m^3 of methane, i.e. *0.235 MWh of electricity,* *0.155 MWh of heat energy,* *350 kg of compost waste, and* *450 kg of liquid fertilizer*
Municipal solid waste	Methane production of 70 – 120 Nm^3 per ton or 50 – 90 Nm^3 per metric ton of treated waste
Organic waste 25 [t]	Provides energy for 1 household per year

Production of biogas

Biogas could be produced with decomposition and fermentation of organic materials with the complete exclusion of oxygen, t. e. with the so-called anaerobic microbic activities. The development of these processes occurs under special conditions, such as the type of substrate, temperature and pH value of the organic mixture. Because microorganisms are highly adaptable, almost any organic matter can be decomposed. In the process of biogas production fermentation residues are always formed which consist of a mixture of water, non-degradable organic substances, usually rich in cellulose and containing lignin, and inorganic substances such as sand, soil residues, salts and few other minerals. Fermentation always takes place in a moist environment, as microorganisms need at least 50% water in the initial substrate.

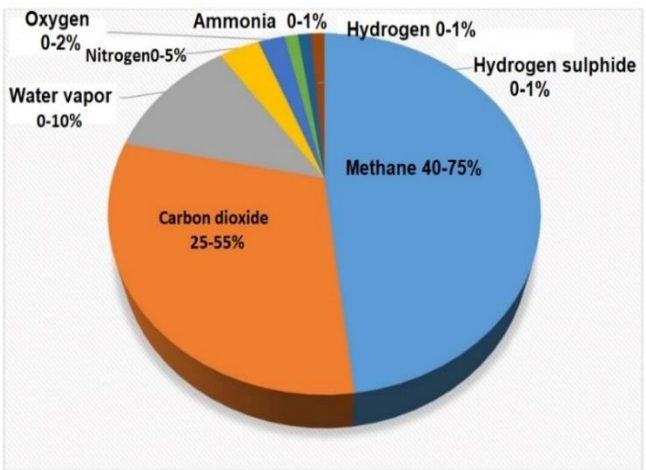

Figure 1: Typical chemical composition of biogas

Addressing its energy value, biogas usually has a heat value of 6.5 kWh/Nm^3, with calorific value and energy potential of approximately 20 MJ/m^3. Thus, from 1 m^3 of biogas with 65% concentration of methane and heat value of 6.5 kWh/Nm3, one could obtain approximately 2.5 kWh of electricity, 3.3 kWh of heat energy, or enough energy for one vehicle to travel almost 8.5 km.

How much and what kind of waste we create

As a result of everyday human activities, waste is constantly generated and disposed. Thus, in addition to the daily problems due to the increasing pollution of air, water and soil, there is a huge increase in the amount of waste materials, which in an ecological sense, leads to an increasing pollution of the environment. Modern way of leaving and packaging of goods creates more and more waste, which is increasingly difficult to deal with in an appropriate way. This leads to unpleasant situation where very soon we can be, plainly speaking, buried in waste. As a result of the excessive use of natural resources, and at the same time as a result of the creation of increasingly large amounts of un-used waste and its inappropriate disposed, today, globally we face occurrence of so-called global environmental crisis. As an example, by adequate treatment of the municipality wastewater and sewage in the specially designed treatment plants, one could produce on average 25 l of biogas per inhabitant per day, which is a significant value of biogas considering the number of inhabitants in one middle size town.

Biodegradable waste from the region of Radovish

The available amounts of biodegradable waste (biomass) from the region of Radovish have not been sufficiently and studiously studied in the framework of some kind of more comprehensive project for its use. In this analysis, we pay our focus on the most important and widely available organic materials in the form of biodegradable biomass that can be obtained from:

- the municipal waste collected daily from the citizens,
- the disposed waste at the landfill,
- the reduced waste sewage deposits,
- the wastewater from the treatment plant,
- wood waste and debris,
- waste and residues from the agricultural complex, and
- the waste from the local farms.

Communal waste

According to the Questionnaire of the European Commission for the preparation of an opinion on the request of the Republic of Macedonia for membership in the EU and the provided answers, with respect to the quantities of municipal waste generated, the daily production of municipal waste per inhabitant amounts to:

- for urban areas 0.70 kg/day/person
- for the rural areas 0.50 kg/day/person

On the other side, Figure 2 represents an average value in percentage shared between different waste materials in the total amount of municipality waste according to the available data from the public waste collection company “Plavaja” of the city of Radovish . Figure 2 shows that biodegradable waste amounts for almost 75% of the total municipality waste.

Solid waste dump

According to JP Plavaja [4] In 2021, from $27641 m^3$ solid waste that has been collected from the places for collecting solid waste at the territory of Radovish and deposited at the regional city landfill , at least 30% was biodegradable.

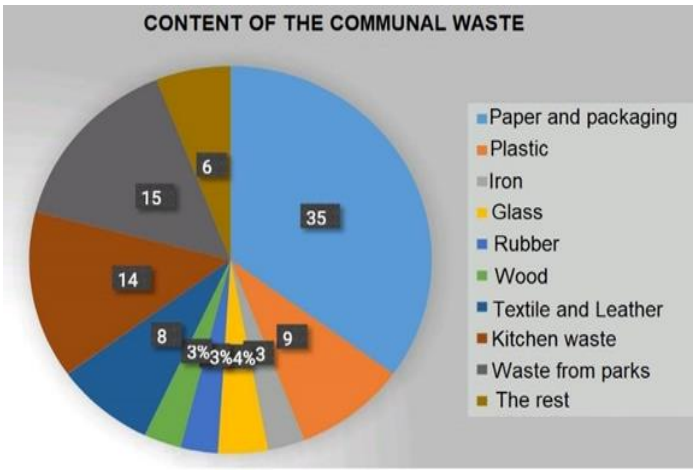

Figure 2: Contents of various waste materials in the total waste in the city of Radovish

Wastewater treatment plant

Realization of the project for putting into operation of the wastewater treatment plant in Radovish was a significant capital project for the creation of biodegradable waste and its future utilization. The outline of this environmental project is given in Figure 3. Only in 2021, this wastewater treatment plant has processed 2.100.400 m^3 of wastewater including fecal, industrial, and infiltrated rainwater [4].

The technological data from the wastewater treatment project show that after the fermentation of municipal wastewater there is the deposited sludge as a by-product. This deposited sludge could be further used and bio-chemically treated because it cannot be simply permanently deposited in or around the treatment plant. If we do that a huge landfill deposit space is required near the plant that would further pollute the surrounding environment. Only in 2021, the treatment plant has produced 624 m^3 deposit, which with the help of centrifuges is brought to an average solid content of at least 20%, This solid waste is currently deposited in the municipal landfill and represents significant environmental problem for JP "Plavaja", and the city of Radovish.

Potential biogas users

Biogas pumps for vehicles

The major chemical component of biogas is methane, that due to its significant energy value and modest price, recently has become widely used as favorable energy source in the transportation sector, especially for driving individual vehicles and tracks. Considering that other fossil fuels (oil and its derivates) are exhaustible and have a limited lifespan, biogas, i. e. methane as an unlimited resource, gradually becomes a fuel of the future.

More and more vehicle manufacturing companies are already producing vehicles that run on methane as an original fuel or produce additional equipment that enables existing vehicles being retrofitted to run on methane. In Macedonia, methane is already being added to vehicles at some of the existing gas stations and provides retrofitting of the existing vehicles which originally ran on petrol or diesel fuel. This provides us with hope to emphasize the installation for biogas production facilities and construction of dedicated biogas pumps have bright future and could be easily built in or near the populated areas.

Figure 3: Bird-view of the wastewater treatment plant in Radovish

Electricity generation from biogas

Biogas produced by means of bacteriological process called anaerobic digestion, could be converted into electricity and heat energy. Electricity can be sold at a preferential price, while thermal energy can be used for heating or cooling buildings, in various technological processes in industry, greenhouses, dryers, etc. Anaerobic fermentation is a stable and proven technology that provides an environmentally friendly energy supply solution.

If a biogas power plant could be erected in the vicinity of the wastewater treatment plant in Radovish, the electricity produced could be used as self-supply for the purposes of wastewater treatment. As a raw material for biogas production, we could use the sludge produced from the biological treatment of wastewater. This is especially important for smaller settlements where there is no possibility, or it is economically not feasible construction of wastewater treatment plant. For such communities, the wastewater from the sewage system can be directly applied to a biogas production installation. Also, from individual entities (business, households and others), which use settling plants (pre-treatment plants, septic tanks, or similar) for municipal wastewater, the entire municipal wastewater can be processed in the biogas production installation.

Biogas production - ecological aspects

Anaerobic digestion technology for biogas production reduces unwanted and uncontrolled methane emissions from landfills and reduce the volume of the waste disposed on landfills. Thus, instead of free methane release from landfills into the atmosphere and preventing forced depletion of the Earth's ozone layer, controlled production of biogas in biogas production facilities enables capture, storing and quality utilization of methane as valuable energy resource. Only methane gas contributes 10% to global warming, and its use as an energy source significantly reduces this percentage, thus also reduces the level of global warming.

At the same time, anaerobic digestion of organic waste for biogas production offers the possibility of reducing anthropogenic emissions of greenhouse gases that pollute the atmosphere and cause the greenhouse effect. An additional environmental advantage is the fact that anaerobic digestion could be considered as CO_2 neutral activity, because it results with no emission of CO_2 gases into the atmosphere. During the process of digestion, up to 99% of pathogenic bacteria are destroyed in the fermenter, and at the same time the considerable number of insects that usually follow the waste are eliminated. Substances that cause

unpleasant odors in untreated waste, such as fatty acids, phenols, phenol derivatives, are degraded in the biogas production installation and the emission of unpleasant odors is reduced by 90%. Finally, production and use of biogas substantially reduces the amounts of other toxic substances such as NO_X, which affects the increase in respiratory diseases in humans.

Knowing that coal and heavy oil reserves are limited and unfavorable due to their high environmental pollution effects, developed countries serious has been paid attention to the production of energy from renewable sources such as solar, wind, and geothermal energy, utilization of biofuels, e. g. biomass and biogas, etc.

Conclusions

The aim of this paper was to make a suitable contribution towards development of awareness of the effectiveness of biogas production, its positive environmental effects, and to renew or launch initiatives for proper activities for development of biogas production facilities. We also initiate and cherish any actions and cooperation with companies from EU and Asia which produce equipment for biogas production and have adequate experience in biogas production and utilization. Such cooperation and knowledge transfer could be of great benefit for the development of such installation in our country.

Construction of such biogas generation plants opens the possibility of reducing the anthropogenic emissions of gases that pollute the atmosphere and cause the greenhouse effect. It would have a positive effect on reducing biodegradable waste that at present we have in the country as mostly agricultural economy and decrease the amount of waste disposal in open or close landfills. Thus, utilizing the disposed waste as a raw material from the existing landfills that continuously pollute nature, underground water and air, in such biogas production facilities, we could, on one side we can protect our environment and improve the environmental footprint of our country, and on the other side we could generate valuable energy resource that can help our energy, transport and agriculture sectors.

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INTELLIGENT POWER MODULE CONTROLLED BY MICROCOMPUTER AND IMPLEMENTED IN AC MOTOR SPEED REGULATOR

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Abstract

In the paper, a V/f AC motor speed regulator based on an intelligent power module (IPM) and a microcomputer is designed and practically implemented. The ATmega 328P microcomputer controls the operation of the IPM TM 35 and generates the SPWM pulses for controlling an asynchronous 3 phase AC motor. The intelligent power module TM 35 works as a power driver that isolates and transmits the SPWM signals from the microcomputer to the AC motor. A basic goal in the design of the device is the reduction of the necessary hardware components and the price, as well as the improvement of the reliability of operation. The control and visualization of the operation modes of the V/f controller is realized with an LCD display. The operation of the controller at idle and under load has been tested.

Key words

IPM-Intelligent Power Module, Microcomputer, V/f AC motor speed regulator.

1. Introduction

An induction motor mainly works as a constant speed motor, however possible in the defined range with some drawbacks such as efficiency drop and aggravation of the power factor to operate at variable speed.
Before discussing the methods to control the speed of three phase induction motor one should know the basic formulas of speed and torque of three phase induction motor as the methods of speed control depends upon these formulas.
The speed of induction motor can be changed from both stator and rotor side. The speed control of three phase induction motor from stator side are further classified as:

- V / f control or frequency control.
- Changing the number of stator poles.
- Controlling supply voltage.

The speed controls of three phase induction motor from rotor side are further classified as:

- Adding external resistance on rotor side.
- Cascade control method.
- Injecting slip frequency emf into rotor side.

Three phase induction motor speed control principle an be made by adjusting the frequency of the input voltage to the motor. The equation used to determine the motor synchronous speed N_s is as follows [2]:

$$Ns = \frac{120f}{z} \quad (1)$$

where, f = supply frequency and z is the number of stator poles.
From the equation (1), the speed of magnetic field varies with the frequency of the voltage,but the 3-phase motor has a shaft that rotates at a speed slightly less than the speed of themagnetic field, i.e. schronous speed. Which is called slip speed with values that are approximately 1-3% lower than the synchronous speed and depend on the motor load.

$$N = Ns(1 - s) \tag{2}$$

Where N is the speed of the motor's shaft, the unit is rpm, while s is called slip which is the ratio of the magnetic field velocity difference to the speed of the motor shaft.
From above relation factors affecting speed of induction motor are frequency, number on poles and slip. From other side torque T on AC motor is given with [2]:

$$T = \frac{P}{2\pi f} \approx \frac{V}{f} \approx \Phi \tag{3}$$

where T is torque in Nm, P is power in W, f is frequency in Hz, V is stator voltage in V and Φ is flux in Wb.
Equation (3) illustrates the so-called scalar, or V/Hz control of an induction motor. The open loop V/Hz control of an induction motor is by far most popular method for speed control because of its simplicity, and these type of speed control is widely used in industry [2]. Voltage is required to be proportional to frequency thus that stator flux Φ remains constant. This causes that the maximum motor torque T also remain constant and independent of supply frequency. In the Fig. 1 is shown the torque-speed curves.

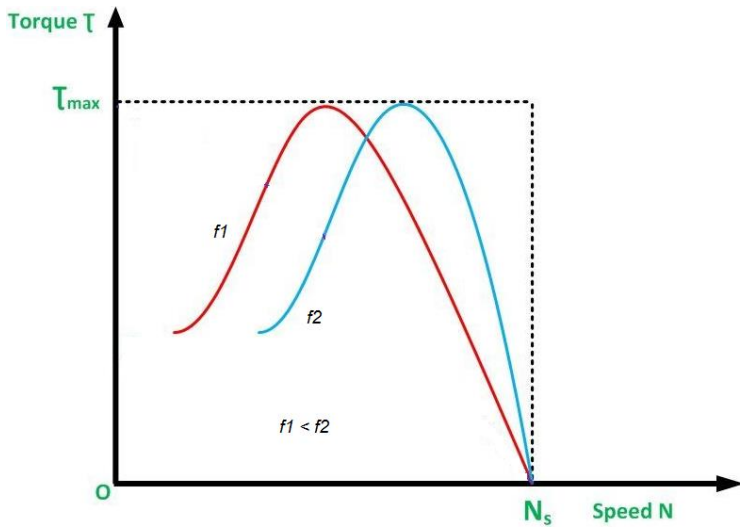


Fig. 1.Torque-speed curves.

Figure 1 shows that speed is increasing proportionally with frequency and maximum torque remains constant if supply voltage also increases with the frequency.
In this paper, the authors used aV/f controller for speed regulation on 3 phase AC motor with nominal voltage 3x380 VAC, nominal power 1.5 kW, nominal current 4.8 A, nominal frequency 50 Hz, and with number of poles z = 8. This controller is based on microcomputer Atmega 328P build on Arduino nano board and intelligent power module TM 35.
The test for proper operation of the designed motor controller is made so that the AC motor driven by the regulator is mechanically coupled to a DC generator with nominal voltage 100 VDC and nominal speed of 1,550 rpm. Heaters are connected to the output of the DC generator. Integrated AC DC power meter used to measure input and output energy. AC power meter is placed at the input of the controller and a DC power meter is placed at the output of

the DC generator. Brief description of the components used in the implemented regulator together with the regulator and controller information are given below.

2. Advantages of AC Motor Speed Regulator based on Intelligent Power Module and Microcomputer

Next, the major advantages of an AC motor speed regulator with an intelligent power module over solutions without intelligent power module and a generator on classic sinusoidal pattern are presented.
In the Fig. 2 the bloc diagram of analyzed 3-phase motor speed regulator is shown.

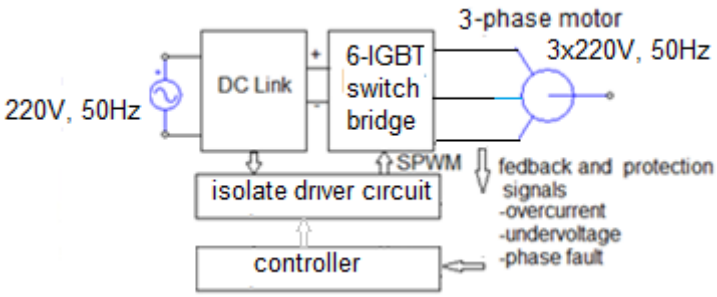


Fig. 2.Block diagram on 3-phase motor speedregulator.

The use of a microcomputer in the design of an AC motor speed controller compared to the classical configuration of controllers for generating SPWM signals provides simpler hardware architecture. The simplification resides in the design of the controlling circuit. In case of classic architecture design with analog circuits, the controller is built from analog and digital circuits including IGBT transistors for generating the sinusoidal voltage and the triangular reference voltage, required for the construction of the SPWM pattern, as shown in Fig 3, [3].

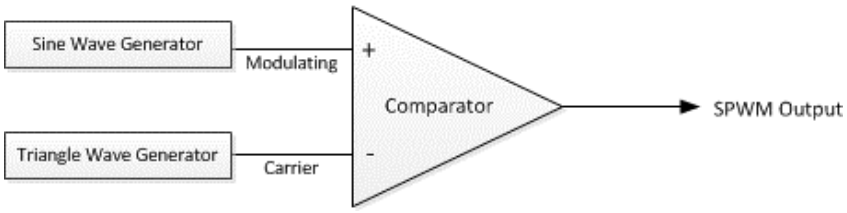


Fig. 3 Classic architecture design for generating SPWM pulses using inverter regulator with IGBT transistors.

The switching signal is generated by comparing the sinusoidal waveform and the triangular carrier waveform. The comparator output is high when the sinusoidal voltage is greater than the triangular voltage. The output pulses of the comparator are used as the gate pulses of the IGBT bridge.
In the case when the controller is implemented with a microcomputer, the sinusoidal pattern is software generated by defining on the points of switching-on and switching-off of the IGBT switches in the bridge. An example of a piece of a software code that generates pulses by variable width to drive the gates of the IGBT switches in the bridge could read as follows.

Code for generates pulses with variable width

```
const int output_1 = 9;
const int output_2 = 10;
const int output_3 = 11;
const int t = 3310;
void setup()
```

```
{
pinMode(output_1, OUTPUT); // Phase 1
pinMode(output_2, OUTPUT); // Phase 2
pinMode(output_3, OUTPUT); // Phase 3
}
void loop()
{
delayMicroseconds(t);
digitalWrite(output_1, LOW);
delayMicroseconds(t);
digitalWrite(output_2, HIGH);
delayMicroseconds(t);
digitalWrite(output_3, LOW);
delayMicroseconds(t);
digitalWrite(output_1, HIGH);
delayMicroseconds(t);
digitalWrite(output_2, LOW);
delayMicroseconds(t);
digitalWrite(output_3, HIGH);
}
```

A. SPWM generator

The PWM Generator (three-phase, two-level) block controls switching behavior for a three-phase, two-level power converter. The block:
Calculates on- and off-gating times based on the block inputs:
three sinusoidal reference voltages, one per phase, and
a DC-link voltage
Uses the gating times to generate six switch-controlling pulses.
Uses the gating times to generate modulation waveforms.
Continuous and Discontinuous PWM
The block provides modes for both continuous and discontinuous pulse width modulation (PWM). Fig. 4 shows the general difference between continuous sinusoidal PWM (SPWM) and discontinuous PWM (DPWM)waveforms.

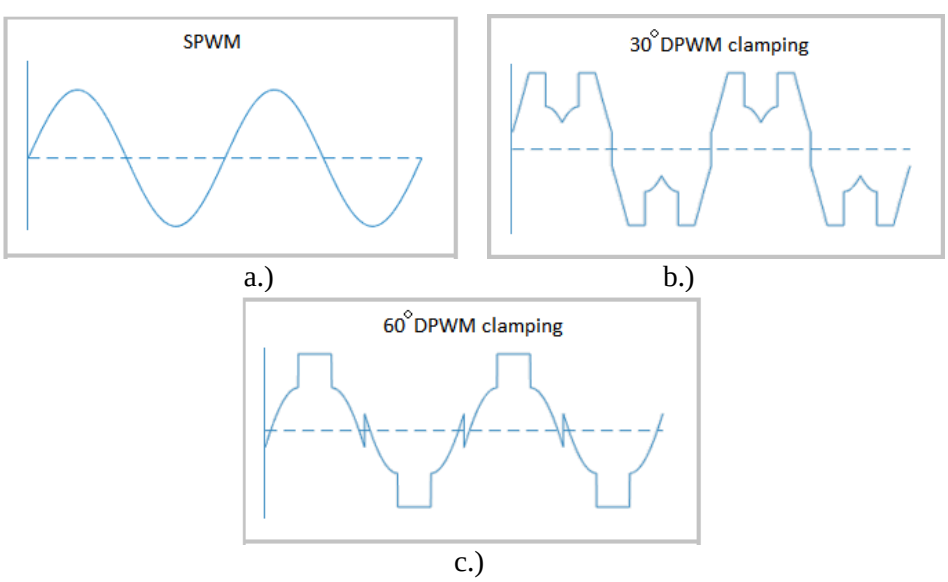


Fig. 4 The general difference between: a.) continuous sinusoidal PWM (SPWM), and b.) discontinuous PWM (DPWM) waveforms with 30º DPWM clamping, and c) discontinuous PWM (DPWM) waveforms with 60º DPWM clamping.

For discontinuous PWM (DPWM), the block clamps the modulation wave to the positive or negative DC rail for a total of 120º degrees during each fundamental period. During the clamping intervals, modulation discontinues. A waveform with 30-degree DPWM has four 30-degree intervals per fundamental period. A waveform with 60-degree DPWM has four 60-degree intervals per fundamental period.
The use of a microcomputer in the design of an AC motor speed regulator is the first advantage presented in this paper. The second advantage of the designed controller derives from the use of an intelligent power module [4], Fig. 5.

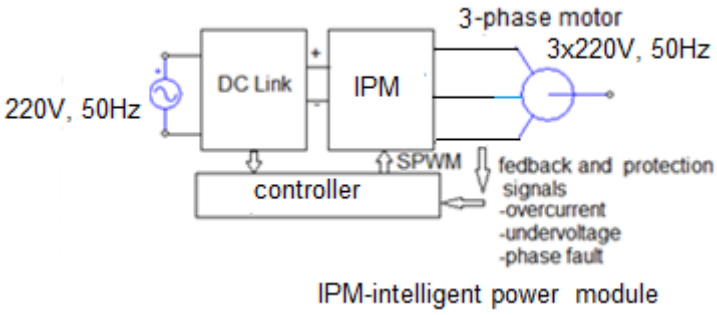


Fig. 5 Block diagram on 3-phase motor speed regulator with intelligent power module.

A comparison of Figs.3 and 5 shows the simplicity of the controller with a built-in intelligent power module.

3.Design on 3 - phase AC Motor Speed Regulator based on Intelligent Power Module and Microcomputer

Block diagram on design AC motor speed regulator based on Intelligent Power Module and Microcomputer is shown in Fig. 6. The design solution is based on an Atmega 328P microcomputer on Arduino nano board and a TM 35 intelligent power module.

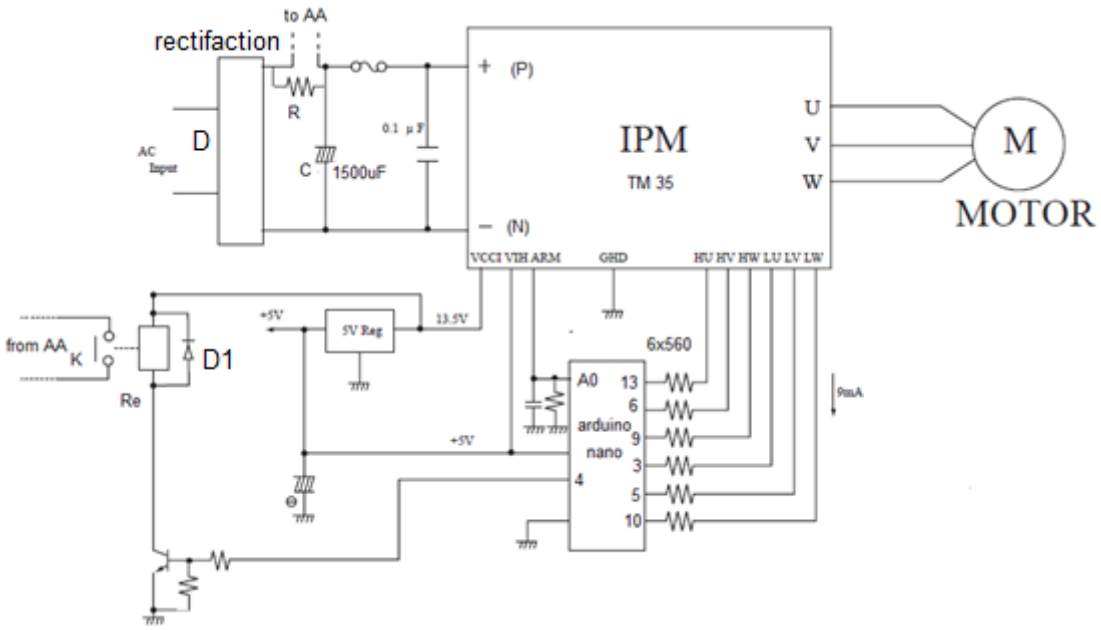


Fig. 6 Block diagram on design 3 - phase AC motor speed regulator based on intelligent power module TM 35, and microcomputer ATmega 328P on Arduino nano board.

3.1 Atmega 328P microcomputer on Arduino nano board

Arduino Nano is a microcontroller board that is similar to the Arduino Uno board but small in size and for readers who are not very familiar with microcontrollers. Microcontrollers are devices that contain a CPU, RAM, ROM, and I/O pins on a single integrated circuit and are used in electronic projects. In order to understand the Arduino boards and to use them effectively, one must first go through the pin configuration of the specific board, [6], [7]. Pinout on Arduino nano board, is represented on Fig.7.

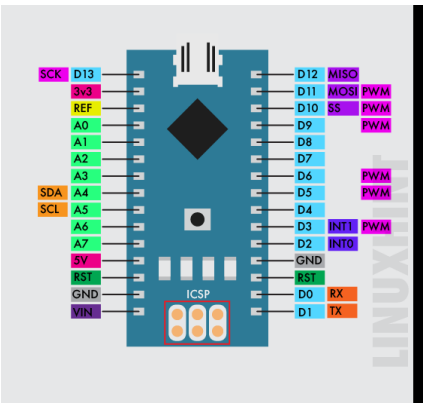


Fig. 7 Pinout on Arduino nano board.

This Arduino nano have 14 8-bit digital I/O, 7 10-bit analog input, 6 PWM output. In our application PWM outputs pins 11 and 3 are used for phase U, pins 6 and 5 for phase V, and 9 and 10 for phase W. For more information about Arduino nano, the reader is advised to consult [8].

3.2 Intelligent Power Module TM 35

Intelligent power module (IPM) TM 35 shown in Fig. 8, makes the inverter to control the speed of the 3-phase AC induction motor extremely easy.

Fig. 8 Intelligent Power Module TM 35.

Intelligent Power Module TM 35 is product of the Shindengen Electric Company, which has a 30A 600V coordinate that can beused up to 2.2 kW, 220V/380V 3-phase AC induction motors [5]. This is a hybrid integrated circuit device that incorporates the IGBT and a driver circuit set connected to the control circuit by opto-couple and switching power supply circuits for supplying 2 external control circuits. In addition, there is an over current and overload protection circuit. Therefore, the IPM TM-35 device is a convenient and easy device to design and assemble the inverter.

A rectifier circuit with the bridge diode D and the resistor device R presented in Fig 6, is limiting the over load current to the diode bridge. The initial charge at the capacitor C 1500µF/400V which has 4 parallel and voltage drop across the capacitor is the input voltage for IPM TM-35 by the positive (+) connected to the P terminal, and the negative (-) connected to the N terminal. When the voltage across capacitor increases to the value of 170V, the

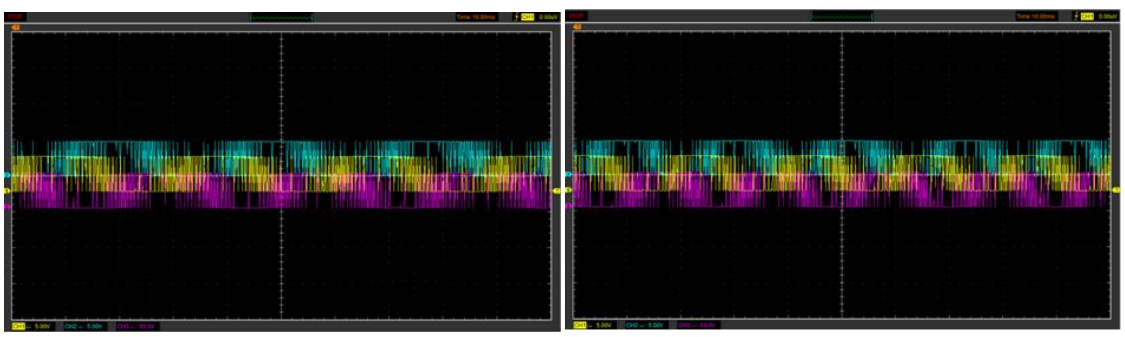
switching power supply in IPM TM-35 circuit will start to supply 5.0V at the Vcc2 pin and 13.5 V at the Vcc1 pin, and the Re will start to work. As a result, the resistor device is short-circuited to direct capacitor current flows. DiodeD1 serves to prevent the reverse voltage of the coil Re.

3.3Microcomputer code test results

In the Fig. 9 is shown Arduino nano board with upload code in test phase.

Fig. 9 Arduino nano board with upload code in test phase.

Obtained waveforms for phase pulse HU (pin11), HV (pin6) and HW (pin 9) for 25 Hz and 50 Hz frequencies, are presented in Fig. 10.

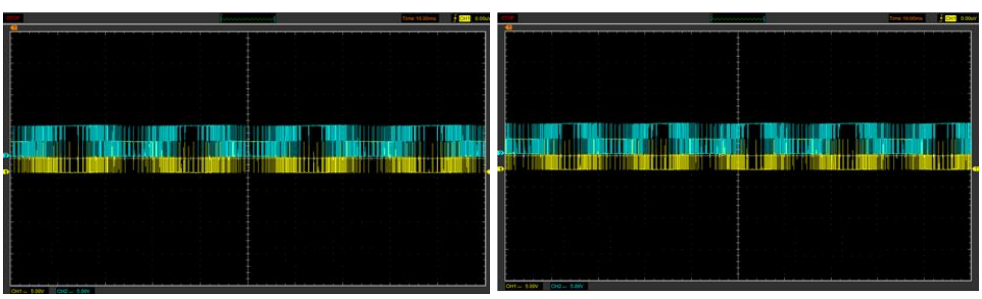


a.) b.)

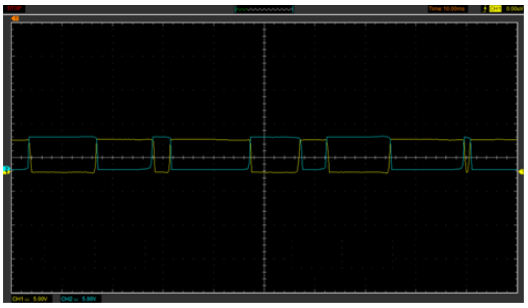
Fig. 10 Waveforms for phase pulse with horizontal 10 ms/div: a.) HU (yellow), HV (green) and HW (purple) for 25 Hz, and b.) HU (yellow), HV (green) and HW (purple) for50 Hz.

Fig. 10 a.) and b.) shows that the phase pulses generated by the microcomputer are phase shifted for120º.

Fig. 11 a) and b) shows waveforms for phase pulse HU-LU (pin11-3) for 40 Hz and 50 Hz frequencies, while on Fig. 11 c) phase pulse HU-LU dead time is given.



a.) b.)



c.)

Fig. 11 Waveforms for phase pulse HU(yellow)-LU (green): a) for 40 Hz, b.) for 50 Hz, and c) HU-LU dead time.

From Fig. 11 a.) and b.) it can be seen that the phase pulses HU (yellow)-LU (green) generated by the microcomputer are phase shifted for 180º. Also, from Fig. 11 c,) it can be seen the dead time on the phase pulses HU (yellow)-LU (green). This dead time ensures that the switching-on of the two IGBT switches in the same half bridge does not overlap.In the specific case, the dead time is about 5 µs.

4.Results of the experimental work of the design AC motor speed regulator

For testing, measurement, visualization and data log of the operation of the designed 3-phase AC motor regulator, an integrated AC DC power meter and mechanically coupled on the AC motor by a DC generator shown in Fig.12 is used. The AC motor data was 3x380V, 50 Hz, 4.8 A, 8 poles, Ns = 750 rpm, and the DC generator data was: nominal voltage 100 VDC, and nominal speed 1,550 rpm.

a.) b.)

Fig. 12. Realized devices used for testing on AC motor regulator: a.) Integrated AC/DC power meter, and b.) mechanically coupled on the AC motor by a DC generator.

The integrated power meter provides the possibility to display input and output energy, power, current, and voltage data on LCD screens and stored them in a compatible EXCEL® data log file. Realized AC motor speed regulator with microcomputer and IPM TM 35 is shown in Fig. 13.

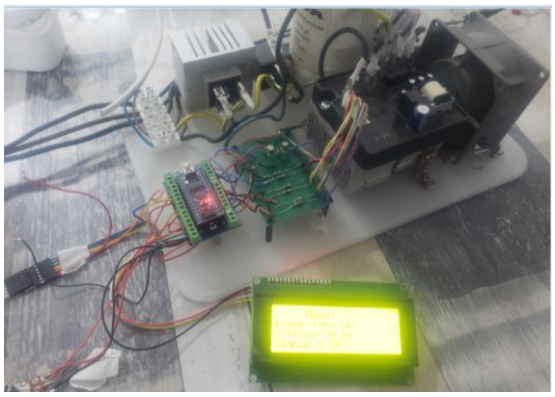


Fig. 13 Realized AC motor speed regulator with microcomputer and IPM TM 35.

Table I consist of given data for input to the AC regulator,the input current Iin, inputvoltage Vin, power factor cosφ, and input power, as well as DC generator's output data such as output current Io, voltage Vo, and output power Po. The data is given for change on motor frequency fmon AC motor regulator in the interval from 1 Hz to 50 Hz, with 5 Hz step. Nm and NDCg are measured speed on the shaft of the AC motor and the DC generator, respectively. Table I also have the calculated data for the torque T (Nm) and the efficiency coefficient η (%).

Table I:

fm (Hz)	Iin (A)	Vin (V)	cosφ	Pin (W)	Io (A)	Vo (V)	Po (W)	Nm (rpm)	NDCg (rpm)	T (Nm)	η(%)
5	2.44	244	0.52	307.2	1.1	8.16	8.94	72	151	40.74	2.91
10	1.21	244.3	0.47	137.4	2.31	16.98	39.22	145	303	9.04	28.54
15	2.84	244.5	0.43	299.2	3.56	25.81	91.76	216	452	13.22	30.66
20	2.74	244.7	0.45	302.8	4.03	33.29	134.11	287	595	10.07	44.28
25	3.98	244.7	0.47	457.8	5.31	42.12	223.5	356	732	12.28	48.82
30	5.04	244.7	0.48	591.9	6.6	50.83	335.27	421	858	13.42	56.64
35	6.16	244.7	0.5	753.7	7.44	57.2	425.82	487	979	14.77	56.49
40	7.50	244.6	0.51	936.3	8.45	64.24	543.08	553	1091	16.16	58.00
45	8.77	244.6	0.53	1136.4	9.26	70.27	650.69	620	1206	17.50	57.25
50	10.40	244.1	0.53	1348.8	10.29	89.26	918.61	666	1230	19.34	68.10

Discussion of the results of the experimental testing:

The main task in the paper was the design and implementation of an AC motor regulator with a microcomputer and IPM. However, some minor omissions were necessary done in the experimental testing phase, e.g.in the calculation of the torque T, the losses of the rectifier and of the inverter in the intelligent power module were neglected. Additionally, the measured input power is assumed to be the same as the power supplied to the motor, although. Clearly this is not the exact power delivered to the motor shaft as its efficiency is not known. The DC generator used as a coupled load with the AC motor does not provide the possibility to load the motor with a constant mechanical load for all operating frequencies from the regulator (starting from 0 to 50 Hz). That affects the calculation of the torque and efficiency coefficient given in Table I. However, the most important fact that should be considered is that the generated torque at low speeds was large. It shows that the solution fulfills one of the basic requirements for such systems to provide a large moment at low speed, very important fact for AC motor starting characteristic. Furthermore, it can be seen from Table I that for aninputfrequency of 50 Hz the torque is close to 20 Nm, which is the moment according to the motor data for a synchronous speed of 750 rpm and a frequency of 50 Hz.

Conclusions

In the paper, the main task was to design, implement and experimentally test a 3-phase AC motor speed regulator based on a microcomputer and an intelligent power module.The use of a microcomputer and IPM has large influence on the reduction of hardware components and thus the price of the device in relation to solutions where analog circuits are used to generate sinusoidal pulses to control the IGBT switches in the inverter and driver circuits as a coupling between the control part and the IGBT the inverter. During experimental testing phase, as a result of the absence of a real constant mechanical load, the designed AC motor speed regulator was loaded with a variable load consisting of a DC generator and output heaters.Such a load showed that the solution provides the motor operation with a high starting torque and a maximum developed power of 1,348 W. This was a good indicator that the goals set in the paper have been realized.

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COMPARATIVE ENVIRONMENTAL ANALYSIS BETWEEN CONVENTIONAL AND COGENERATION GAS-FIRED CENTRAL HEATING SYSTEMS

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Abstract

Heating power plants are the major source of hot water intended for heating of communal areas or districts, or even whole cities for any developed country on a large scale. The usual concept for conventional heating power plants is burning fuel into combustible chambers called boilers and production of heat in the form of hot water. Then, using already developed heat network consisted of pipes and pumps, the hot water is distributed to final customers. At the cogeneration power plants, the process is almost similar, with the major difference that in the boilers instead of hot water, the so-called superheated water vapor is generated which initially is used in the steam turbines for electricity generation, and later the exhausted steam is re-used using condensers for production of heat in the form of hot water for central heating purposes.

In this paper, the authors present comparative environmental analysis between two gas-fired plants used for central heating of the city of Skopje. The first one is the conventional gas-fired heating plant which has only one product, hot water for central heating purposes. The second power plant is cogeneration gas-fired power plant; thus, it simultaneously generates electricity and heat used for central heating. Since 2013, both plants use natural gas as primary fuel, which although still a fossil fuel, is less polluting and environmentally more acceptable. The obtained results of the analysis and comparison between both power plants are given in details showing that both plants are within the prescribed environmental regulations.

Key words

heating power plants, central heating, cogeneration, environment protection, pollution

Introduction

The conducted research indicates analyzed one of the most important heating plants in the main town in our country. One heating plant is intended only for central heating, while the other one is cogeneration power plant intended to generate both, the electricity and the heat, simultaneously. In this analysis, particular attention is paid to the environment impact of both power plants. Heating plants are the major source of public heat in various developing country, using primary fuel, usually coal or fuel oil burnt inside the combustible chambers/boilers at high temperature and generating heat energy. The heating plant has serious negative environmental impacts on soil, air and wastewater, and emits a large amount of CO_2 particles aggravating the surrounding environment. Various mitigation measures for the control of pollution caused by heating plants along with some new technologies have already been discussed.

The conventional heating power plant (HP) “West” treated in this analysis until 2013 used fuel oil as primary fuel. However, during 2013 a replacement of the fuel oil as primary fuel with natural gas occurred, keeping fuel oil as reserve or backup fuel in case of emergency. On other side, the cogeneration plant TE-TO, also treated for comparison in this analysis, uses only natural gas as primary fuel. Natural gas is a fossil fuel, nonetheless the global pollution emissions during its combustion, especially particles, CO_2 and NO_X emissions are much lower

in comparison with fuel oil and especially coal. This fact enables us to make comparison between environmental impacts of both plants using the same primary fuel. Detailed presentation of the operation system and distribution of heat energy for both plants are presented.

Research methodology

As a basic methodology for researching the problem, elaboration, evaluation and proposing measures that can improve the process, initially we used the usual concept of an Environmental Impact Assessment (EIA) with Sustainable Development Analysis (SDA) and Sustainable Development Goals (SDGs) [1]. This methodology allows us to make comparative analysis between both generation plants and provides an easy tool for analyzing advantages and disadvantages of each of them independently. To use the proposed methodologies, a system analysis needs to be performed for the system under consideration. Speaking about the system, we follow the definition *"a system is a set of components and the connections between them"* as given in [1], or simply said, we consider all relevant parts of the system, such as, the input to the system *(e. g. material, energy, information)*, the type of transformations that will occur within the system and the output to the system that needs to be analyzed.

Case-study

General information about the companies

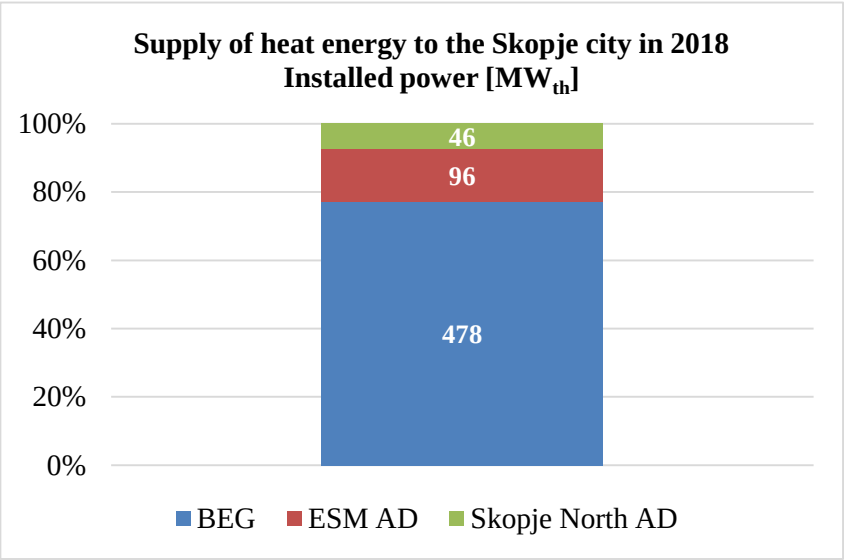

Figure 1: Participation with heat energy of the three heating systems of the Skopje city in 2018 [2]

Figure 1 shows the total required heating energy for 2018. The BEG has the largest share with an installed production capacity of 478 MW_{th}, followed by ESM AD with 96 MW_{th}, and Skopje North AD with only 46 MW_{th}, [2]. The percentage share of heating energy from BEG is approximately 75%, and it can be concluded that the importance of this company is the largest in the central heating of the city of Skopje.

The BEG company has three heating plants for heat energy production, two of which are active, with a total installed power of 470.19 MW_{th} (100%):

1. Heating plant (HP) "East", located in the eastern industrial zone of the city, installed heat power of 279.12 MW_{th} (58%), and steam power of 16.30 MW.
2. HP "West", located in the municipality Taftalidze with installed heat power of 162.82 MW_{th} (36%), and steam power of 20.09 MW, and

3. HP “11 October”, located in the Kisela Voda municipality with an installed heat power capacity of 28.25 MW_{th} (6%).

The meaning and impact on the environment of each of the heating plants is equally important, but in order to make a comparative analysis of the environmental characteristics between conventional and cogeneration gas district heating systems, a detailed presentation of the impact itself will be analyzed only on one of the BEG heating plants, the "West" heating plant. This heating plant is designed for the production of heat energy with a total capacity of 182.91 MW [3]. There is an installation of a total of:

- Four superconducting drive units,
- two combined boiler – steam units, and
- one steam propulsion unit.

Two high-flow propulsion units are connected to their own chimney, while the others are connected to a common chimney. This plant is designed in such a way that the transport of flue gases from each hot water boiler to the entrance to the chimney takes place through separate flue ducts for each boiler, but the flue ducts are also run separately even in the multicycle of each boiler. The remaining flue gases from the other boilers are removed through a common collection flue channel with a special opening on the chimney.

The plant has also additional (auxiliary) boilers:

- one boiler for combined production (steam – hot water), which can change the mode of operation in a very short time. This boiler can be used for the production of heat in the central system and for meeting one's own energy needs in the plant itself, and
- two steam boilers.

During the preparation of the application for obtaining of the unified A-type environmental permit, the old heating burners that work on fuel oil were substituted with natural gas burners. Today, natural gas is mainly used as a burning fuel, while fuel oil is used only as a backup fuel.

The other plant used for environmental comparison, the TE-TO company is a cogeneration power plant with production of electricity and heat in the so-called combined cycle and uses only natural gas as fuel. This power plant is in the eastern industrial zone of Skopje city. The installed capacity of this power plant is 220 MW_{el} electric power and 160 MW_{th} heat power.

The combined cycle involves the use of waste heat produced by the gas turbine for steam generation in the so-called heat recovery steam generator (HRSG) for driving the steam turbine and electric generator. This enables better utilization of primary fuel energy which usually exceeds 50%, significantly higher than the efficiency of conventional electricity generation power plants. Additionally, after utilization of the steam in the steam turbine for electricity generation, the heat energy that the steam still retains is used for generation of heat for heating purposes using energy conversion unit (the condenser). In that way, the total utilization factor of the primary fuels rises additionally above 75%.

This cogeneration plant is designed to work in two modes:

- **Cogeneration mode** (simultaneous production of electricity and heat energy), when the efficiency of the power plant in this mode of operation is over 75%. The produced heat is delivered as hot water to the public heating distribution system in the city of Skopje.
- **Condensation mode** (electricity production only), when energy efficiency is on average around 50%.

In addition to the improve utilization factor for the primary fuel, an additional environmental advantage of the TE-TO plant compared to conventional power plants is the use of a hybrid

cooling tower instead of a conventional wet cooling tower in the water-cooling process. This concept, which is also being applied for the first time in the country, has environmental benefits due to reduced water consumption and the occurrence of fog associated with the evaporation of cooling water from the towers. Table 1 summarizes the main technical data for the TE-TO installation.

Table 1: Basic project technical data for TE-TO

	Units	Data
Electricity production capacity		
– Gross	MWel	around 220 to 240
– Net	MWel	around 214 to 234
Mode of operation		basic work with approx. 8,300 h/annual operating hours
Heating production capacity	MWth	max.160
Fuel		
– Type	-	Natural gas
– LHV	MJ/Nm³	36
– Consumption	Nm³/h	About 52,000
Expected emissions dry, at 15% O_2		
– NOx emissions	mg/Nm³	< 75
– CO_2 emissions	mg/Nm³	< 100

Source: [4]

Heat Distribution

The distribution of heat energy is carried out by a two-pipe distribution network (DN) from the point of receipt of the produced heat energy, through the main connecting lines and heating stations to the place where the heat is delivered for heating of the end consumers. The transport of natural gas as a separate part of the distribution to HP "West" takes place via the natural gas pipeline network that passes through the city of Skopje. Some main technical characteristics of the existing DN are shown in Table 2. We could notice that the length of the DN is almost 400 km with normal pressure of 16 bars.

Table 2: Technical characteristics of a distribution system

Distribution system of pipelines	Two-pipe distribution system
Length of the distribution network	cca 200 km (400 km pipelines)
Primary side temperature mode	110/65 °C
Nominal pressure	16 bar
Annually distributed heating energy	500 GWh

Source: [5]

During distribution, chemically prepared and diaurated water is used through the supply and return pipelines. Technical water used in the process of heat energy production and with which energy is transferred to the end users is softened by ion exchange with ion exchange resins, whereby the calcium and magnesium ions that define the hardness of the water are removed. The gases (mainly O_2 and CO_2) are then removed in a high vacuum deaeration plant. Softened

and diaurated water is stored in expansion supply tanks. During the preparation of the chemical and diaurated water, there are waste particles as a residue that have a negative impact on the environment [6].

Pros & Cont analysis of fuel oil and natural gas

As previously stated, the HP "West" which is the subject of this analysis, until 2013 operated on fuel oil to produce heat energy. Then, the plant has been repowered using natural gas as an energy source, and it should be noted that all burners are adapted to burn both fuel oil and natural gas. Since 2014, due to the huge positive aspects that characterize natural gas, fuel oil has been set only as a backup fuel, while the plants continue to operate using only natural gas.

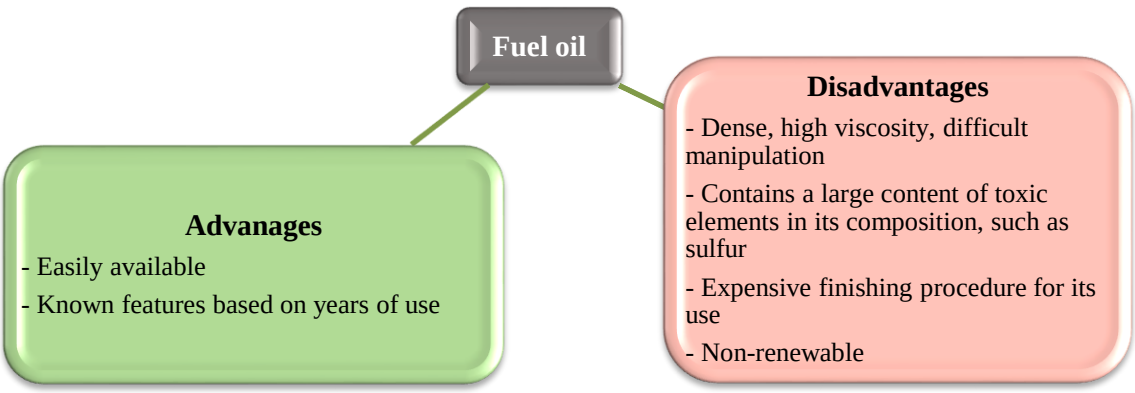

Figure 2: Advantages and disadvantages of fuel oil

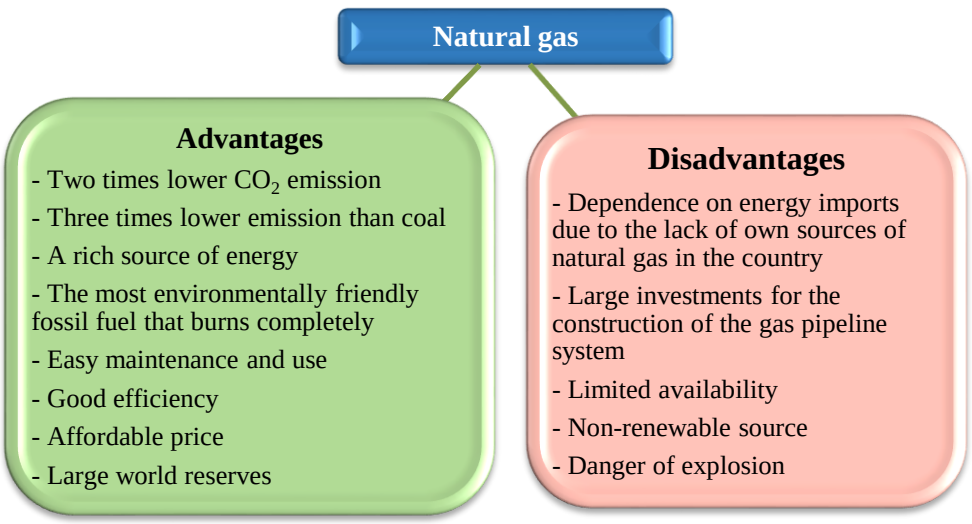

Figure 3: Advantages and disadvantages of natural gas

Figures 2 and 3 show the main advantages and disadvantages of fuel oil and natural gas. It can be concluded that natural gas has more advantages than fuel oil. Fuel oil is a fuel that has been used in the country for many years, while natural gas can be considered as a *"new"* fuel because it has been used on a large scale only in the last several years, despite the large world reserves. One of the reasons or shortcomings of this energy source is that there are no existing sources of natural gas in the territory of the Republic of North Macedonia, so the country is entirely dependent on imports.

The biggest advantage of natural gas is that it is the cleanest fossil fuel. It does not contain SO_X in its composition, so it follows that there will be no SO_2 emissions in the combustion products.

Unlike natural gas, when fuel oil is burned, there is a large amount of SO_2 in the combustion products. SO_2 in contact with hydrogen creates sulfuric acid, which is not suitable for the plant and for the heating energy production process itself, thus natural gas is much more environmentally friendly.

Research results and discussion

Analysis of NOx emissions and reduction proposals

Table 3 shows data for annually delivered heat energy and emissions of NO_X from 2014 to 2019, according to the BEG company. The reason why the emissions after 2014 were analyzed is that after 2014 only natural gas is used as primary fuel. Since NO_X emissions are significant, we recommend the installation of gas burners with ultra-low NO_X emissions with < 30 [mg/kWh]. A good example of such burners are the burners produced by the Weishaupt burner company, like WM-G10 ZM-PLN and/or WM-G20 ZM-PLN [7]. The calculations in the table were given in case the burners with NO_X emissions < 30 [mg/kWh] were installed in HP "West" from 2014 to 2019. The reduction of annual NO_X emissions could be at least 4 times lower when using gas burners with ultra-low NO_X.

Table 3: NO_X emission: real, measured values and values in case of using ultra-low NO_X burners,

	Delivered heat energy into distribution network	Emissions	
		NO_X - Measured	NO_X in case of using ulta-low NO_X burners with <30 [mg/kWh]
	[MWh]	[t/year]	[t/year]
2014	112,864	29.17	3.39
2015	109,381	23.18	3.28
2016	115,473	15.72	3.46
2017	140,233	19.09	4.21
2018	124,698	17.02	3.74
2019	108,968	13.14	3.27

Source: BEG

Emissions of CO_2

Table 4 shows annual emissions of CO_2 obtained by using different types of fuel. The values of emissions in tCO_2/MWh are taken from the Regulator for Energy Control [8]. The value of 125,526 MWh/year is the annual thermal energy production by the HP "West" in 2018 [9].

Table 4: Emissions of CO_2

Emissions of CO_2			
Fuel	tCO_2/MWh	MWh/year	tCO_2/year
Heating energy (central heating)	0.259	125,526	32,511
Individual heating with natural gas	0.202	125,526	25,356
Individual heating with fuel oil	0.279	125,526	35,022
Individual heating with electricity	0.915	125,526	114,856
Individual heating with lignite (brown coal)	0.364	125,526	45,691

Source: BEG, [8] [9]

Figure 4 shows the types of energy sources that can be used to obtain heat energy and the value of annual CO_2 emissions. It can be noted that individual use of natural gas in each household would result in the lowest possible emissions of CO_2. However, considering that there is no natural gas distribution pipeline network in the city of Skopje delivering natural gas to every household, central heating remains the best option for obtaining thermal energy. It is interesting to mention that the use of electricity enables the largest emission of CO_2. Although the emission of CO_2 is not directly hazardous for human health, it is significant because of its contribution to the greenhouse effect creation. Additionally, the emission of other harmful substances should also be analyzed, however, that was not part of our analysis.

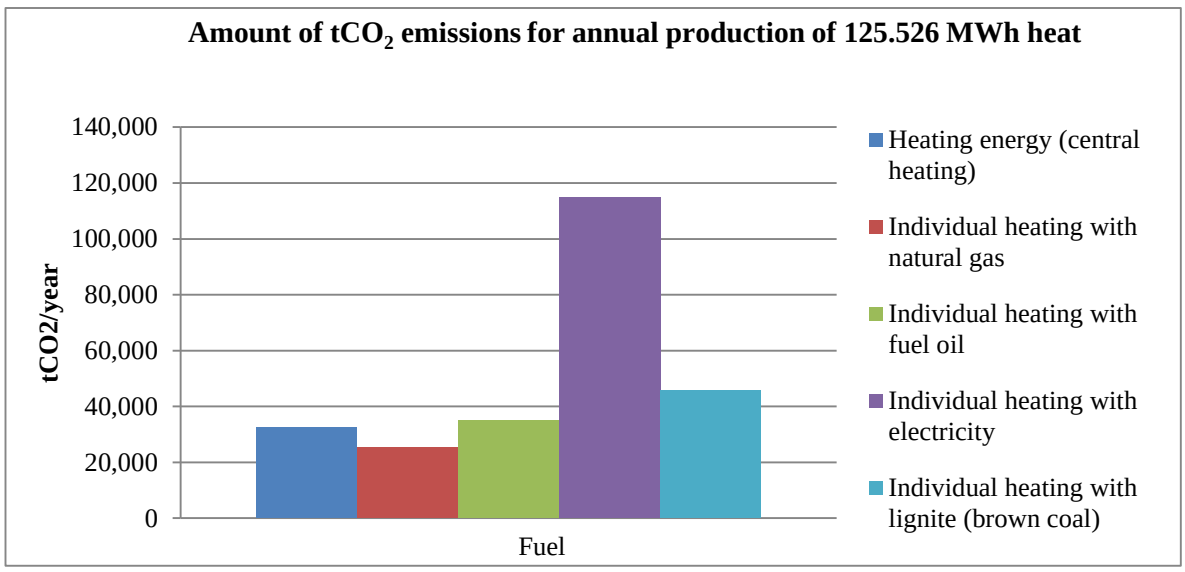

Figure 4: CO_2 emissions from different fuel sources for annual production of 125.526 MWh of heat

Source: BEG, [8] [9]

Comparison between fuel oil and natural gas

A comparison of these two energy sources, fuel oil and natural gas, in relation to emissions of pollutants such as CO_2, NO_X and SO_2 when burning 1 kg of fuel for heat generation are presented in Figure 6, where the values of the CO_2 emission of fuel oil and natural gas per kWh heat energy are 0.278 kg/kWh, and 0.202 kg/kWh, respectively [11], [12].

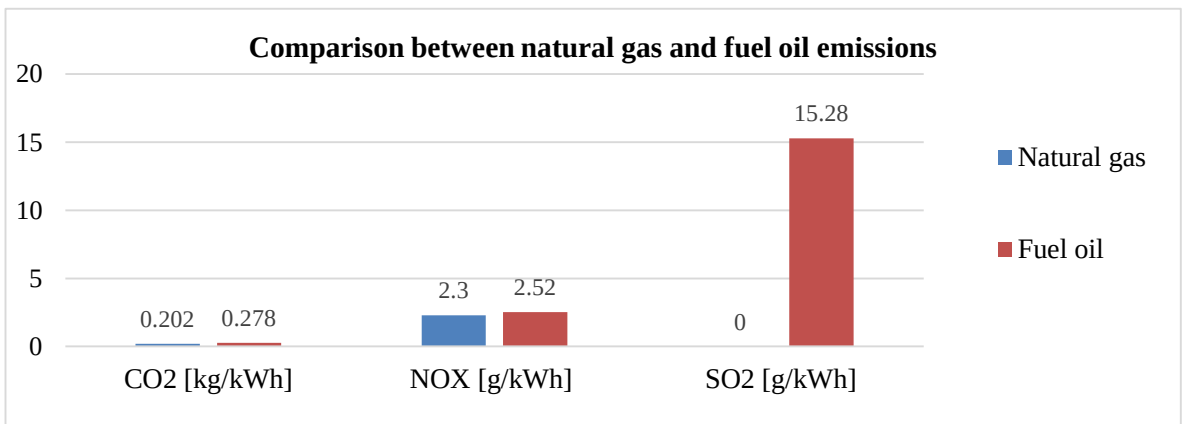

Figure 6: Comparison between natural gas and fuel oil emissions per kWh generated [11]

As shown in Figure 6, the emission of NO_X burning fuel oil is also higher compared to natural gas. Although there are no huge differences in emissions, even this small difference could be significant when it comes to environmental protection. Unlike the emission of CO_2 and NO_X, when it comes to the emission values for SO_2, there is a significantly large difference between these two fuels, that is the main reason and a decisive factor to switch primary fuel from fuel oil to natural gas. The amount of primary fuel per year before and after transformation from fuel oil to natural gas is shown in Figure 7.

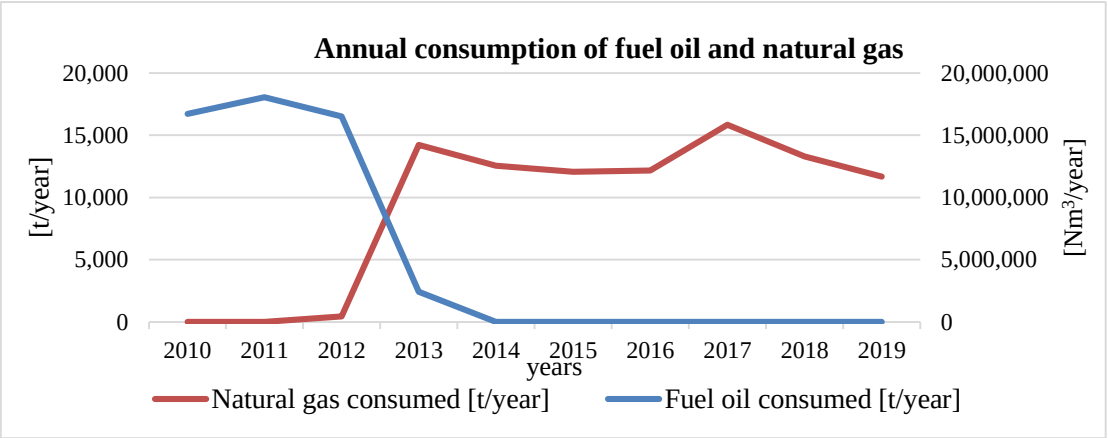

Figure 7: Annual consumption of fuel oil and natural gas from 2010 to 2019 [11]

Distribution of heat energy – Environmental impact

During the distribution of heat energy through pipelines, water, which is the carrier of the heat, is in contact with the pipelines which are buried in the ground. It is obvious that at the slightest damage to the pipeline, there is a possibility of direct contact of the water that carries heat with the soil, as well as potential underground and/or surface water.

According to BEG company, due to water losses in the DN, water is constantly replenished. In the last 4 years, i.e. after 2015, in order not to use drinking water, the DN was fed from a well within the HP "East". According to the obtained data of BEG on the addition of water to the HP "West" DN, the amount of added water in the distribution system for different years (2010-2019) was given in Figure 5.

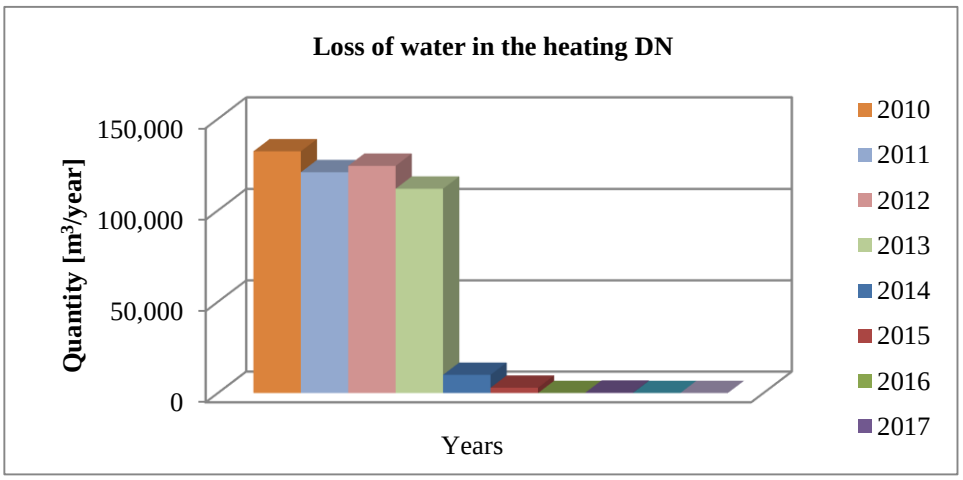

Figure 5: Loss of water during distribution of heat in the heating DN

The hot water that carries heat has a pressure higher than atmospheric at temperature of about 90°C at the exit from the plant and 70°C at the return to the plant. This, the water may contain some mechanical and chemical impurities and agents that can negatively affect the environment. Suggested measures to eliminate or reduce these pollutants could be:

- Installation of filters in the DN,
- Use of flow meters along the length of the DN to detect sinkholes, and
- Remedy of possible breakdowns in the DN

Possible impacts of waste on the environment

According to the data provided in the regulation [9], waste can be temporarily stored at the location itself until the arrival of an authorized person who will take it over. Storage takes place in accordance with all legal requirements. The conditions of waste storage depend on the type of waste itself and could be clasified as:

- Waste that must not be washed into the soil, such as:
  - scrap iron,
  - sludge from washing boilers, and
  - Stack filter deposits.
- Waste that is not allowed to be washed into the soil and with the possibility of external ciculations, such as:
  - motor oil,
  - filters, towels, etc.,
  - packaging waste, and
  - packaging wast from any raw materials.

Disposing of waste in an inappropriate place can cause negative impacts on the environment such as soil, ground water and wastewater pollutions. If there is a large amount of waste oil in this waste, it can penetrate into the soil and cause the extinction of the live in the soil. The waste must be taken to appropriate landfills after being collected by the competent companies. Waste that can be recycled is separated and selected at landfills.

Potential Achievements of the Sustainable Development Goals (SDG)

Due to their nature, both power plants under this analysis have an impact on the fulfillment of all SDGs [10]. However, the focus of the research was their impact on the HP "West" especially for the following SDG goals:

- SDG 6 – Clean water and Sanitation,
- SDG 7 – Affordable and Clean Energy,
- SDG 8 – Decent Work and Economy Growth,
- SDG 9 – Industry, Innovation and Infrastructure,
- SDG 11 – Sustainable Cities and Communities, and
- SDG 13 – Climate Action.

 The impact on **SDG 6** is negative because the quality of the water used is changing. Most of the wastewater is generated when washing boilers, but this only happens when heating oil is used as fuel. Wastewater is properly treated before being discharged into the sewer system. Pollution of surface and underground water is possible. For complete water purification, mechanical, biological and chemical water purification is recommended. In this way, the water can be completely purified, which would have a good quality. Adequate protection should also be provided in the event of improper operation or failure that would lead to pollution of surface or underground water. By applying these measures, the influence of HP "West" would change from negative to positive or neutral.

 The impact on **SDG 7** is positive for both power plants from an energy, social and environmental perspective. Using natural gas as a fuel means using an energy source that has a less negative impact on the environment compared to other conventional energy sources. The population has at its disposal heating energy that is produced in such a way that it has a positive and avoiding any negative impact on the environment.

 The impact on **SDG 8** is considered mostly from a social aspect, thus a huge positive impact can be noticed, especially on the population living in the city of Skopje. A significant percentage of the population is employed in the heating industry, which has a positive effect on the level of employment in the city of Skopje.

 The operation of the plant positively affects **SDG 9**, especially considering increasing the value of the Target 9.2: Global manufacturing value added (MVA) per capita [10].

 The existence and functioning of the plant has a huge effect on the sustainability of the city, and thus has a positive impact on **SDG 11**. The existence of the plant is of particular importance for the city of Skopje, due its impact on the generation of heating energy.

 The use of natural gas enables reduction of pollution that would occur if another energy source were used to obtain the necessary heat energy, such as coal or fuel oil that was used previously. A positive effect according to **SDG 13** was done only because changing of primary fuel from fuel oil to natural gas was possible and enabled.

Conclusions

Central heating is used in many cities in developed countries, and often in developing countries as well. Natural gas, as a fuel in central heating systems is a frequently used fuel due to a number of advantages it has compared to other used fuels. On the other hand, the fuel oil which was once used in one of the analyzed heating plants and is still used often as an reserved fuel, has numerous environmental disadvantages. According to the results obtained from the made analyzes, it can be concluded that, overall, the impact of this heating plant on the environment is positive for both plants mostly due to recent replacement of primary fuel for the HP "West" from fuel oil to natural gas.

The energy significance of the heating power plants HP "West" and TE-TO Skopje for the city of Skopje is great considering that they produce a significant amount of heating energy that the city needs. If these facilities, or the entire DN for the city's central heating, did not exist, every household would be forced to use its own heating system, which in any case would have additional negative impact on the environment compared to this method of heating.

According to the analysis made from the perspective of three main pillars of sustainable development, social, economic and ecological, it was concluded that in most cases heating plants have positive impacts and effects. The operation of these facilities contributes to the better achievement of SDGs, in particularly SDG 6^{th} , 7^{th} , 8^{th} , 9^{th} , 11^{th} and 13^{th}.

It is obvious that the operation of heating plants results with the emission of CO_2, which negatively affects the ozone layer of the Earth. Therefore, from the analyzes carried out in relation to CO_2 emissions, it was concluded that compared to other types of fuel that would be used to obtain heating energy, the use of natural gas and fuel oil as a secondary or reserve fuel means reduced CO_2 emissions, and additionally a reduced contribution to global warming.

It is evident from the analysis that negative impacts occur only when the heat carrier – in this case hot water – is intentionally or unintentionally discharged out of the pipelines of the DN. A proposal to reduce this negative effect is the installation of filters for purifying the heat carrier, which will reduce/eliminate mechanical contamination of the soil and potentially

groundwater. It is also proposed to install multiple flow meters along the length of the pipeline, to identify any water leakage along the DN and repair it quickly and promptly. This investment would be small, however, with great importance for the environment, as well as for the company itself, because the annual costs of maintaining and replenishing the water system would be considerably reduced.

Based on the analysis of the type of waste generated by these plants and the methods of storage, separation, and transportation to the appropriate landfill, in order to reduce or avoid the negative impact on the environment of the generated waste, it is suggested to minimize the generated waste, i.e., reduce it to the smallest possible extent, act appropriately and store in appropriate conditions.

According to the fact that in the past fuel oil was used for production of heat energy, and since 2013 natural gas burners have been installed, a comparison was made between these two types of energy sources. From the discussion it can be concluded that the advantage of using natural gas is huge. Pollution caused by the burning fuel oil which exceeds the permitted limits, has been reduced using natural gas. From the available data, it is evident that the emission of harmful substances into the atmosphere using natural gas instead of fuel oil is within the permissible limits. Although it is within the permissible limits, the emission of NO_X that still exists when using natural gas should not be ignored. In order to minimize NO_X emissions, the proposed measure is the installation of ultra-low NO_X burners, which are available on the market and are used in many plants. This would make the plant a minimal polluter of the environment in respect to the NO_X emissions.

Finally, by reviewing the available data related to the considered heating plants and the analyzes made, it was concluded that in most cases the effect that the conventional and the cogeneration heating plants on the environment is positive and they contribute towards bringing our country closer to the developed countries. Although there are still some negative effects, taking appropriate measures can be reduced or eliminated and thus be good example of how other similar plants should function.

List of abbreviations
BEG – Balkan Energy Group
DN – Distribution network
MOEPP – Ministry of Environment and Physical Planning
SP – Sustainable Development
SDGs – Sustainable Development Goals
HP – Heating plant
EIA – Environmental Impact Assessment

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COMPARATIVE ANALYSIS BETWEEN BIFACIAL AND MONOFACIAL SOLAR PANELS USING PV*SOL SOFTWARE

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Abstract

Traditional solar panels commonly used in today's solar power projects are monofacial i.e., with solar cells only on one side of the panels. Recently, many solar panel producers have improved their panel designs by introducing so-called bifacial solar panels which feature solar cells on both sides of the solar panel. Producers claim that the bifacial solar panels, regarding energy generation, typically overperforms the traditional monofacial solar panels by about 5.5%, with additional investment cost between 10% and 25%, which strongly depends on the producer and the size of the project.

*In this paper, the authors made a simulation and comparative analysis between bifacial and monofacial solar panels using PV*SOL simulation software. The simulation was done on a solar power project with an installed capacity of 1 MW using exact solar insolation values for the exact geographical location. Typical bifacial and monofacial half-cell solar panels available at the local market were used for the analysis. For enhancing the analysis, two common placements of the panels were utilized, ground placement, and rooftop placement parallel with the roof at the same inclination (pitch) and orientation (azimuth). Obtained results using PV*SOL simulation software for both panels and both placements are presented with accompanying discussion. For ground placement, bifacial solar panels resulted in increased energy generation of approximately 2.5%, while for rooftop placements the amount of the increased energy generation was negligible. Ground-placed bifacial solar panels have increased energy generation all year around, while rooftop bifacial solar panels provide larger energy generation only during summer months, from June to August. For the rest of the year the energy generation difference, although in favor of bifacial over monofacial solar panels, was still negligible.*

Key words

*Photovoltaics, monofacial solar panels, bifacial solar panels, PV*SOL, renewables*

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https://js.ugd.edu.mk/index.php/bjami

TECHNO-ECONOMIC EVALUATON OF RETROFITTING A 210 MW THERMAL HEAVY-OIL POWER PLANT WITH A PHOTOVOLTAIC SOLAR THERMAL ENERGY STORAGE SYSTEM USING MOLTEN SALT: A CASE STUDY OF TEC NEGOTINO

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Abstract

This study evaluates the techno-economic feasibility of retrofitting a 210 MW thermal heavy-oil power plant, TEC Negotino, with a photovoltaic solar thermal energy storage system using molten salt. The analysis includes a sensitivity analysis of key parameters such as discharging duration, thermal storage and electric salt heater capacity, and charging duration to assess their impact on the annual energy yield, load factor, total investment cost (CapEx), and operational expenditure (OpEx). The results demonstrate that retrofitting the power plant with the proposed system can significantly improve its sustainability and economic viability. The sensitivity analysis highlights the importance of carefully considering these key parameters in the techno-economic evaluation of renewable energy (solar photovoltaic) technology and thermal energy storage systems (using molten salt) for retrofitting existing power plants. Moreover, the study's findings can provide valuable insights for decision-making in the planning and implementation of greenfield projects, underscoring the potential benefits of incorporating renewable energy technologies into the design and construction of new power plants. The assessment of both CAPEX and OPEX ensures a comprehensive understanding of the financial implications of the retrofitting process, aiding in the successful integration of renewable energy solutions into existing power infrastructure.

Key words

TEC Negotino, molten salt, solar thermal energy storage, integration, techno-economic evaluation, sensitivity analysis

Full paper is published in Journal of Energy Technology
https://www.fe.um.si/en/jet.html

CHARGING STATIONS CONNECTED TO STREET LIGHT POWER SYSTEM

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Abstract

The paper deals with the types of hydrogen production, methods for its storage and transport and possibilities of end use of hydrogen. The basics of hydrogen economy are briefly describing and then the SWOT analysis of hydrogen economy is performed. The strengths, weaknesses, opportunities, and threats of hydrogen economy are summarized in the SWOT analysis. Based on that analysis, the biggest problems, and threats with possibil-ities of solving those problems are summarized. SWOT analysis considers aspect of hy-drogen economy e.g. from energy demands, financial difficulty, safety, and awareness about hydrogen. Conclusions involve suggestion how to avoid above-mentioned aware-ness, and how could rise hydrogen utilization.

Key words

street lighting, public lighting, charger, charging station, power quality, electric vehicle, lamp, luminaire

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ELECTRICITY PRODUCTION OF PVPP FOR ELECTRICITY MARKET

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Abstract

The photovoltaic power plants (PVPP) have various applications. PVPPs are used for household applications, electricity production in off-grid systems, electric consumption reduction from the power grid, generation of electricity to the grid, etc. Solar energy is a primary energy source which can be converted into electricity. This type of energy source is highly dependent on the weather conditions, or in other words, they are intermittent. PVPP without supporting devices could not produce electricity directly for the energy market, since they would have too large deviations between the traded and produced electricity, what would lead to high financial penalties. Batteries are one of the possible solutions to overcome the intermittent electricity production from PVPP, by controlling the energy output. Collaboration of PVPP and battery storage systems would potentially enable a direct energy production of the PVPP on the market, and new operating options.

Key words

battery storage system, photovoltaic power plant, electricity market, pay back

Introduction

Slovak decree 309/2018 amending Act 309/2009 Coll. no longer provides support for PVPP with a surcharge. It is not possible to apply for supplemental support for PVPP power plants from January 1, 2019. The surcharge support is the only support mechanism for subsidizing the price of electricity produced from PVPPs from this date. The size of the surcharge is determined by the Ministry of Economy of the Slovak Republic (MESR) based on the evaluation of the public auction of the PVPP production price offers. There was only one auction announced on February 3, 2020. This auction was cancelled on March 31, 2020 [9]. This means that there is currently no mechanism to subsidize the price of the electricity produced from PVPP. Support by assuming responsibility for deviations and support by purchase applies only for PVPPs with an installed capacity of up to 250 kW [12].

Newly built PVPPs (mainly with an output of more than 250 kW) have to deal with the new rules and have to ensure the trading of the produced electricity on the energy market or produce within the trader's balance group. This energy market can be divided into 3 categories:

1) Market with long-term products (trade of electricity for a period of one month, several months or years).

2) Market with short-term products (trade of electricity for a time interval of hours to a week).

- Block market (trade in blocks lasting several hours - base, peak and off-peak loads).
- Daily or spot market (trade organized day ahead in hourly intervals).
- Intraday electricity market (trade organized one hour before production/consumption).

3) Market of the regulation electricity (trade of electricity for the purpose of equalizing deviations in the network) [4].

The price of electricity produced by newly built PVPPs will depend on the price of electricity on the market and their business strategy. The study from 2004 [1] already pointed out that the group of energy equipment (virtual power plant) with a preponderance of distributed power plants (e. g. PVPPs) is more suitable for selling electricity on the daily market. The installation of an energy storage system is useful.

The advantage of battery storage systems (BESS) is their high flexibility. They are able to respond to high dynamics of PVPP production in a short time [6] and [7]. According to IEC 62933-2-1, BESSs are classified as follows [13]:

Class A - Devices used for quick regulation. Devices are discharged and charged intermittently and cyclically (hourly or even shorter). The most important parameter of devices is their electrical power.

Class B - Devices for regular and long-lasting regulation and/or accumulation function. Important parameters of these devices are power and capacity. Charging and discharging take place in longer time intervals (lasting from hours to days).

Class C - Emergency services equipment. The most important parameter of these devices is the time of secured power supply during the limited operation of the primary source. The devices are kept constantly charged, and their capacity is used only in case of failure.

Characteristics of PVPP and BESS Power production for electricity market

The primary energy source of PVPP cannot be stored, unlike thermal and water power plants. Due to the high intermittency of the primary energy source, it is difficult to operate a PVPP as a commercial power plant. On the other hand, financial independence from mineral raw materials and low ecological impact are some of the main advantages of this resource. BESSs are characterized by high flexibility and quick response to changes in the consumed and supplied power. The disadvantage of these accumulation systems is their high investment price. However, the combination of PVPP and BESS will reduce some main disadvantages of these devices.

PVPP

When trading electricity on daily market, it is necessary to contract the quantity of traded electricity before the physical supply. The electricity has to be contracted a day before supply at the daily market and 30 min before at the intraday market. The available PV generation prediction models are not able to accurately predict the PV electricity generation. Similarly, with a system of trading in hourly intervals and accounting of deviations in 15-minute intervals, it is not possible to ensure a deviation-free operation for PVPP (PVPP cannot supply constant power during one hour). The power plant is penalized for each deviation, i.e. its revenues are reduced, and the payback of the power plant is prolonged.

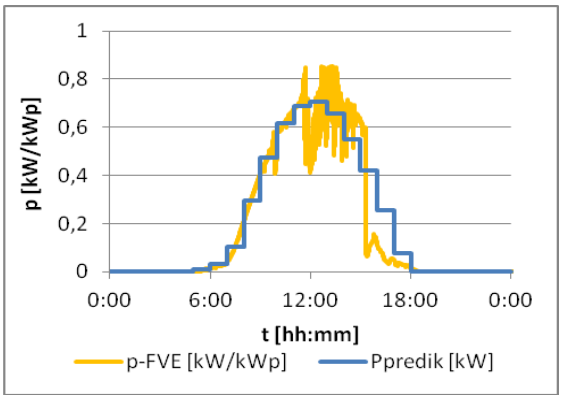

Fig. 1. Real and predicted (traded) energy production of PVPP

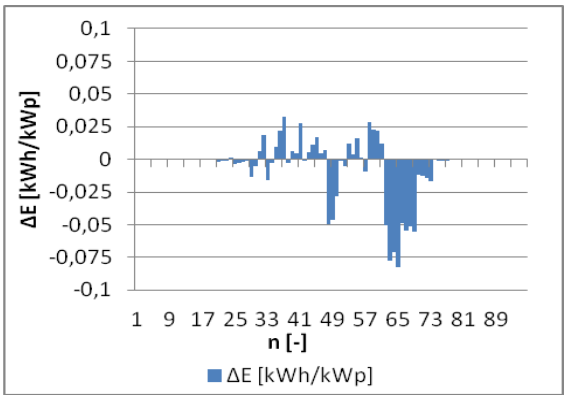

Fig. 2. Generated energy deviations at 15 min accounting intervals

Source: Measured data at Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences.

In the next we will use production data of the PVPP installed at the Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences (IMMM SAS). The difference between the predicted amount of delivered power for trading hours (p_{predik}) and the real course of PVPP generation (p_{PV}) in proportional units converted to installed power is seen in the **Error! Reference source not found.**. Predicted amounts of electricity were provided by Solargis Ltd. The real production of experimental PVPP was 4.53 kWh per installed kWp (the prediction was 4.98 kWh) on the analysed day. The sizes of deviations in individual 15-minute trading intervals are shown in Fig. 2, where n is the departure interval number. 0shows the result of accounting for the delivered electricity for a given day on the daily market. In this case, the power plant's income is reduced by 12.1% due to deviation payments.

Table 1 The dayly result of settlementa

Sign	Value	Total price	Label
E_{prod}	4,97 kWh/kWp	0,4873 €/kWp	Price of production
E_{neg}	0,741 kWh/kWp	0,0587 €/kWp	Payment for negative deviations
E_{poz}	0,298 kWh/kWp	0,0002€/kWp	Payment for positive deviations
E_{sum}	4,97 kWh/kWp	0,4284 €/kWp	Income

The source of electricity prices on the daily market and the prices of the deviation fee is OKTE, a.s. (Organizer of the short-term electricity market), https://www.okte.sk/sk/kratkodoby-trh/zverejnenie-udajov-dt/celkove-vysledky-dt/ and https://www.okte.sk/sk/zuctovanie-odchylok/zverejnenie-udajov/odchylka-sustavy/

On the considered day, the converted income per kWh of electricity produced would be 0.0862 €/kWh. If the power plant would produce electricity with the income mentioned above throughout the year with an annual production of approximately 1150 kWh/kWp [2], it would have an income of 99.13 €/kWp. The investment price for a PVPP is around 860 €/kWp [3], but it also depends on the size of the installation. In the above-mentioned case, the power plant would pay back the investments in 8.64 years (operating costs are not considered). However, such operation is too risky and is completely dependent not only on the electricity prices but also on the accuracy of the prediction of PVPP production. A trading strategy for such an operation could be to trade a slightly lower amount of electricity compared to the prediction, because the price of positive deviations is significantly lower than the price of negative ones.

BESS

The high flexibility of supplied and withdrawn power allows the BESS to charge in times of low electricity prices and discharge in times of high electricity prices. The price of electricity

is unknown at the time of preparation of the trade (i.e. at the time of contracting the quantities). This means that if the BESS operator has to estimate the price during trading day D at time D-1 [11], if he chooses an arbitrage trading (i.e. buying electricity at a time of low price and selling at a time of high price). In this study, the price is estimated as the average price of the last 100 business days. The BESS model was created on the basis of experimental measurements of the laboratory battery system of the IMMM SAS with a power of 20.4 kW and a total capacity of 49.7 kWh. The installed capacity of the PV plant is 15.52 kWp [8]. It is possible to determine the operation with the greatest income using a non-linear programming optimization algorithm. The model was created based on the input datasheet parameters and the measured parameters of the IMMM SAS devices. The optimization task was solved by GAMS software and manual correction. The diagram in Fig. 3 shows the course of the price c [€/MWh] on the daily market and the amount of electricity supplied to the system (negative values) and withdrawn (positive values) from and to the BESS in relation to the total storage capacity.

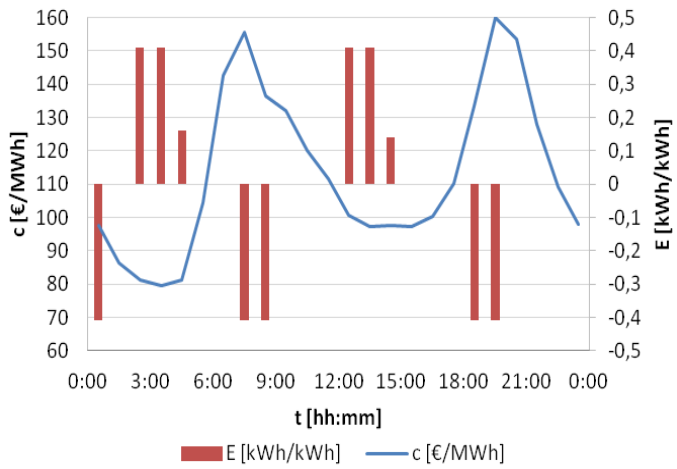

Fig. 3. Simulated supply and withdrawal of BESS and electricty prices on the market
Source: Measured data at Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences

The model estimated the resulting daily billing income at 0.0782 € per kWh of installed capacity (after correction due to the change in the state of charge before and after operation). However, the prices on the market were more favourable, and with such operation, the accumulators would reach revenues of 0.0914 € per kWh of installed capacity. Accumulators would do 2 complete cycles, which means that the income for one cycle would be 0.0391 €/kWh. If the price of electricity was know at the time of closing the deal on the market, it would be possible to the income by 14.2%.

The price of BESS currently varies in a wide range. It depends primarily on the technology, but also on the total installed capacity. Published prices [10] are at the level of 350-730 €/kWh. The price of the system installed at IMMM SAS was approximately €1,000/kWh of the installed capacity of the lithium-ion storage system (LiFePO4). In the model we considered a price of €900/kWh. The simplified estimated number of cycles during which the investment will be returned can be determined as follows:

$$n = \frac{I + O}{z} \tag{1}$$

where n is the number of cycles of the accumulator, I is the investments of the BESS installation in €/kWh, O represents the costs associated with the operation for the given period/number of cycles and z represents the income of the BESS for one cycle in €/kWh.

If the accumulator system would operate according to the above shown diagram (Fig. 3) at the same prices, it would pay back the investment input according to eq. (1) after 23 017 cycles (without considering operating costs). This value is significantly above the maximum lifetime of this technology in the number of cycles, but also in years of operation (23 017 cycles are approximately 31.5 years). The most common systems are declared for 6 000 cycles or occasionally for 10 000 cycles. At the given prices, such an operation is unfavourable for BESS, and the income is significantly affected by the electricity prices on the market. The study **Error! Reference source not found.** compares individual European electricity markets in terms of suitability for the BESS arbitrage. The results of this study showed, that for the German market (mainly influencing the Slovak market), the arbitrage strategy is suitable only for 15% of the year.

Joint production of PVPP and BESS

The laboratory PVPP with BESS at IMMM SAS enables experimental operation for the simulation of various conditions. The results of simulation models and measurements on these devices are processed to verify the profitability of PVPP operation in cooperation with BESS.

Compensation of PVPP production with BESS

It was found at IMMM SAS that to equalize the production of the PVPP to the predicted (traded) power, the battery capacity is required, which is comparable to the energy that the PVPP is able to supply for 0.4 to 0.8 hours at the installed power. The size of the required capacity depends primarily on the accuracy of the prediction of the PVPP's production. Since machine learning (artificial intelligence) is based on historical data, the prediction becomes more and more accurate. Therefore, we would use the capacity coefficient k_{cap} = 0.7 hours for the simulation model. This means that, for example, an accumulator with a capacity of 0.7 kWh would be sufficient for a PVPP with an installed capacity of 1 kWp. The price of such a system for 1 kWp of installed PV power would then be:

$$N_{SYS} = N_{BESS} \cdot k_{cap} + N_{PVPP} \quad (2)$$

where N_{SYS} is the total price of the system per kWp of installed PV, N_{BESS} is the price of 1 kWh of BESS and N_{PVPP} is the price of 1 kWp of PV. Such a system will have an input cost of 1 487 €/kWp.

The course of PV power delivery to the grid (p_{dod} [kW/kWp]) and the course of PV production (p_{FVE} [kW/kWp]) are shown in Fig. 4. The graph also shows the state of charge (SOC [%]) during the simulation. At a given operation, the BESS would perform 0.7 cycles. It is apparent, that the BESS capacity would by significantly used in the early evening hours due to the inaccurate prediction of the PVPP production. The inaccuracy in the total daily production caused the BESS to be completely discharged after the daily cycle. With such an operation, an income of 0.5026 €/kWp could be achieved. Since at the end of the cycle, the accumulators were discharged more than at the beginning, it is necessary to correct for this income by the cost of recharging the accumulators. After this correction, the income would be 0.4113 €/kWp. The recharge price was determined from the average price during the given day. With such an income, the simplified investment would return is 14.4 years, where the BESS would perform 3670 cycles, which is within the lifetime of the accumulators.

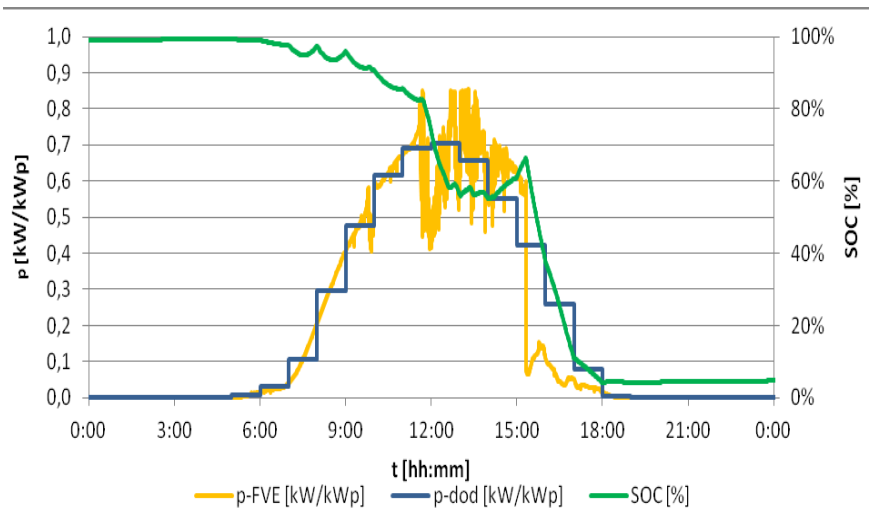

Fig. 4. Simulated supply of linked PVPP and BESS - compensation operation
Source: Measured data at Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences

Active trading of joint PVPP and BESS

For simulations of active electricity trading the entire capacity of BESS of IMMS SAS was used. This BESS is able to accumulate 3.2 hours of operation of the PVPP at the installed capacity (k_{cap} = 3.3 hours). The investment costs of such a system is up to 3,740€/kWp of the installed PV plant. With these BESS is possible not only power compensation, but also selling electricity on the market when it is expensive and recharging the BESS when it is convenient. In this case, the optimization task was solved using GAMS software and manual correction.

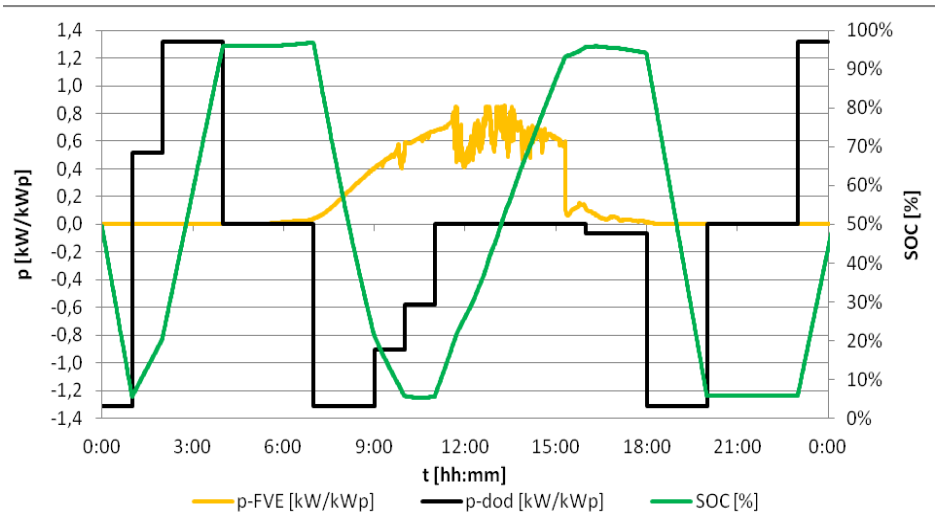

Fig. 5. Production and consumption of linked PVPP and BESS - active trading simulation Source: Measured data at Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences

The power production and consumption curve (p_{dod} [kW/kWp]) of supply and consumption can be seen in Fig. 5. At the given prices, it is possible to achieve an income of 0.7153€/kWh and during the day BESS would complete 2.25 cycles. The simple return on investment would be 20.8 years at 17079 cycles. The currently available batteries (with technology like BESS installed at IMMM SAS), are not yet capable of such high number of cycles during their lifetime.

However the high investment costs of the PV plant and BESS in the case of the IMMM SAS is utilised in Microgrid thermal system which use produced electricity to store heat in a rock exchanger as well as expanded thermal reservoirs using a heat pump. The photovoltaic

electricity is consumed by TESS thermal battery, when the heat is transformed and stored in the TESS based on PCM. Although overall investment costs have increased, the usage of PV has grown to 6.3 hours on average per year but rising a ratio of PV electricity utilisation for heating and cooling processes.

Conclusions

Today, renewable energy sources such as PVPPs are still very demanding for investments and are difficult to integrate into the electricity market among entities whose portfolio mainly includes power plants using fossil and other fuels or water energy as a primary source of energy. The financial complexity of BESS fundamentally hinders their construction, even if they could eliminate the intermittency of PVPPs.

The study pointed out that BESSs alone are not suitable for market trading. However, the connection of BESS to PVPP has a positive effect on the return of the system. A very important input in the payback analysis is the capacity of the BESS itself in relation to the installed power of PVPP. Of the analyzed scenarios, the most advantageous would be the one where the battery capacity was 70% of the hourly PVPP production at the installed capacity. In other scenarios, the investment would not be returned during the lifetime of the BESS. It is important to mention that at given market prices, standalone PVPP without BESS had a shorter payback than with BESS, even though PVPP revenues were reduced by penalties due to the generation of deviations.

This study focused on scenarios with three different capacities of BESS compared to PPVP installed power. There was analyzed only one operation day with one daily pack of market electricity prices. For further deeper analyses, it is necessary to statistically evaluate many operating conditions at different electricity prices and different installed BESS capacity. Extension by TESS contributes positively on PVPP utilisation although bring complexity of such systems but positive impact to minimise risks of penalties due to the generation of deviations.

It is important to note that nowadays the minimum tradable quantity on the daily and intraday electricity market is 0.1 MWh. Therefore, the opportunity to trading on the market is narrowed down to a small number of power plants with an output of the order of 1 MW and above. At the current time new smaller power plants could not trade electricity on the market because their deviations would depend not only on the prediction but also on the difference between the estimated output and the multiples of the minimum amount of tradable electricity. They have to supply electricity to the balance group of purchaser.

On the other hand, from the end of November 2022 the shortest time block for intraday market trading is a 15-minute block. It is possible to close deals up to 30 minutes before the actual delivery. This means that with a successful trade, it is possible to reduce PVPP deviations even during the day of supply.

The flexibility of electricity supply and consumption, or control the power factor by BESS, can also be used for other services in the electricity system. To find the application of BESS in the electricity system, it is necessary to carry out a comprehensive analysis of the possibilities and its contribution, not only from the technical aspect, but also from the financial aspect. Such options are, for example, availability when starting from the blackout, primary, secondary, or tertiary power regulation, local voltage regulation by supply and withdrawal of reactive power and others. Through a complex analysis, it would be possible to find the most advantageous distribution of the use of the total BESS capacity for individual services.

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ENERGY MIX OF THE SLOVAK REPUBLIC

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Abstract

This paper deals with the energy mix of the Slovak Republic with a focus on renewable energy sources and their development in recent years. The share of renewable energy sources in electricity production in Slovakia rose from 310 GWh in 2011 to 2 380 GWh in 2021. This number does not include hydro energy, which has had a very good position in Slovakia for many years and its installed capacity is almost unchanged, in 2021 it was 2 546 MW, and electricity production was at about 4 600 GWh. The energy sector in Slovakia, as well as in other European countries, must reflect worldwide changes and challenges. It needs to consider problems in many fields, such as technical, economic, ecological, legislative, social, and political.
The current situation in the Slovak energy system is described with a focus on energy dependence and the usage of renewables. Some energy statistics are shown in this paper. Finally, possible scenarios and plans for the reduction of energy dependence are discussed.

Key words

energy, renewable energy sources, energy consumption and production, energy dependency

Introduction

European Union (EU) is one of the major players in global energy consumption. Despite its leading position, the EU has a very small influence on energy price markets. Moreover, the EU and Slovakia as one of the EU´s member states, must be independent of one monopoly supplier, as well as boosts the production from renewable energy sources (RES). Many of the EU´s countries are already successfully implementing this strategy. This is not only about minimizing our dependence on fossil fuels (and with its connected monopoly supplier), but also about the necessary increase in renewable energy production. The current energy mix in Slovakia could be considered as a good, which consists mostly of nuclear power plants and hydropower plants. Nowadays, political authorities are searching for new, stable, and environmentally friendly energy sources that could be able to cover all energy demands and moreover assign energy safety and sustainable development of the energy industry.

Slovakia has untapped potential for renewables. However, its utilization must go hand in hand with legislation and regulation. It is important to diversify the sources and to come up with systematic solutions that consist of sensible steps and considering the opinions of experts.

1. Energy in Slovakia

Slovakia is located in east Europe, between latitudes 47° and 50° N, and longitudes 16° and 23° E. It has an area of 49 035 km^2 and 5 428 792 inhabitants (data from 31 December 2022), [2]. The Slovak climate lies between the temperate and continental climate zones with relatively warm summers and cold, cloudy, and humid winters. The Slovak landscape is primarily mountainous nature, extending across most of the northern half of the country. The average temperature is 8.7 °C, the warmest average maximum temperature is 26 °C in July and the coolest average minimum temperature is -7 °C in January. Slovakia receives on average 605 mm of precipitation annually or 50 mm each month [1].

Slovakia is highly dependent on energy commodities import. The energy dependence of the Slovak Republic (56%, without nuclear energy) is only 2% lower than EU average - in 2020, the EU imported 57.5% of the energy it consumed. When nuclear energy is included, Slovakia with 81% is the fifth most dependent EU country after Malta (98%), Cyprus (92%), Luxembourg (91%) and Greece (81%) [3].

The energy mix represents an overview of individual energy sources in the total electricity production. Slovak energy sector structure is diversified in terms of fossil and nuclear fuels and renewable energy sources (RES) including water. Considering t electricity production, Slovakia was an exporter till the end of 2006 when unit 1 of the nuclear power plant Jaslovske Bohunice was shut down. The second unit was shut down in 2008. The reason for shutting down was the condition of Slovakia's accession to the European Union. Nowadays, Slovakia is an electricity importer, electricity balance is low, in 2011 it was 2.5%, and in 2021 it was very similar [5]. In 2021, the total installed capacity in Slovakia reached 7 779 MW, with total electricity consumption at 30 867 GWh and total electricity production at 30 093 GWh [5], see table 1. The share of RES at electricity production is increasing, but excluding large hydroelectric plants, the share of RES is at about 8%. In the last decade the highest new installed capacity was from the photovoltaic power plants, the share of wind energy is very low.

Table 1 Share of energy sources covering electricity production in GWh in Slovakia, in 2006, 2011, and 2021

	Nuclear Power Plants	Fossils	Hydro Power Plants	RES	Others	Production	Consumption
2021	15 730	7 274	4 604	2 380	105	**30 093**	**30 867**
2011	15 441	5 726	4 006		2 992	**28 165**	**28 862**
2006	18 013	5 935	4 447		2 832	**31 227**	**29 624**

Source: Ročenka SED 2021. National Control Centre of Slovakia. Online. Available at: https://www.sepsas.sk/media/6115/rocenka-sed-2021.pdf

2. Power Plants in Slovakia

The energy mix of the Slovak Republic is diversified in terms of fossil and nuclear fuels and renewable energy sources and hydro energy, see fig. 1.

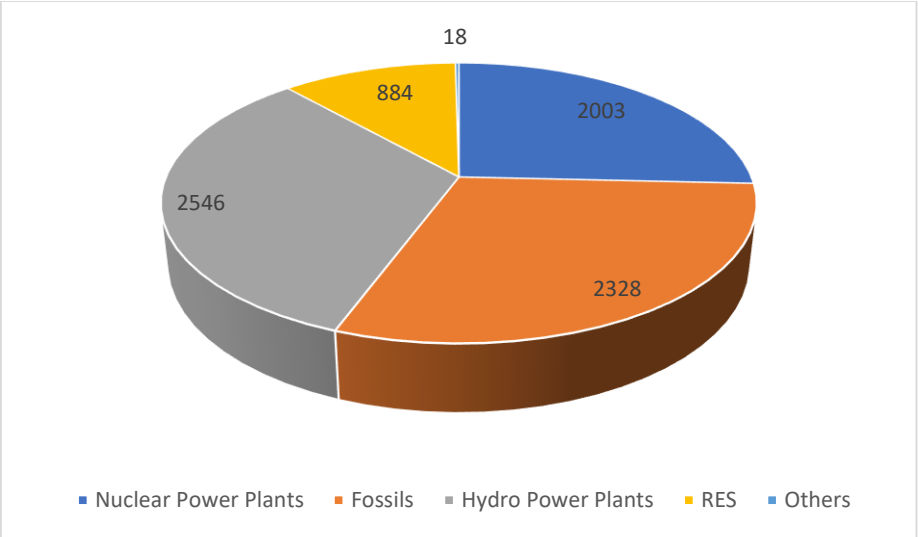

Fig. 1 Installed Capacity of Slovak Power Plants in MW, 2021
Source: Ročenka SED 2021. National Control Centre of Slovakia. Online. Available at: https://www.sepsas.sk/media/6115/rocenka-sed-2021.pdf

There are two thermal power plants in Slovakia, in Vojany and in Nováky. Despite coal, both plants also use biomass, in Vojany since 2009 and in Nováky since 2011. One black coal fired 110 MW unit can avoid about 21 000 tons of CO_2 emissions annually when co-firing biomass. Because they provide reliable electricity generation both for the baseload as well as for peak load demand, they play a very important role in the power grid. Resent years, the main role of fossil fuels has played natural gas. The history of coal mining is long, brown coal mining started in Slovakia in 1913, but at the end of the 20th century, coal and lignite mining began to decrease. After February 2022, several countries resumed their coal production due to gas supply complications, but it is no longer possible in Slovakia because the process of transformation of the region and termination of mining has begun. In addition, the state will no longer support it.

Two nuclear power plants, one in Jaslovské Bohunice with 2 units of pressurised water reactors, type WWER 440, and one in Mochovce also with 2 units same type, are currently in operation. Two new units, located in Mochovce, being planned, Unit 3 is now in a start-up phase and Unit 4 is still under construction. The electric power of each new unit will be 471 MW_e and will cover 13% of the electricity demand in Slovakia [4].

The installed capacity of hydropower plants in Slovakia was 2 546 MW in 2021, including pumped storage power plants (there are four of them - Čierny Váh 734,4 MW, Liptovská Mara 98 MW, Dobšiná 24 MW and Ružín 60 MW). There are currently 234 hydropower plants in operation, but only 24 are large hydropower plants. The share of hydropower plants in annual production is on average 15%. Due to their flexibility and rapid changes in output, they can cover power requirements at the top of the daily load diagram, and they are therefore also suitable for covering emergency conditions in the grid [6].

In 2021, a share of energy from renewables was 17.4% (houses heated by wood are also included, what cannot be considered as inappropriate), considering only electricity from renewables without water, it was only 8%. Compared to recent years, the improvement is only marginal. The installed capacity of RES (without water) was 884 MW in 2021, while in 2016 it was 876 MW. When we consider also hydropower, in 2021 RES achieved a share of 22.9% in electricity production (6 984 GWh, water 2 380 GWh, and other RES 4 604 GWh), while in 2020 it was 7 205 GWh, and in 2016 it was 7274 GWh, what represents 26.5% (overall production was 27 452 GWh).

The main share has solar energy, followed by biomass, see table 2. In addition to energy from water and sun, biogas or wood, geothermal energy can also be a suitable option to increase the share of renewables in the overall energy mix. There are several areas, e.g., around Galanta, veľký Meder, Žiar nad Hronom, Prešov or Košice, which have the potential not only for heat production but also for electricity.

Table 2 Share on the installed capacity of RES in MW in Slovakia in 2021

Solar	Biomass	Biofuel	Wind	Others	Total
532	234	104	3	11	**884 MW**

Source: Ročenka SED 2021. National Control Centre of Slovakia. Online. Available at: https://www.sepsas.sk/media/6115/rocenka-sed-2021.pdf

Upon bigger installed power in RES, their impact is manifested in the overall ES management, especially from the view of assurance of the necessary volume of particular kinds of supportive services. The establishment of the necessary volume of particular kinds of supportive services is solved based on the methodology of transmission system operator in the Slovak Republic (SEPS, a.s.). Renewables increase the necessary volume for supportive services in secondary power regulation and tertiary power regulation.

Conclusion

Renewable energy sources alone are not able to cover all our demands. Obviously, they are environmentally friendly, and they help to decrease fossils consumption. In a short time, it is not realistic and not economically reasonable to replace all conventional (nuclear and thermal) power plants with RES due to their unpredictable behaviour and high investment costs. However, recent months have shown us we should look at our natural resources and because of the lack of other sources, the improvement of RES is welcome.
The instability of supplies, security of supplies, environmental concerns as well as economic constraints the energy issues must be solved. It is important to mention that for RES support are many EU grants that provide research, development, and innovation in the field of renewable energy sources.

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SWOT ANALYSIS OF HYDROGEN ECONOMY

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Abstract

The paper deals with the types of hydrogen production, methods for its storage and transport, and possibilities of end use of hydrogen. The basics of the hydrogen economy are briefly described and then the SWOT analysis of the hydrogen economy is performed. The strengths, weaknesses, opportunities, and threats of the hydrogen economy are summarized in the SWOT analysis. Based on that analysis, the biggest problems, and threats with possibilities of solving those problems are summarized. SWOT analysis considers aspects of the hydrogen economy e.g. energy demands, financial difficulty, safety, and awareness about hydrogen. Conclusions involve suggestions on how to avoid the above-mentioned awareness, and how could increase hydrogen utilization.

Key words

Energy accumulation, energy, greenhouse gas, hydrogen, hydrogen economy

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PHYSICAL LIMITATIONS OF DIMMING OF 400 W RATED HALIDE LAMPS (A CASE STUDY)

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Abstract

The aim of the expertise in this case study was to find out the cause of the malfunctioning of the lamps in the production hall. The light source was a halogen discharge lamp with a nominal power of 400 W. In accordance with the requirements of the investor, the lighting intensity regulation was installed in the premises of the production hall according to the daily light conditions. In conclusion, we explain the physical and chemical mechanism of the cause of failures of a halogen lamp with a nominal power of 400 W. Due to uncontrollable non-equilibrium states and changes in activation energy, the regulation of the discharge of halogen lamps with a nominal power of 400 W is inappropriate.

Key words

Halide lamps, dimming, regulation of light flux.

Introduction

The eighty-eight lamps were installed in the production hall. Over the course of 15 months, changes were noted on all fixtures. 46 lamps were completely non-functional and had to be completely replaced with new ones, light sources were replaced in 28 lamps, a choke or lighter had to be replaced in other lamps, and 2 lamps in the production hall remained non-functional even after repairs, because the lamps were not accessible. The objective of the expertise was to find out the cause of the failure of light sources and lamps in the production hall.

1. Basic data

The lighting of the production hall was realized with lamps designed for high-pressure halogen discharge lamps. The rotationally symmetrical reflector of the lamp was aluminum with a lower cover made of tempered glass. The electrical accessory was a conventional electromagnetic ballast with an igniter. Electrical components - igniter, choke, compensating capacitor are located inside the lamp box on a galvanized sheet metal installation plate. The lamp box was plastic with one cable entry for the power cable. The internal wires have a twisted copper core and silicone insulation, ensuring heat resistance up to 130°C. The light source was a halogen discharge lamp with a nominal power of 400 W. The lamps were installed vertically on a support structure at a height of 7 m above the floor. According to the investor's requirements, regulation of the intensity of artificial lighting according to daylight conditions was installed in the premises of the production hall. The lighting intensity was measured using 6 sensors in the production hall. The power unit of the regulator was controlled by programmed lighting

control schedules and superimposed the modulating voltage on the mains voltage AC 230 V, which is used to power the regulators and lamps. Based on the received control signals, the controller was supposed to smoothly regulate the power of the connected lamp.

2. Experimental

The subject of the experiment was to simulate the operating electrical conditions in the lamp with the aim of identifying the influence of the regulator connection on the current and voltage on the discharge lamps. The experimental sets were designed in a combination of a lamp with and without a regulator and powered by a stabilized voltage source CHROMA model 61505, first with a voltage of 230 V and then with a limit increased voltage of 253 V. The values and courses of the output voltage and current were recorded by an ELCOM network analyzer type ENA500. The analyzer records waveforms simultaneously, time-synchronized. From the measured values and oscilloscope waveforms, current and voltage deformation waveforms were evaluated. Due to measurement safety and high ignition voltage values, the voltage on the discharge lamp was measured only after the discharge was ignited. After the onset and stabilization of the discharge (after about 15 min), the time courses of voltages and currents were recorded. The effective values of voltages and currents were recorded at 200 ms intervals. The boundary conditions of the measurement - temperature and humidity in the room varied between 24°C and 26°C and 52% and 55% during the experiment. The experimental sets were 24 combinations of specific components that were used in the production hall. Fig. 1 shows the discharge lamps on which the measurements were carried out. Fig. 2 shows a change in the color of the cover of choke due to increased temperature

Fig. 1 The mercury lamps on which the electrical parameters were monitored.

Fig. 2 A choke showing a change in the color of the cover due to increased temperature

3. Results

We present only selected results from the experiments. In the Note 1, the measured quantities are described in more detail. The measured values of voltages and currents after stabilization on the lamp and the discharge lamp are shown in the table 1 and table 2. The manufacturer's permitted values of voltage and current on the observed discharge lamps are shown in table 3.

Note 1: Name of the measured quantity and description

Supply voltage: 50 Hz sinusoidal AC voltage set on the power supply (230 V, 253 V) and measured by the analyzer at the same time
Voltage on the lamp: Voltage measured on the terminals of the lamp

Current flowing through the lamp: Current measured by current clamps placed in front of the lamp
Voltage on the discharge lamp: Voltage measured at the discharge lamp leads
Current flowing through the discharge lamp: Current measured by current clamps placed in front of the discharge lamp
Current flowing through the regulator: Current flowing from the power supply to the regulator, measured by current clamps located in front of the regulator

Table 1: Measurement without voltage regulator

Measurement number	Supply voltage [V]	Voltage on the lamp [V]	Current flowing through the lamp [A]	Voltage on the discharge lamp [V]	Current flowing through the discharge lamp [A]
1	230	230.2	2.051	136.8	3.626
2	253	253.3	2.232	148.3	4.099
5	230	230.1	2.016	127.3	3.862
6	253	253.1	2.205	137.5	4.351
7	253	253.1	2.233	148.4	4.078
8	230	230.1	2.053	137.3	3.598

Table 2: Measurement with a voltage regulator

Measurement number	Supply voltage [V]	Current flowing through the regulator [A]	Voltage on the lamp [V]	Current flowing through the lamp [A]	Voltage on the discharge lamp [V]	Current flowing through the discharge lamp [A]
3	230	2.071	229	2.011	136.9	3.609
4	253	2.254	252	2.19	147.8	4.096
9	230	2.077	229	2.022	136.1	3.641
10	253	2.252	251.9	2.196	147.7	4.099
11	230	2.034	229	2.013	126.5	3.849
16	253	2.204	252	2.182	137.1	4.321

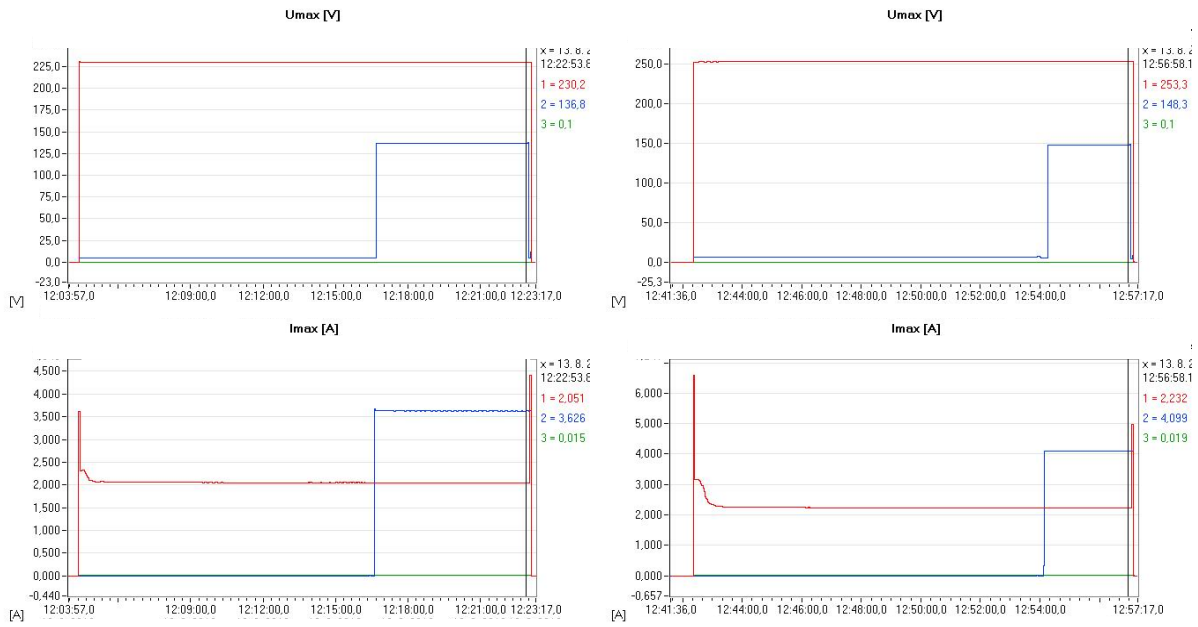
Table 3: Manufacturer's permitted values of voltage and current on measured discharge lamps

Measurement number	Voltage on the discharge lamp [V]	Current flowing through the discharge lamp [A]
1 - 8	120	4.0
9 - 11 and 16	130 *	3.5
* **Note 2:** The manufacturer allows a parameter tolerance of 118±12V, therefore a limit value of 130V is calculated here.		

The aim of measurements No. 1 and No. 2 without a voltage regulator was to capture the effect of the increased supply voltage of 253 V on the current flowing through the lamp and the discharge lamp and on the voltage on the discharge lamp. Voltage 253 V represents the upper limit normative value of voltage 230 V ± 10%. From the waveforms in fig. 3 it can be seen that the increased supply voltage causes an increased voltage on the discharge lamp and an increase in the current flowing through the choke and the discharge lamp and a change in the current

flowing through the compensating capacitor. From measurements No. 1 and No. 2, it can be seen that at the limit value of the supply voltage of 253 V, the nominal value of the discharge lamp current as well as the voltage given by the manufacturer were exceeded. Here it should be pointed out that even with a voltage of 230 V, the voltage measured on the discharge lamp was 136.8 V compared to the manufacturer's recommended value of 120 V. However, the increase in supply voltage does not have a deforming effect on the course of voltage and current and the content of higher harmonics.

The aim of measurements No. 3 and No. 4 was to analyze the influence of the regulator, as an electrical component, on the electrical characteristics of the lamp and the discharge lamp and to compare it with the results without the voltage regulator (that is, with measurements No. 1 and No. 2). The system of the lamp with the regulator was monitored at a nominal voltage of 230 V and at an increased voltage of 253 V. During the measurement at the nominal voltage, the behavior of the lamp during repeated start-ups, which can be caused by power supply voltage failures, was also monitored. From the waveforms in fig. 4, it is clear that after the ignition of the discharge, a change in the effective value of the voltage on the lamp occurs even during stabilization (see the curves highlighted in the circle). It can be seen from the voltage and current curves that the controller disconnects the power supply to the lamp if the discharge fails to ignite. The same can happen with an insufficiently cooled discharge lamp.



1 AC 230 V 2 AC 253 V

Fig. 3 Measurement without voltage regulator. Course of voltage and currents during measurement No. 1 (left) and measurement No. 2 (right). The red curve is the measurement on the terminals of the lamp. The blue curve is the measurement at the terminals of the discharge lamp.

By analyzing the time course of voltages and currents during laboratory operation with the regulator, after igniting the discharge, it was found that the voltage at the terminals of the lamp is deformed and voltage-free pauses occur, as can be seen from fig. 5. On the discharge lamp (e.g. fig. 5 green waveform) the harmonic current waveform is preserved, but a phase shift with respect to the voltage waveform is visible. When the igniter is in the open state, then the choke and the compensation capacitor act as a low-pass filter, which causes the current through the lamp to approach the harmonic curve even when the voltage is inharmonic, but this LC element always has a phase shift, just like any passive filter. Behind the regulator, the shape of the voltage wave on the lamp is changed, which is also reflected in the change in the current curves (fig. 6). The applied regulation manifests itself in the course of the current by rapid step changes.

In the stable operation of the lamp, the influence of the regulator on the power supply of the lamp, the content and deformation of the harmonics is small and the voltage drop on the regulator is minimal. But even during the stable stage of operation of the lamp, increased effective values of the voltage on the discharge lamp were recorded, and at the limit value of the supply voltage, the maximum values of the current as well as the discharge lamp voltage set by the manufacturer were exceeded.

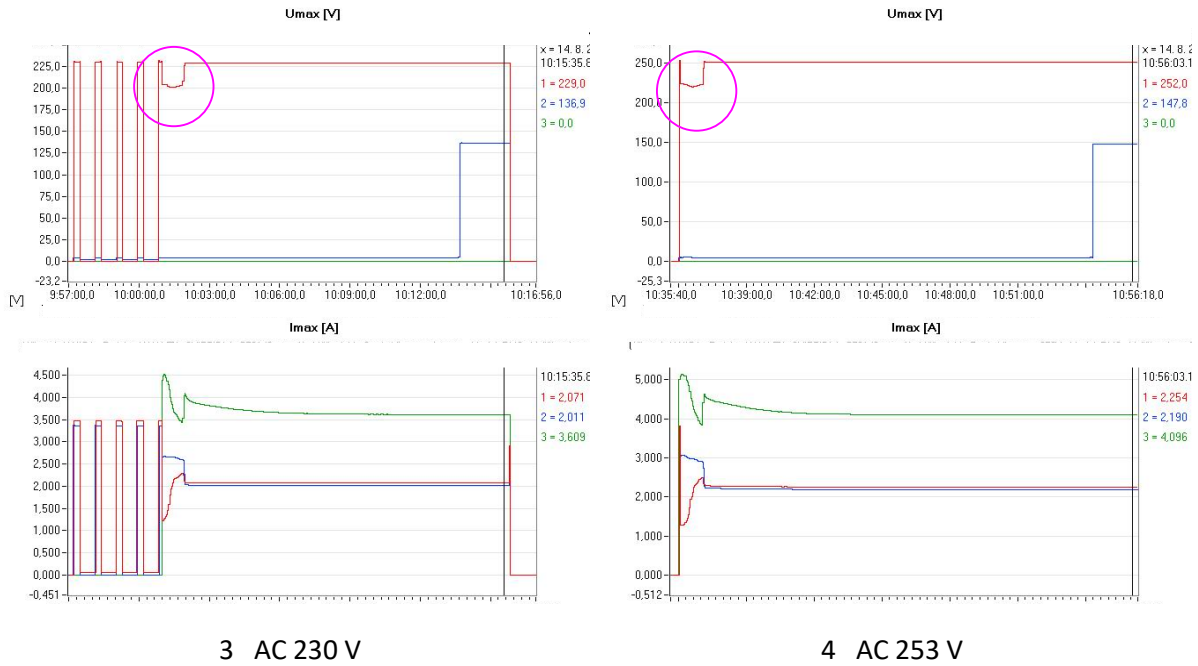


Fig. 4 Measurement with a voltage regulator. The course of voltage and current during measurement No. 3 (left) and measurement No. 4 (right). The red voltage curve is measured at the terminals of the lamp. The blue voltage curve is sensed at the terminals of the discharge lamp. The red course of the current is sensed at the input of the regulator. The blue current flow is on the current terminals of the lamp. The green circuit is on the current terminals of the discharge lamp.

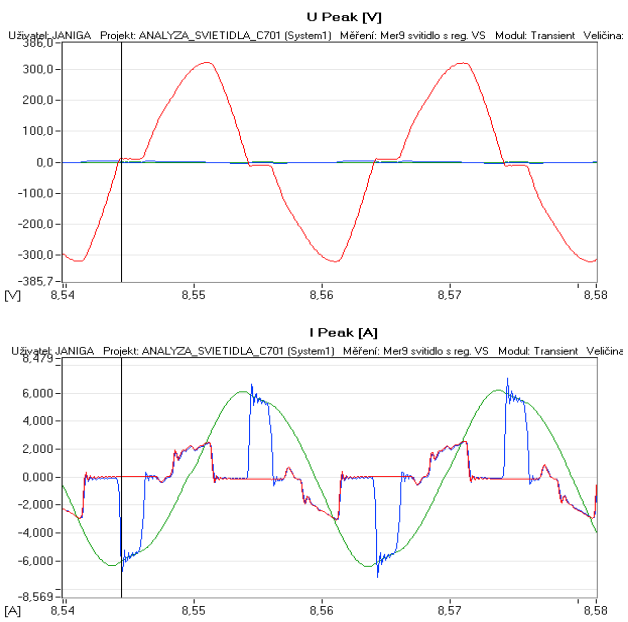


Fig. 5 Time course of voltages and currents during laboratory operation with a regulator at a supply voltage of 230 V. The red voltage curve is measured at the terminals of the lamp. The red course of the current is sensed on the current terminals of the regulator. The blue course of the current is sensed on the

current terminals of the lamp. The green current is sensed on the current terminals of the discharge lamp. The time t(s) is recorded on the x-axis.

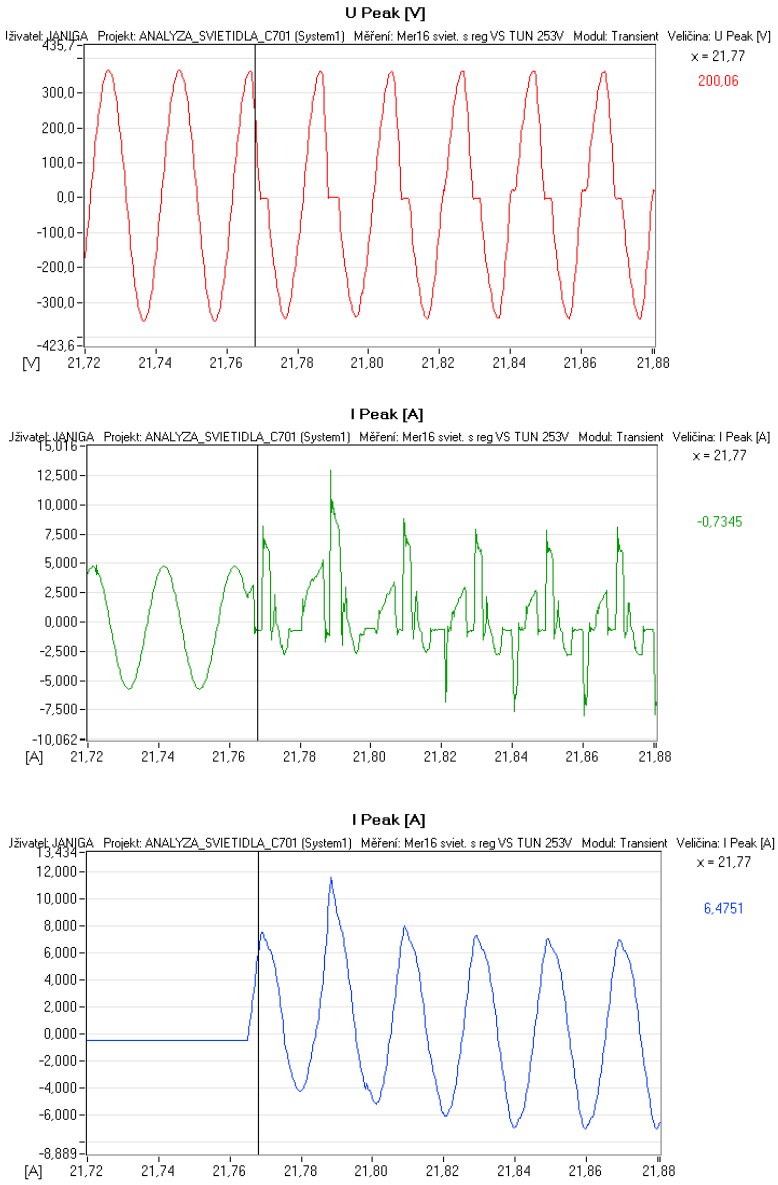


Fig. 6 Time course of voltages and currents capturing the ignition of the discharge and the deformation of the voltage and current on the discharge lamp at the limit value of the supply voltage of 253 V. The red voltage curve is measured at the terminals of the lamp. The green current flow is the current at the current terminals of the lamp. The blue current flow is on the current terminals of the discharge lamp. The time t(s) is recorded on the x-axis.

Conclusion

The objective of the expertise was to find out the cause of the failure of light sources and lamps in the production hall. After the measurements and analysis of the electrical installation, we came to the following conclusions:

1) The light source was in the wrong position. The installed lamps were used in accordance with the manufacturer's specification in the basic characteristics, i.e. as a lamp for halogen discharge lamps with a nominal power of 400 W. However, according to the manufacturer's information in the product type and catalog sheet, the installed light sources should be placed in a horizontal position at an angle of ± 45°, not in a vertical position as it was in the installation.

2) The discharge in the torch of the discharge lamp is ignited by an external high-voltage pulse with an amplitude of up to 5 kV. The discharge first takes place in mercury vapor and inert gas. By discharge, the halides formed by polar covalent to covalent bonds break down into starting substances: metal atoms and halogen atoms or their ions. The chemical reaction initiated by the ignition voltage leads to the formation of substances formed by the decomposition of the metal halide in one part of the burner, while the reverse reaction will also take place in another part of the burner , formation of a metal halide. In the discharge lamp, a concentration gradient of metal and halogen atoms is created in the axial and radial direction, their subsequent diffusion to the walls of the burner with a lower temperature occurs, where the original metal halides are formed again. The metal halide formation reaction is already taking place spontaneously. When a metal is directly combined with a halogen, a lot of energy is released and either it is converted into heat and the reaction proceeds slowly, or there can be a rapid release of energy and the reaction is explosive in nature. Therefore, a stable state of discharge (back reaction) is reached only after a certain time. In order for the event to take place in the necessary balance, the burner and the electrodes must be in such a spatial orientation that keeps the ignition and the existence of the discharge in a stable state, and at the same time part of the discharge must allow heat to be dissipated. These are two essential reasons for the discharge lamp to be in the prescribed mounting position.

3) The voltage and current curves were changed by the regulator. A common feature of all performed laboratory voltage and current measurements on discharge lamps, both at the nominal voltage value of 230 V and at the limit value of the supply voltage of 253 V, is the exceeding of the voltage and current values specified by the manufacturers. By analyzing the time courses of voltages and currents during the laboratory operation of the lamp with a regulator, it was found that the voltage at the lamp terminals is deformed and voltage-free pauses occur. Behind the regulator, a changed shape of the voltage wave on the lamp and an increase in steep current jumps were observed.

4) Rapid sudden changes (of current or voltage) will be manifested by transient events in the discharge lamp, also on the choke and capacitor. Their obvious external manifestation is the heating of the choke (also the capacitor) and, of course, the cable line, contacts, which was visible on the components from operation. Heat losses in the choke were also manifested on the outer shell of the choke. (Increased voltage, even if the choke manufacturer guarantees its operation only at 230 V, should not cause the choke to be destroyed, but accelerates the degradation of its insulation.) Jump changes, voltage and current fluctuations shorten the life of the discharge lamp.

5) Halide lamps are used wherever high demands are placed on color fidelity, which is their dominant advantage. An unexpected change in the state of the discharge due to a change in voltage will change the color presentation, that is, the unique property for which halide lamps are used in the lighting system. The physical cause of the change in the spectral behavior of halide lamps under the influence of a change in supply voltage is a change in the energy state of dissociated metal and halogen particles, which results in undefinable changes in the emitted spectrum of the light source.

6) The disadvantage of halogen lamps is the slow start-up to a stable light flux (approx. 4 min), the delay between switching off and the possibility of re-switching on (i.e. the impossibility of immediate ignition of warm lamps, the cooling time is approx. 15 minutes), therefore the possibility of dimming them is limited.
7) In the case of a regulated reaction (regulated discharge), the speed of ongoing reactions changes, but also the type of reactions. The reaction rate of metal halide formation is higher

than the reaction rate of its decay. Every change in electrical voltage and fluctuation of voltage on the electrodes changes the activation energy, i.e. the speed of the metal halide formation or decay reaction and thus affects the type of reaction mechanism of the ongoing reactions.

8) By changing the voltage (regulation) and current density, the balance of the ongoing reactions will change. If the discharge lacks an energetic component of radiation (e.g. UV), which initiates a reaction leading to the formation of a metal halide, only the oxidation-reduction reaction prevails, which generates heat in the discharge and causes a reaction with the burner material as well. Due to the exothermic nature (release of heat during the reaction) of the formation of the metal halide, it is necessary to let the discharge lamp cool down after turning it off in order to restore the metal halide on the electrode. Therefore, the extinguishing and re-igniting of the discharge requires a time interval.

Due to the uncontrollable non-equilibrium conditions, speed and type of reaction occurring due to the change in activation energy, the regulation of the discharge of halide lamps with a nominal power of 400 W is inappropriate.

In the technical characteristics of the discharge lamps, information about the possibility/impossibility of dimming the discharge lamp is usually indicated by the manufacturer. Frequency modulation of the supply voltage for lamps with an electronic ballast is real and implemented in lighting systems with halide lamps with a rated power of up to 250 W [1], [2]. Halide lamps (with a rated power of up to 250 W) designed by manufacturers for dimming, have a modified internal structure, geometrically (elongated) or material (ceramic) adapted burner and electrodes. Despite the advantages of the color excellence of halide lamps, lighting is currently oriented towards LED technologies. According to our experience, lighting with halide lamps is now only used in special requirements.

Acknowledgement

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ФУНКЦИОНИРАЊЕ НА ПАЗАРИ НА ЕЛЕКТРИЧНА ЕНЕРГИЈА: МОДЕЛИ НА ПАЗАРИ НА ЕЛЕКТРИЧНА ЕНЕРГИЈА

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Апстракт

Енергетската економија е збир на економии кои ги анализираат енергетските пазари, според најнови истражувања на Кембриџ. Во 1990-тите, сè поголем број земји организирале пазари на големо за електрична енергија. Иако пазарните правила може да се разликуваат од земја до земја, тргувањето со електрична енергија генерално се заснова на униформни механизми за аукција на цени, а тоа е систем каде секој активен производител ја добива истата цена за секоја единица производ за која е повикан, се додека неговите понуди се пониски од клириншката (пречистената) цена пресметана од операторот на пазарот. Пазарот е механизам кој се појавил многу одамна, во многу цивилизации. Со текот на годините, пазарите еволуирале од едноставна локација, каде што неколку луѓе без претходен договор се собирале и разменувале стоки, до виртуелна средина каде информациите циркулираат електронски, а трговијата се прави со едноставен клик на компјутерот. И покрај овие технолошки промени, основните принципи не се променети - пазар е место каде продавачите и потрошувачите се среќаваат за да тргуваат. За да се анализира конкуренцијата на пазарите на електрична енергија, неопходно е да се разјаснат претпоставките за понудата и побарувачката, но и за пазарните правила и регулаторни инструменти, кои ќе бидат опфатени во понатамошниот текст на трудот.

Клучни зборови:

електрична енергија, пазари на енергија, модели на тргување

Вовед

Развојот на пазарите на електрична енергија се заснова на претпоставката дека електричната енергија може да се третира како стока. Меѓутоа, има разлики помеѓу електричната енергија и другите стоки, како што се литар нафта, тон пченица или кубен метар гас. Овие разлики имаат големо влијание врз организацијата и правилата на пазарите на електрична енергија.

Основна разлика е тоа што електричната енергија е неразделно поврзана со физички систем кој функционира многу побрзо од било кој пазар. Во тој физички електроенергетски систем мора да се одржува баланс помеѓу понудата и побарувачката, односно производството и оптоварувањето. Ако не се одржува баланс, системот се распаѓа со катастрофални последици. Распад на системот е недопустлив бидејќи не само што системот за тргување ќе престане да работи, туку и целиот регион или земја можат да останат без напојување многу часови. Враќањето на електроенергетскиот систем во нормална работа е многу сложен процес кој може да потрае 24 часа или повеќе во големите, индустриски земји. За да објасниме како функционираат пазарите, прво ќе развиеме модел со кој ќе го објасниме однесувањето на потрошувачите. Прво е развиен модел на потрошувачи, потоа е развиен модел на производители, со комбинирање на овие модели се дефинираат условите под кои може да се тргува.

Во зависност од начинот на организација на електроенергетскиот сектор (ЕЕ сектор) и односите помеѓу учесниците на пазарот разликуваме четири генерички модели на пазари на електрична енергија (ПЕЕ): [7]

- монополистички модел (Monopoly model)
- модел на единствен купувач (Single buyer model)
- модел со конкуренција на „пазарот на големо“ (Wholesale competition model)
- модел со конкуренција на „пазарот на мало“ (Retail competition model).

Треба да се забележи дека во праксата пазарите можат да имаат карактеристики од два или повеќе модели, а припадноста кон некој од генеричките (типични) модели се дефинира според доминантните карактеристики на пазарот. [1]

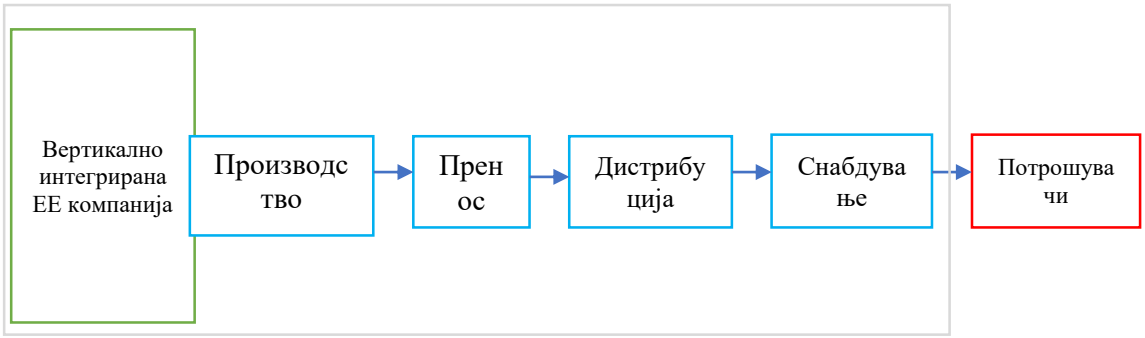
Електричните мрежи, како и други слични техничко-технолошки целини, се природни монополи по дефиниција. Поради тоа, иако првиот типичен модел во името ја има карактеристиката монополистички модел, монополот во ЕЕ сектор што произлегува од мрежните сервиси постои во сите модели.

Во многу држави, а особено во Европската унија, тенденцијата е пазарите постепено да се развиваат, со цел да го достигнат нивото на максимална конкуренција, т.е. да го достигнат моделот со конкуренција на пазарот на мало.

1. Преглед на истражениот материјал

1.1. Монополистички модел

Кај монополистичкиот модел на пазари на електрична енергија (ПЕЕ) сите дејности во секторот се концентрирани во една компанија, т.н. „вертикално интегрирана“ ЕЕ компанија. На слика 1 е прикажана принципиелната шема на ПЕЕ организиран на монополистички принципи. Во основа на овој модел е „вертикално интегрираната електроенергетска компанија“ (ВИЕЕК) која во себе ги содржи (обавува) четирите основни дејности: производство, пренос (и управување со ЕЕС), дистрибуција (и управување со ДС) и снабдување. Покрај тоа, во многу случаи, надвор од ЕЕ компанија можат да постојат т.н. независни производители на електрична енергија (НПЕЕ) (Indipendent Power Producers, IPPs). НПЕЕ се сопственички независни од ЕЕ компанија што оперира на определена територија. Во групата на НПЕЕ спаѓаат и когенеративните постројки во поголемите индустриски постројки или пак увоз од соседните системи. Во поголемите држави територијата може да биде поделена на повеќе вертикално интегрирани компании, но карактеристично и за тие случаи е дека на дадена територија ВИЕЕК има комплетен монопол во сите дејности од ЕЕ сектор. [2]



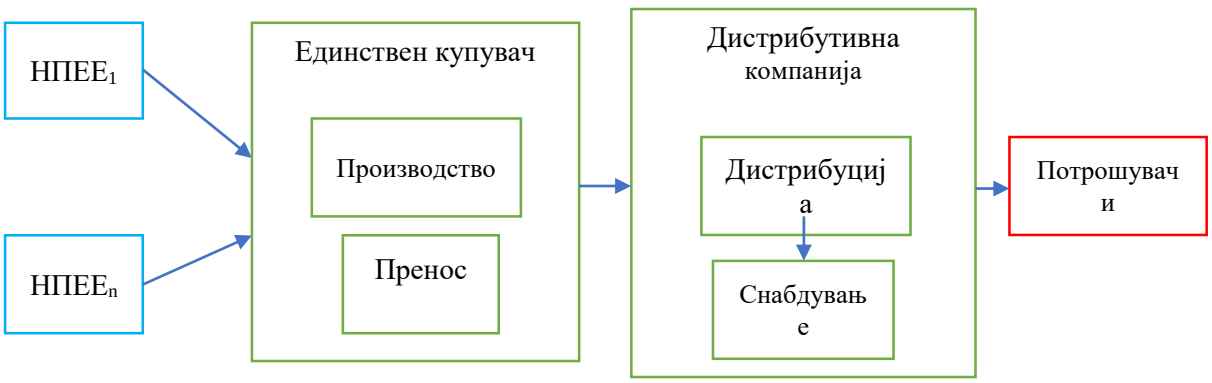
Слика 1 - Шематски приказ на монополистички модел на ПЕЕ

Сопственоста на ВИЕЕК може да биде приватна или државна. Типот на сопственоста влијае врз начинот како државата ја регулира и ја контролира монополската работа на ЕЕ компанија. Во случаите каде државата е сопственик на ВИЕЕК, по правило, не постојат посебни (независни) регулаторни институции што ја регулираат електроенергетиката. Заштитата на потрошувачите од монополската моќ на компаниите е во рацете на државните институции (Влада или министерства). Преку овие институции

државата ги контролира цените (тарифите) и не дозволува компаниите, користејќи ја нивната монополистичка позиција на пазарот, да остваруваат екстра профити. [2]
Во државите каде ВИЕЕК е во приватна сопственост постојат независни регулаторни институции (Регулатори) што ја надгледуваат работата на ВИЕЕК, ги одобруваат цените на услугите и на тој начин овозможуваат заштита на потрошувачите. Во овој модел на ПЕЕ, по правило, ВИЕЕК не работат доволно ефикасно од економски аспект. На пример, ако во дејноста дистрибуција и снабдување компанијата остварува висока добивка, компанијата може таа добивка да ја искористи за покривање на (финансиските) загуби во другите дејности. Во таквите случаи компанијата нема некој посебен мотив да го подобри работењето на одделните организациони единици со цел да ги намали трошоците на работа, а со тоа и цените за крајните купувачи (потрошувачите). Дури и во случаите кога работата на компанијата е надгледувана од соодветна регулаторна институција, многу е тешко да се раздвојат трошоците по одделни дејности и активности, за компанијата да се принуди да работи поефикасно. [3]

1.2. Модел на единствен купувач

Главен недостаток на монополскиот модел е недостатокот на конкуренција, т.е. целосен монопол на една компанија (на определена територија) во обезбедувањето на потрошувачите со електрична енергија. Во моделот со единствен купувач овој недостаток е делумно надминат со воведување на (делумна) конкуренција во делот на производството на електрична енергија. На слика 2 е прикажана принципиелната шема на организација на ПЕЕ по моделот на единствен купувач. [1]



Слика 2 - Шематски приказ на моделот на ПЕЕ со единствен купувач

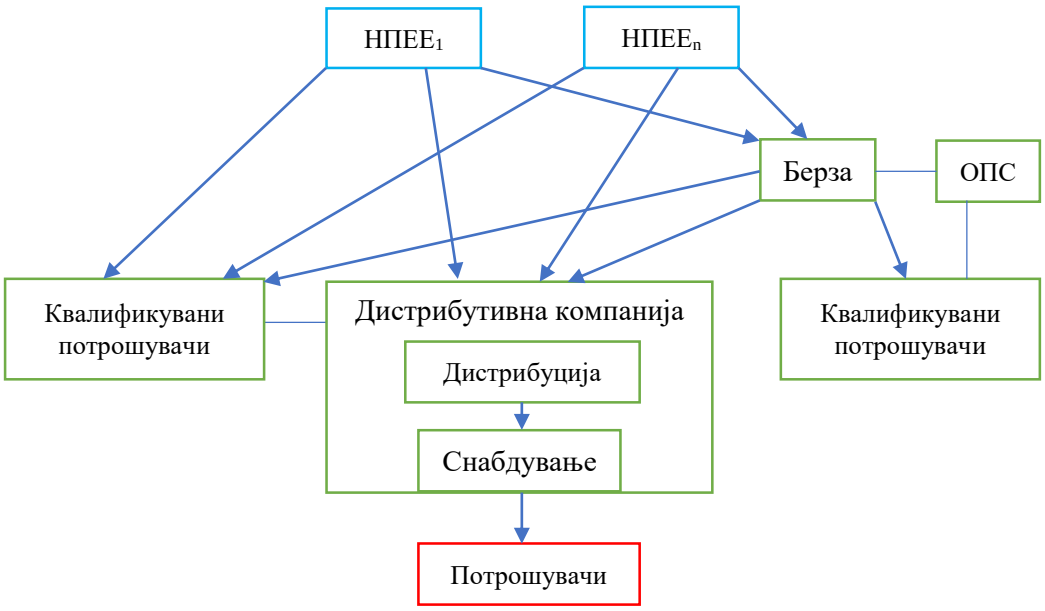
Во многу случаи, ПЕЕ базиран на принципот на единствен купувач еволуирал од монополскиот модел со разделување на ВИЕЕК во (најмалку) две компании: компанија со улога на единствен купувач (ЕК) и дистрибуција. Во рамките на ЕК, покрај преносната компанија, најчесто се и постојните производни капацитети во ЕЕС. И во овој случај, потрошувачите се „заробени“ и тие мораат да ја купуваат електричната енергија од локалната дистрибутивна компанија (ДК) без можност за избор.
Во овој модел, покрај природниот монопол во делот на преносот и дистрибуцијата, монопол има и дистрибутивната компанија во делот на снабдувањето на потрошувачите (трговија на мало). Исто така, монопол има и ЕК во делот на снабдување на ДК, т.е. ДК нема можност за избор на добавувач. [2]
На сликата ЕК и ДК се прикажани како посебни институции. Во пракса, тоа можат да бидат одделни делови на иста компанија, одделни компании во рамките на холдинг или комплетно (сопственички) независни компании. Исто така, ЕК не мора да има свои производни капацитети. Најчесто, при поделбата на ВИЕЕК во рамките на ЕК остануваат постојните производни капацитети, коишто во најголем број случаи се отплатени и трошоците за нивна работа се релативно мали. По правило, НПЕЕ се нови

производни капацитети, когенеративни постројки кај поголемите индустриски потрошувачи или увоз на електрична енергија од соседните ЕЕС. Независно од тоа каква е организационата поврзаност на ЕК и ДК, ако една компанија обавува повеќе енергетски дејности, таа е должна да води сметководство за секоја дејност одделно, т.е. зборуваме за раздвојување на сметководството (*accounting unbundling*). На пример, ако во ЕК има производни капацитети како што е прикажано на сликата, ЕК има посебни (жиро) сметки за секоја дејност одделно (производство и пренос).
Единствениот купувач откупува потребни количини на електрична енергија од производните единици за задоволување на потребите на потрошувачите приклучени на ЕЕС. Доколку во системот има вишок на електрична енергија, ЕК набавува енергија од оние НПЕЕ што ќе понудат најниска цена. Цената по која ЕК ја продава енергијата на ДК претставува просечна цена од набавките од НПЕЕ и цената на производство од сопствените производни единици (ако ги има во рамките на ЕК), зголемена за трошоците за пренос и управување со системот. [7]
Со оглед на тоа што и во овој модел има дејности што ја задржале монополистичката позиција на пазарот, неопходно е тие дејности да бидат регулирани од страна на Регулаторот. Регулаторот ги одобрува цените на сите монополски дејности (регулирани дејности). Во овој случај тоа се: цените на набавената електрична енергија од страна на ЕК, цените на произведената електрична енергија во производните единици на ЕК, цените на услугите за користење на преносната мрежа и управување со ЕЕС, цените на услугите за користење на дистрибутивната мрежа (ДМ) и управување со ДС и цените за снабдување.
Моделот со ЕК воведува позитивни, но и негативни, промени во однос на монополскиот модел. Позитивните промени се карактеризираат со воведувањето на (делумна) конкуренција во производниот дел од ЕЕС. Како резултат на тоа, цените на електричната енергија за крајните купувачи (потрошувачи) постепено се намалуваат. Од друга страна, управувањето и планирањето на системот станува посложено. Мотивирањето на инвеститорите за изградба на нови производни капацитети сега зависи од сигналите што ги испраќа пазарот. Во таквите случаи, можно е да се случи реакцијата на зголемената побарувачка на енергија да задоцни, со што во определен период може да се јави недостаток од (релативно евтина) електрична енергија, што доведува до зголемување на цените на електричната енергија. [7]

1.3. Модел со конкуренција на пазарот на големо

Моделот на ПЕЕ со конкуренција на пазарот на големо воведува можности за дополнителна конкуренција во снабдувањето. И во овој модел потрошувачите остануваат „заробени“ (*captive customers, tariff customers*) и тие не можат да го бираат својот снабдувач, т.е. снабдувачот за овие потрошувачи е локалната ДК. Но, за разлика од моделот со ЕК, ДК сега не ја набавува енергијата од ЕК, туку од различни НПЕЕ, вклучувајќи и увоз на електрична енергија. Трансакциите можат да биде реализирани преку соодветна берза на електрична енергија (БЕЕ, *Power Exchange – PX*) или преку билатерални договори со НПЕЕ. Постоењето на БЕЕ во овој модел не е предуслов, а и во системите каде таа постоела, количините електрична енергија што се тргувале преку неа биле релативно мали. Во најголем број случаи, во времето кога овој модел бил доминантно застапен, тие количините не надминувале 20% од вкупната потрошувачка на електрична енергија во рамките на ЕЕС [5]. На сликата 3 е прикажана шема на моделот со конкуренција на пазарот на големо. За ефикасно функционирање на ПЕЕ базиран на овој модел, неопходна е поинаква организациона поставеност на учесниците на ПЕЕ. Операторот на преносниот систем (ОПС) е независна компанија (институција) и тој, заедно со операторот на пазарот (ОП, не е прикажан на слика 3) се клучни институции во организацијата на пазарот и управувањето на системот. Сите трансакции

(билатерални или преку БЕЕ) мораат да бидат пријавени и регистрирани од страна на ОП. ОП, заедно со ОПС, кој е задолжен за диспечирање, ги одобруваат договорените трансакции. Процесот на одобрување е базиран на транспарентни принципи дефинирани во соодветните пазарни правила и мрежни правила за пренос. ОПС може да не ги одобри трансакциите што можат да предизвикаат задушувања во преносната мрежа. Во најголем број случаи, поради големата поврзаност помеѓу ОП и ОПС, овие институции се во рамките на една компанија, но со раздвоени сметки. [1]



Слика 3 - Шематски приказ на моделот на ПЕЕ со конкуренција на пазарот на големо

Квалификуваните потрошувачи поврзани на ПМ и ДК ја набавуваат електричната енергија од снабдувач по свој избор и ја плаќаат договорената цена, а на ОПС му плаќаат соодветна надокнада за користење на ПМ и за системски услуги (управување на системот). Квалификуваните потрошувачи приклучени на ДМ, покрај претходните трошоци, се должни да му платат на операторот на дистрибутивниот систем (ОДС) за користење и управување на ДМ.

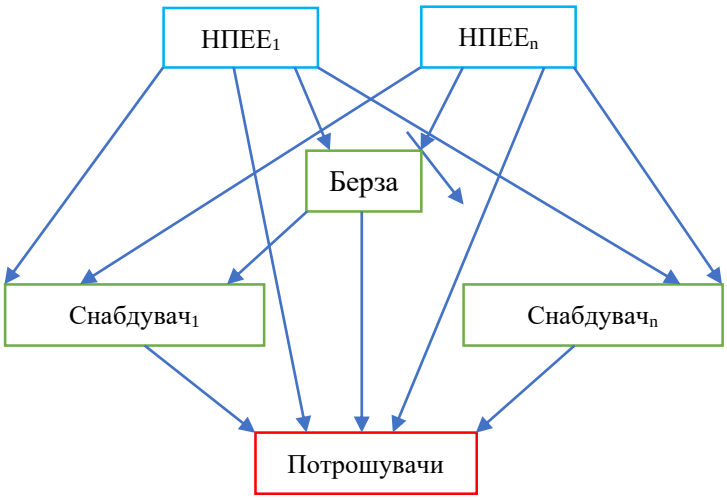
Регулаторот е надлежен за одобрување на цените на електрична енергија за тарифните потрошувачи и поради тоа цените по кои ДК ја набавува енергијата се исто така предмет на соодветна регулатива. По правило, набавките преку БЕЕ се сметаат за транспарентни и конкурентни. Но, кога ДК набавува електрична енергија преку билатерални договори од НПЕЕ, цените и условите на тие договори се предмет на одобрување од страна на Регулаторот затоа што тие имаат влијание врз цената за потрошувачите поврзани и напојувани преку ДМ.

ОПС во овој модел нема производни капацитети во своја сопственост, така што сите потреби за обезбедување на помошни услуги (ладна и топла резерва, покривање на загубите во ПМ, регулација на напоните, регулација на фреквенцијата) ги реализира на сличен начин како и останатите учесници на пазарот (преку билатерални договори или преку берзата). На идентичен начин како и ОПС, ОДС ги обезбедува своите потреби за помошни услуги (загуби во ДМ и регулација на напоните). [7]

Имено, во рамките на овој модел, за сите отстапувања од договорените, односно пријавените трансакции кај ОП, купувачот или продавачот се должни да ги покријат трошоците на ОПС за балансирање, според цени што се постигнуваат на делот од пазарот за помошни услуги и балансна енергија, кој е управуван порамнет од страна на ОП.

1.4. Модел со конкуренција на пазарот на мало

Моделот на ПЕЕ со конкуренција на пазарот на мало се разликува од моделот со конкуренција на пазарот на големо во тоа што сите крајните купувачи (потрошувачи) имаат можност да го избираат својот снабдувач. Потрошувачите ја купуваат енергијата од снабдувачи или, во случај на поголеми потрошувачи, директно од трговци, БЕЕ, или од производителите. Останатите елементи на овој модел се идентични како и кај моделот со конкуренција на пазарот на големо. [1]
На слика4 е даден шематски приказ на моделот на ПЕЕ со конкуренција на пазарот на мало. На сликата не се прикажани ОПС, ОДС и ОП. Нивната улога е идентична како и во претходниот модел.



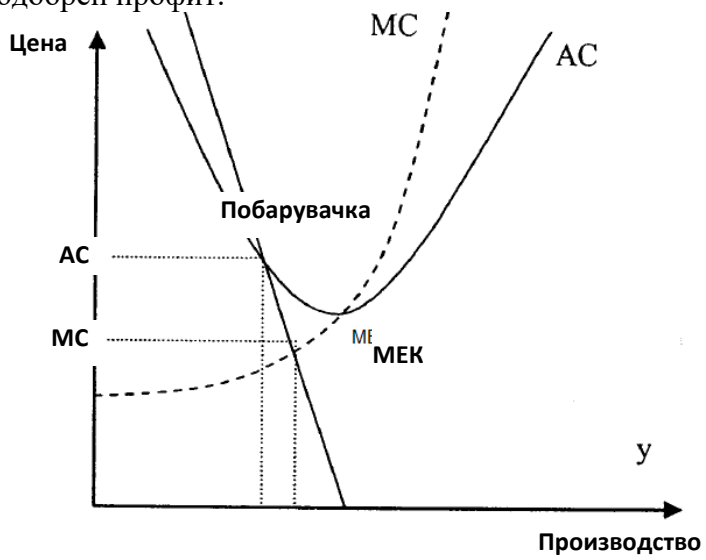
Слика 4 - Шематски приказ на моделот на ПЕЕ со конкуренција на пазарот на мало

За да се обезбеди конкуренција во делот на трговијата на мало, локалната ДК, која што во претходните модели обавува две функции, мора да биде разделена на две компании: ОДС и снабдувач. Снабдувачот што ќе произлезе од постојната ДК се натпреварува со останатите снабдувачи на пазарот на мало. Во овој случај, со оглед на тоа што не се работи за мрежна услуга, на една територија може (дури, е пожелно) да постојат повеќе снабдувачи.
И во ПЕЕ организирани според овој модел најголем дел од енергијата се тргува преку билатерални договори. По правило, во еден ЕЕС постои само една БЕЕ, но постојат исклучоци (ЕУ, САД) каде што на една територија можат да постојат повеќе БЕЕ.

2. Регулација на природните монополи

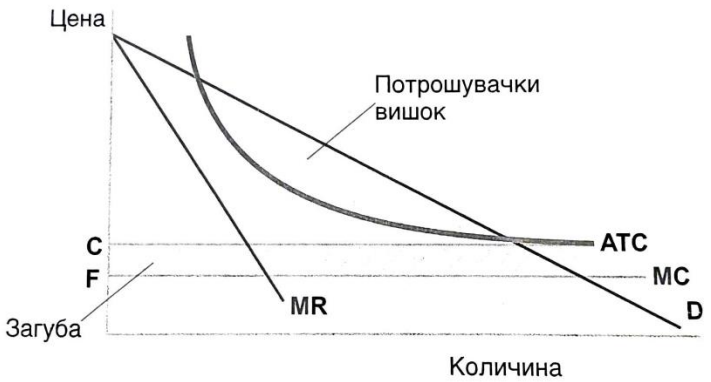
Процесот на дерегулација претставува реструктуирање на правилата, законите и економските мерки со кои владите воспоставуваат контрола и ги регулираат односите во електростопанството. Главната идеја на дерегулацијата е воведување на конкуренција во дејностите на производство и снабдување (продажба) на ЕЕ. Преносот и дистрибуцијата на ЕЕ остануваат природни монополи.
Во одредени области на индустријата, производството на одредена стока е поврзано со високи фиксни трошоци и релативно ниски варијабилни трошоци. Во тој случај, МЕК излегува надвор од кривата на побарувачка и не може да се воспостави конкуренција. Тоа е природен монопол (Слика 5). Ова е типичен случај во преносот и дистрибуцијата на електрична енергија и гас. Регулаторното тело врши анализа на работењето и влијае на цената со цел да ги заштити потрошувачите од монополот.

Во овој случај, доколку МЕК е поголемо од побарувачката и доколку цената (според анализа и одобрување од регулаторното тело) се формира според маргиналните трошоци (MC), ниту една компанија нема економски интерес за тргување бидејќи просечните трошоци ќе бидат поголеми и ќе се работи со загуба. Регулаторното тело треба да одобри цена која ќе биде најмалата од просечните трошоци (AC), односно пресекот на кривата на просечни трошоци и кривата на побарувачка, така што компанијата нема да работи со загуби. Тоа е случај со државниот непрофитабилен природен монопол. Исто така, регулаторното тело може да одреди и малку повисока цена, така што компанијата би имала одреден одобрен профит.



Слика 5 - Непрофитен природен монопол

Сепак, најприфатливо решение за регулација на природните монополи е концептот на First – best и Second – best солуции. Доколку Владата (регулаторот) се одлучи цената на природниот монопол да ја утврди на нивото на маргинален трошок (со цел да се максимизира благосостојбата на граѓаните), тогаш се постигнува First – best солуција (MC=P). При ваквото решение, монополот е соочен со загуби и истото не е оптимално, затоа што Владата ќе биде принудена да даде субвенции за покривање на загубите, а тоа доведува до пазарни нарушувања (дисторзии).
Оттука доаѓа Second – best солуцијата, каде регулаторот мора да прифати цена која на производителот ќе му осигура покривање на просечните трошоци и нулта економски профит (елиминирање на загубата) или MC<P. Истата е прикажана на слика 6.



Слика 6 - Графички приказ на First – best и Second – best солуција за природен монопол

Точките F и C се двата концепти на оптималност, каде во F цената е еднаква на маргиналниот трошок и овозможува највисок можен потрошувачки вишок (First – best),

која спомнавме претходно дека не е прифатлива за ПМ. Точката С ја претставува Second – best, каде потрошувачкиот вишок е помал и му овозможува на монополот да работи без загуби и да продолжи со производство, со што станува пооптимална солуција.

Заклучок

Првиот чекор во процесот на порамнување се состои од утврдување на позицијата на секој учесник на пазарот. За таа цел, секој производител мора да го пријави на порамнувачкиот систем нето количеството на енергија кое договорил да го продаде, вклучувајќи ја и енергијата истргувана преку управуваниот непосреден пазар. Кога од измерените вредности за произведена електрична енергија ќе се одземат договорените вредности се добива разликата. Доколку разликата е позитивна, тоа значи дека производителот инјектирал повеќе од договореното и излегува дека вишокот енергија ја продал во системот. Обратно, доколку разликата е негативна, производителот инјектирал помалку од договореното количество и се третира како да ја купил разликата од системот. На сличен начин се третираат и големите потрошувачи, трговците и снабдувачите.
Цената на електричната енергија за покривање на дебалансите се одредува преку однапред утврдена и објавена методологија. Методологијата може да се разликува од пазар до пазар, но начелно се настојува цените за отстапувањата да бидат такви што ќе ги стимулираат учесниците на пазарот да изработуваат што попрецизни прогнози за своето производство/потрошувачка и да тргуваат на отворениот непосреден пазар сè до неговото затворање со цел подобрување на своите позиции, наместо да бидат пасивни и да чекаат ОПС да го направи тоа за нив преку управуваниот непосреден пазар.

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EASY AND FAST ESTIMATION OF THERMAL STABILITY OF HTS MAGNETS UNDER SIMPLE SITUATION

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Abstract

Since the advent of 2nd-generation high-temperature superconducting (HTS) tapes which show great features on critical temperature, critical current density, and critical magnetic field, many researchers have been trying to generate ultra-high magnetic fields using HTS coils. One more promising technology is a no-insulation (NI) winding technique. This technique drastically suppresses the possibility of thermal runaway and burning-out of HTS coils. The interest into compact nuclear fusion magnets wound with HTS conductors is increasing rapidly within these 5 years. The simulation of such magnets larger than MRI/NMR HTS magnets takes an unfeasibly long time. Therefore, we present a simple expression of the coil temperature rise under a simple assumption derived from the simple coil model to investigate the stability of large-scale magnets. The advantages of the method are simplicity, versatility, and nearly no computation, enabling a reduction of time in first-cut design.

Key words

HTS magnets, no-insulation technique, thermal stability, analytical expression

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INVESTIGATION OF TURN-TO-TURN CONTACT RESISTANCES OF LARGE-SCALE D-SHAPED NO-INSULATION HIGH-TEMEPERATURE SUPERCONDUCTING MAGNETS TO ACHIEVE SHORT CHARGNING DELAY AND HIGH THERMAL STABILITY

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Abstract

To generate ultra-high magnetic fields, a no-insulation (NI) winding technique was proposed by Hahn on 2011. By removing insulators between turns, the NI winding technique enables a high-temperature superconducting (HTS) magnets to improve the thermal stability while generating ultra-high magnetic fields. The NI winding technique has commonly been applied to circular coils for the targets of magnetic resonance imaging (MRI), nuclear magnetic resonance (NMR), air-core cyclotron called as skeleton cyclotron, and so on. Recently, meter-class (large-size) D-shaped NI HTS magnets used for compact fusion reactors are under development applying the NI winding technique. One of critical issues is that large-size D-shaped NI magnets have a long excitation delay. High turn-to-turn contact resistances on NI HTS coils shorten the charging delay times, although high turn-to-turn contact resistances deteriorate the thermal stability. Therefore, the relation between the excitation delay and the thermal stability was investigated on different turn-to-turn contact resistances. Finally, we could find the appreciate resistances with the short charging time and the high thermal stability for two different sizes of D-shaped NI HTS coils.

Key words

High-temperature superconducting magnets, no-insulation winding technique, thermal stability, excitation delay, D-shaped coil

Introduction

A few compact fusion reactors have been under research and development worldwide in recent years [1]. To miniaturize fusion reactors, high magnetic fields are required in small spaces. Since Rare-Earth Barium Copper Oxide (REBCO) superconductors show excellent properties [2]; i.e. a high critical current density under a high magnetic field and a high critical temperature, REBCO coated conductors have a great potential for high field generation [3]-[5]. To suppress a normal-state transition or a quench event derived from a hotspot, a no-insulation (NI) winding technique which is one of the tape-shaped conductor winding techniques is often applied to high-field REBCO coils as a thermal stability improvement method [6]. The NI winding technique allows an operating current to directly flow into adjacent turns through turn-to-turn contact surfaces by removing insulators between turns. The turn-to-turn currents in the coil-radial direction prevent the operating currents from flowing into REBCO superconductors with high resistances at hotspots. It enables the Joule heat reduced drastically comparing with ordinary turn-insulated REBCO coils. The NI winding technique has already been applied to many small-scale circular REBCO coils [7],[8]. The expectations are growing for the introduction of the NI winding technique into large-scale D-shaped REBCO coils for toroidal field (TF) magnets of compact fusion reactors [1],[9]. A critical issue is that as the D-shaped NI REBCO coils are larger, the charging delay times are longer because of large leakage currents in the radial direction. Large turn-to-turn contact resistances on NI

REBCO coils can shorten the charging delay times. Whereas, when a normal-state transition occurs or a hotspot appears on NI REBCO coils, large turn-toturn contact resistances generate large Joule heats, and then a quench would follow. Consequently, it is necessary to investigate the current behaviors of D-shaped NI REBCO coils with a partial element equivalent circuit (PEEC) model depending on different turn-to-turn contact resistances in the terms of the charging delay and the thermal stability.

1. D-shaped coils for tokamak-type fusion reactor

A tokamak-type fusion reactor consists of some large D-shaped TF magnets and some other magnets [10]. In tokamaks, fusion fuel is confined in a plasma state by placing some TF coils in a torus shape which generate high magnetic fields closed in toroidal direction. Several central solenoid (CS) coils are also needed at the center to suppress a charge separation. Due to a spatial constraint on the CS coils, the TF coils are required to be D-shaped instead of circular. In addition, to suppress the hoop stresses of plasma, the tokamak needs several poloidal field (PF) coils which generate a magnetic field penetrating up and down. In common, three different purposes (shapes) of coils are used in tokamak systems. A size of tokamak fusion reactor is not questionable in making fusion fuel in a plasma state. However, to extract enormous energy from reactors, enough space must be made in reactors. Hence, tokamak-type fusion reactors are usually large, comparing with MRI and NMR [4],[7]. Meanwhile, a tokamak-type fusion reactor which is under R&D at the plasma science fusion center, Massachusetts Institute of Technology (PSFC, MIT), well-known as the ARC/SPARC project, is much compacter than the ITER reactor constructed in France [9],[11]. The PSFC succeeded 20-T generation by a demo HTS TF coil [9]. But, the detailed electromagnetic features are not investigated yet. In this study, we have investigated about the relation of the excitation delay and thermal stability on a D-shaped NI REBCO TF coil with different turn-to-turn contact resistances through simulation.

2. Effect of turn-to-turn contact resistance on excitation delay and thermal stability

The thermal stability of NI REBCO coils is closely related to the turn-to-turn contact resistances. An HTS coil with the NI winding technique which was proposed by Hahn in 2011 has no insulation between turn-to-turn contact surfaces [6]. Due to mechanical friction, a local normal-state transition occasionally occurs on a REBCO coil. In the case of a conventionally turn-insulated REBCO coil, the enforced current flows through a thin copper stabilizer surrounding the normal-transitioned REBCO layer, emitting extremely large Joule heat. Subsequently, it leads to burning-out, irreversible mechanical damage, critical current degradation, or rarely explosion. In the case of an NI REBCO coil, whereas, the enforced current flows directly into the turns adjacent to the normal-transitioned turn through turn-to-turn contact surfaces, emitting much less Joule heat. Still, the Joule heat on turn-to-turn contact surfaces may lower the thermal stability of REBCO coil. Excessive turn-to-turn contact resistances deteriorates the thermal stability due to large heat generation on turn-to-turn contact surfaces. The excitation delay time is also closely related to the turn-to-turn contact resistance. The operating current on NI REBCO coil can flow into both the radial and azimuthal directions. Therefore, while the operating current of NI REBCO coil increases, some of the operating current goes into the radial direction according to the balance of the coil inductive voltage and the turn-to-turn contact resistive one. In addition, it takes a long time for the radial current to attenuate even after the coil excitation finishes. Consequently, to reach the desired magnetic field is delayed, as opposed to the operating current, which is called an excitation delay problem. Since a meter-class (large-size) HTS coil has a large inductance compared to a low turn-to-turn contact resistance, it may have a long time constant exceeding one hour. The excitation delay (the time constant) can be improved by increasing the turn-to-turn contact resistance. In this paper, we investigate appropriate turn-to-turn contact resistances of large-

size D-shaped NI REBCO coils to improve the excitation delay while maintaining the inherent thermal stability of NI REBCO coils by simulation coupled with the PEEC model and the thermal finite element method (FEM).

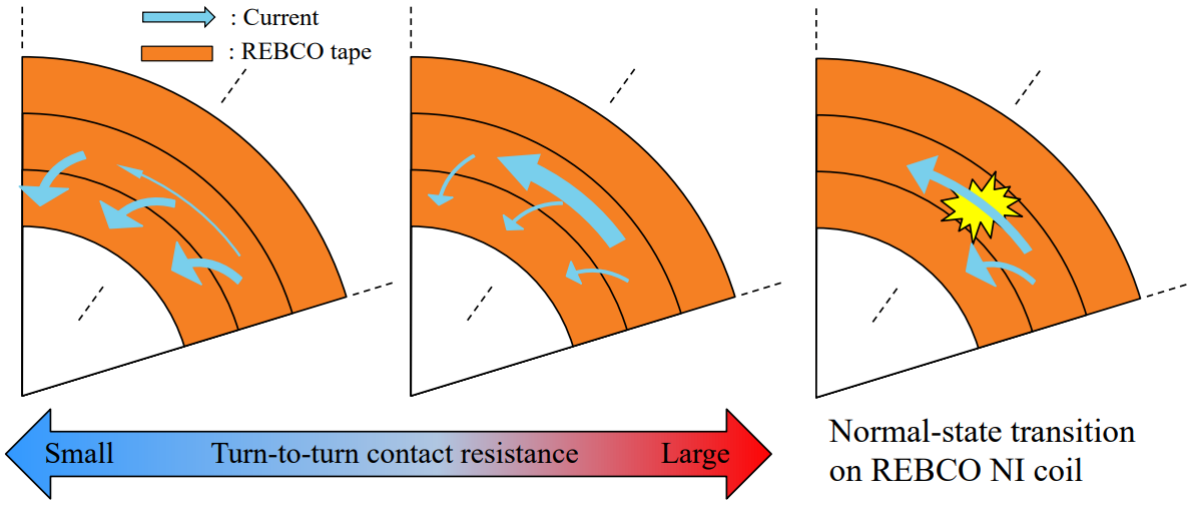

Fig. 1 Schematic views of the excitation delay and the normal-state transition in a part of NI REBCO coil

3. Electromagnetic and thermal simulation method

As an electromagnetic simulation method, we have employed the partial element equivalent circuit method (PEEC) model because the finite element method (FEM) well-known as a conventional electromagnetic simulation method is time-consuming for NI REBCO coil simulation. In the PEEC model, an NI REBCO coil is subdivided into partial elements in the REBCO-tape-longitudinal and coil-radial directions. A schematic view of the PEEC model is shown in Fig.2, where i is the index of local winding PEEC elements, k is the number of turns, M is the self-/mutual inductances, R_θ and I_θ are the resistance and current in the REBCO-tapelongitudinal direction, R_r and I_r are the turn-to-turn contact resistance and current in the coilradial direction, respectively. R_θ is the composite resistance of the REBCO superconductor layer and the copper stabilizer. The REBCO superconductor resistance is computed according to the I-V characteristics of REBCO tapes, called the index model. The PEEC method as an electromagnetic analysis can reproduce a local normal-state transition or a quench event derived from a local hotspot, with dramatically reducing a computation time compared to FEM [12],[13]. As the thermal analysis, we employed the FEM method.

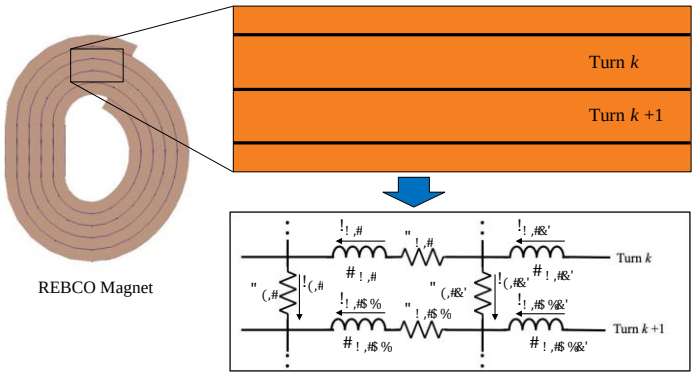

Fig. 2 A schematic view of the PEEC method

In the simulations, two different D-shaped NI REBCO coils were modelled: ~1.12 m (Coil 1) and ~2.24 m (Coil 2) length. A sudden discharging test and a local normal-state transition test were applied for each coil with different turn-to-turn contact resistances.

4. Local normal-state transition tests

On the local normal-state transition tests, one of superconducting-state REBCO elements is enforced into a normal-state one. The temperature rises were investigated for 20 s with the

Table 1: REBCO Tape Condition and Coil Condition

Parameters	Value: Coils 1 / 2
REBCO tape	
Tape width [mm]	4.0
REBCO tape thickness [mm]	0.1
Copper stabilizer thickness [μm]	20.0
REBCO layer thickness [μm]	1.0
Critical current at 77K, self-field [A]	120.0
Pancake coil	
Number of turns	60
Flange width [mm]	1.0
Azimuthal element division	19
D-shaped coil	
dimensions Arc degree	120.0
of big circle [°]	
Arc radius of small circle [**m**]	0.3 / 0.6
Arc radius of big circle [**m**]	0.6 / 1.2
Number of pancake coils	1

Table 2: Simulation Condition of Normal-State Transition Test

Parameters	Value
Time step [s]	0.01
Simulation time [s]	20
Operating Temperature [K]	30
Operating current [A]	300

operating current of 300 A. The location of normal-state-transitioned REBCO elements is around the innermost turn of the upper and lower small arcs on the model which has the largest curvature. These elements experience the highest magnetic field perpendicular to the wide surface of REBCO tapes. The simulation conditions are listed in Tables 1 and 2.

Fig. 3 shows the temperature rise on Coils 1 and 2. The temperature on Coil 1 exceeds 77 K at 20 s when the turn-to-turn contact resistance is 2100 $\mu\Omega \cdot cm^2$, whereas it does not exceed 77 K when the turn-to-turn contact resistance is smaller than 1600 $\mu\Omega \cdot cm^2$. Additionally, a rapid temperature rise is observed around 15-20 s. Fig. 4 shows the current distributions obtained

with PEEC models. The region of no azimuthal current flow means the occurrence of normalstate-transition of REBCO superconductors, with high resistances. In the cases that the turn-toturn contact resistance is 1600 μΩ·cm^2 and 2100 μΩ·cm^2, a normal-state transition region on Coil 1 expands over time, which means a formation of hotspots occurred and normal-state transition region expands. In the case that the turn-to-turn contact resistance is below 1100 μΩ· cm^2, no expansion of a normal-state transition region appears. Therefore, on Coil 1, the range of turn-to-turn contact resistance below1100 μΩ·cm^2 is suitable for keeping the high thermal stability. Likewise, on Coil 2, the range of turn-to-turn contact resistance smaller than 2100 μΩ·cm^2 is suitable for keeping the high thermal stability.

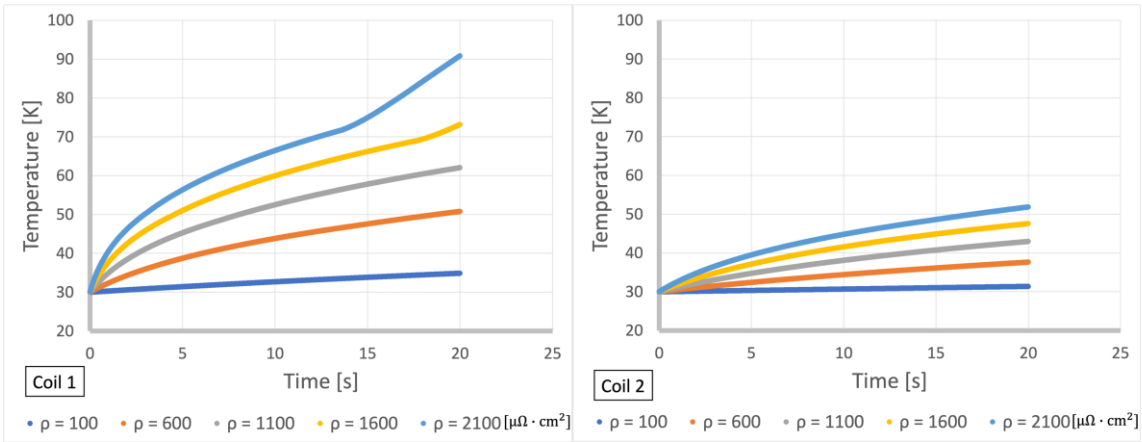

Fig. 3 Temperature rise

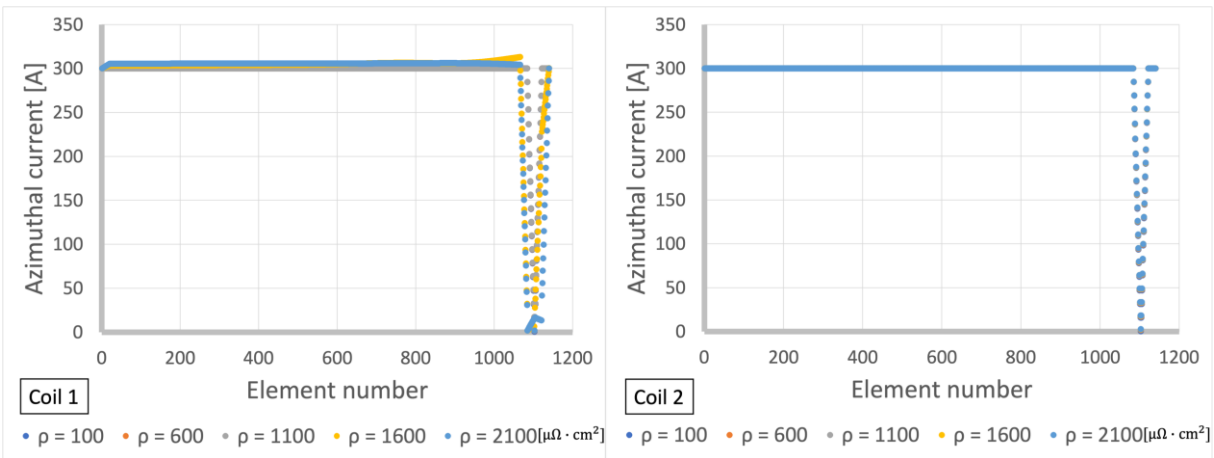

Fig. 4 Azimuthal-current distribution on PEEC elements

5. Sudden discharging tests

On the sudden discharging tests, a steady-state current and a steady-state magnetic field are initially set on the models. Subsequently, after the operating currents are shut down, the time constants are computed from the attenuating magnetic fields. Since the time constant of the excitation delay is identical to the time constant of the sudden discharging test, we indirectly evaluate the time constant of excitation delay in this paper. Tables 1 and 3 list the simulation conditions.

Table 3: Simulation Condition of Sudden Discharging Test

Parameters	Value
Time step [s]	0.2
Simulation time [s]	300-1100
Operating temperature [K]	30
Operating current [A]	50-0

Figs. 5 and 6 show the results of sudden discharging test. Fig. 6(a) shows that the time constants rapidly decreases from minute to second order at 100-1000 μΩ·cm^2. The logarithmic graph of Fig. 6(b) shows that the time constants are inversely proportional to the contact resistivities. Based on the results of the normal-state transition test, the appropriate time constants satisfying the short charging delay while keeping the high thermal stability is 20.0 s or longer on Coil 1 and 44.4 s or longer on Coil 2.

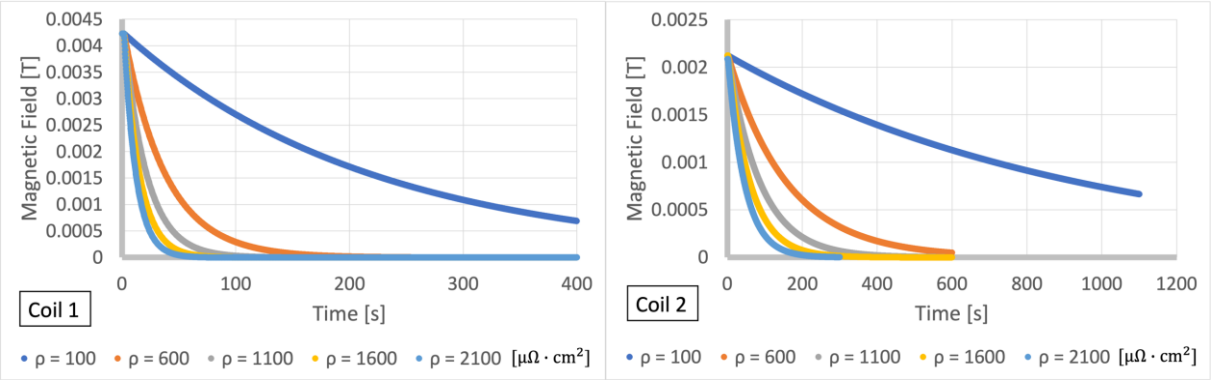

Fig. 5 Magnetic field time-transition

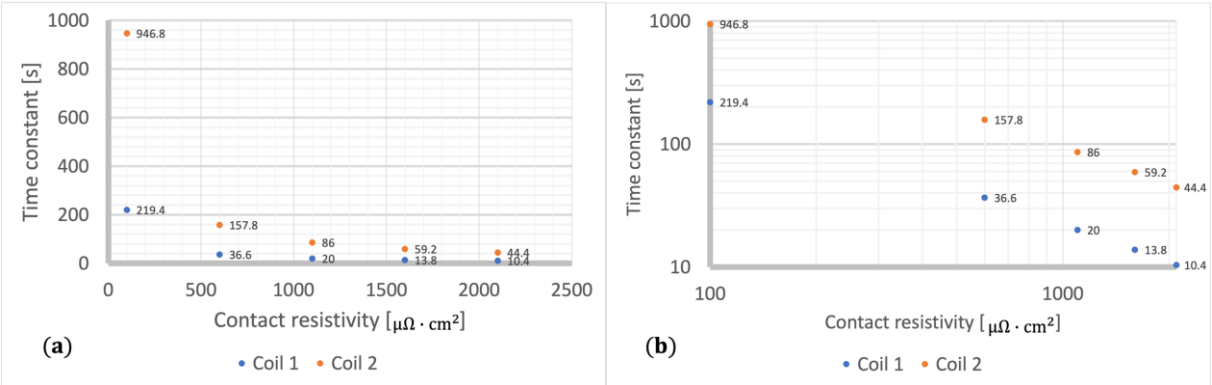

Fig.6 Time constants with (a) linear scale and (b) logarithmic scale

5. Conclusions

In this paper, we have evaluated the charging delay and the thermal stability of the largescale D-shaped NI REBCO coils depending on different turn-to-turn contact resistances. Two PEEC models of D-shaped NI REBCO coils have different sizes: (1) approximately 1.12 m length and 0.75m width and (2) ~2.24 m length and ~1.51 m width. The current behavior was simulated with the PEEC model, the thermal one with FEM. Consequently, The turn-to-turn contact resistances with the short time constant of excitation delay and the high thermal stability are lower than 1100 μΩ·cm^2 for Coil 1 and 2100 μΩ·cm^2 for Coil 2.

In the near future, we will also investigate large-scale D-shaped NI REBCO coils with different types of winding techniques, such as metal insulation and partial insulation.

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IMPACT OF CORE SATURATION ON OPERATING CHARACTERISTICS OF THREE-PHASE SQUIRREL CAGE MOTOR

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Abstract

The induction motors are considered to be the largest electricity consumers worldwide. Therefore, the exact calculation of their operating characteristics in various operating modes is important for determining their operation, electricity consumption and the various types of losses that occur during their operation that have the considerable impact on efficiency of the motors. Paper analyses two models of three-phase squirrel cage induction motor, modeled in Simulink. The first model is considered to have linear magnetizing characteristic while in the second model the core saturation is taken into account by introducing the non-linearity of the magnetization characteristic. The models are analyzed with fifteen percent increased voltage which shifts the operating point into the saturated part of magnetizing characteristic for the saturated model. The impact of core saturation on motor current, speed and torque is observed. The obtained results of the transient characteristics from Simulink are compared with data of current and torque from steady-state models. The core saturation increases the motor current, losses and decreases the motor efficiency. The areas where the core saturation occurs, mainly located in stator teethes, are also observed in Finite Element models (FEM). The derived models contribute to the better understanding of effect of core saturation and its impact on motor operation, thus providing the guidelines for the motor designers.

Key words

Core saturation, squirrel cage induction motor, transient characteristics, steady-state characteristics, FEM models

Introduction

Three phase squirrel cage motors can be found in many industrial applications and they still represent the major portion from all of the industrial motors, in comparison to other types of motors. Therefore, it is important to calculate as accurate as possible, the operating characteristics of this type of the motor in various operating regimes (no-load, rated load and short circuit) as well as to take into account the various operating factors that have impact on the motor performance i.e. its operating characteristics such as the no-load current, the core losses or the efficiency factor. One of them is the core saturation that increases the no-load current and consequently the no-load losses. Furthermore, the core saturation implies higher magnetizing current, lower power factor and current harmonics feeding back to the line. The majority of the mathematical models and equivalents circuits of the three-phase squirrel cage motor do not take into account the core saturation which can be considerably enhanced during motor operation at lower speeds or at lower frequencies. These can result in noticeable deviations of the calculated dynamic and static characteristics of the induction motor from real ones [1]. The steel losses in high saturation mode can reach up to 50 % of the total losses for induction motor, for transformers more than 20% and for the induction generators with capacitor excitation about 20-60 % [2]. The saturated model of AC machine with taking account of harmonic components of air gap flux is presented in [3]. The model is generated from classical model of AC machine with modification that takes into consideration the saturation. This modification depends on making the air gap length as a function of the air gap flux position and amplitude. It is shown that as a consequence of saturation a third harmonic

flux component exists and the response of the rotor cage to this component is a third harmonic current which will create a ripple in total torque [4]. Due to core saturation it is observed distortions on the air gap flux as a result of non-linear magnetic characteristics that lead to appearance of space harmonics in the resultant flux density distribution [5]. l. The impact of magnetic saturation, considering the stator currents and magnetization flux in the (d–q) axis as a state variables for six-phase induction machine is presented in [6]. If high accuracy is required, conventional saturation models used in conjunction with equivalent-circuit models may not be sufficient. In controlled drives, for example, an oversimplified saturation model may result in poor accuracy of the produced torque or even instability in speed-sensorless drives. Explicit functions are proposed for the saturation characteristics—including the mutual saturation in [7]. The inductances become functions of two variables (fluxes or currents) [7]. The power quality has become a paramount in electricity distribution utilities as the voltage fluctuations may have impact on core saturation which has been analyzed in [8]. Improvement of the mathematical models of the induction machine and their modeling by taking into account the core saturation has been present in [9]. According to findings of this research there is an increase in the starting current of a machine with a nonlinear magnetic characteristic. This can be explained by the fact that to obtain a certain value of flux linkage in the saturation zone, a larger magnetizing current is required than to obtain the same value of flux linkage in an unsaturated machine [9]. This paper presents the Simulink model of three phase squirrel cage motor where the core saturation has been considered in motor modeling and obtaining the motor transient characteristics of speed, current and torque. The 2.2 kW three-phase squirrel cage motor and its parameters have been input in Simulink models of the machine. The comparison of transient characteristics when motor is operating with core saturation and without it is presented. The transient characteristics are presented for two typical operating regimes: no-load and rated load. Adequate conclusions are derived in terms of increase of motor current when motor core is saturated at no-load operating regime. The increase of current has impact on increased motor losses and decreased efficiency of the motor. Moreover, the steady-state characteristics of the motor when it operates with and without saturation are calculated and presented as well. The obtained data from the steady-state characteristics should verify the results from Simulink models. The distribution of magnetic flux density in motor cross-section is presented in motor FEM models, enabling detection of local areas where the core saturation occurs. The presented analysis is useful in designing electric drive systems, especially in developing motor protection. Neglecting to take into account the increase of the current when the motor is saturated can be the reason for arbitrary shutdown of the electric drive by protection devices.

2. Simulink models and transient characteristics

Simulink models of the asynchronous squirrel cage motor requires motor nameplate data such as motor power, number of poles, motor inertia but also the motor parameters (the resistances and reactances) to be input in the Simulnik block that represents three-phase squirrel cage induction motor (IM). Therefore, IM type: H5AZ 100LA-4 of 2.2 kW was modeled in software module Rmexprt of Ansys program and its parameters and steady-state characteristics are calculated. Motor data are presented in Table 1 [10].

Table 1 Motor data

Parameter	H5AZ 100LA-4
Output power [kW]	2.2
Rated speed [rpm]	1445
Rated torque [Nm]	14.5
Current [A]	4.8
Power factor [/]	0.76

Efficiency full load [%]	86.7
Locked-Rotor Torque Ratio [/]	3.5
Locked-Rotor Current ratio [A]	7.1
Break-Down Torque Ratio [/]	3.8

Source: author based on Končar, Electric motors-catalog

The Simulink model is presented in Fig.1. It contains two machine blocks. The upper machine block is modeled with saturation. The saturation is incorporated in the machine block by inputting the no-load charactersitics of the analyzed motor (Fig.2).

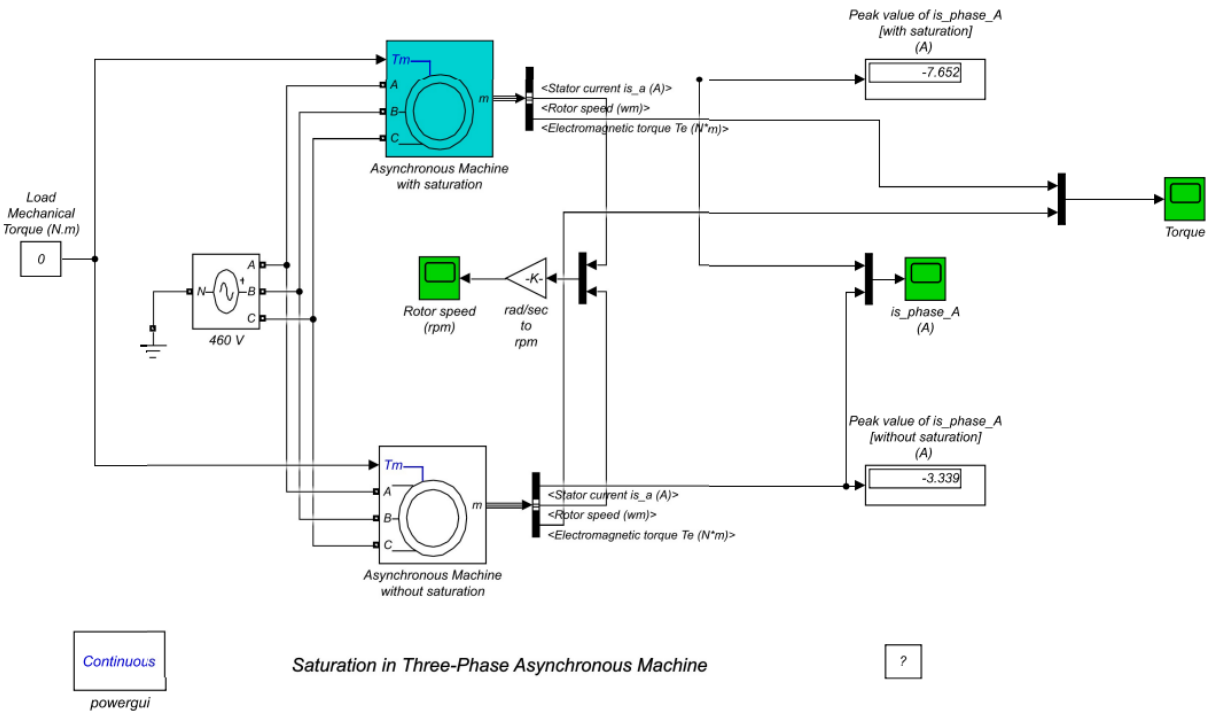


Fig. 1 Simulink model of saturated three-phase squirrel cage motor
Source: Simulink Simcape Power Systems Examples

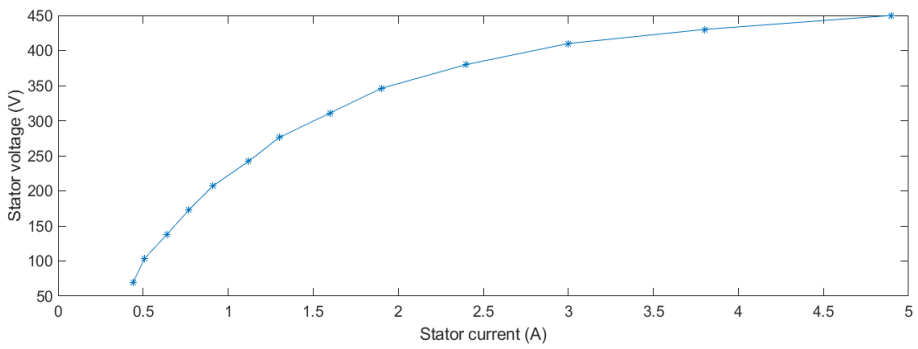
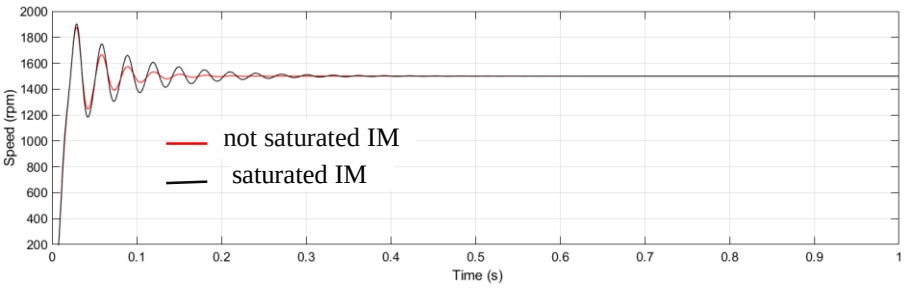
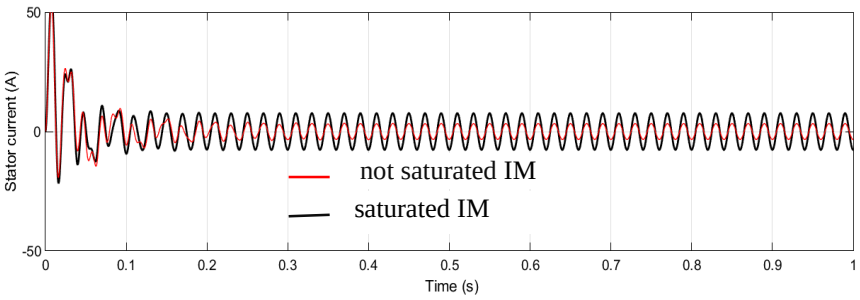


Fig. 2 Accounting for the nonlinear part of the magnetic characteristic at Simulink models

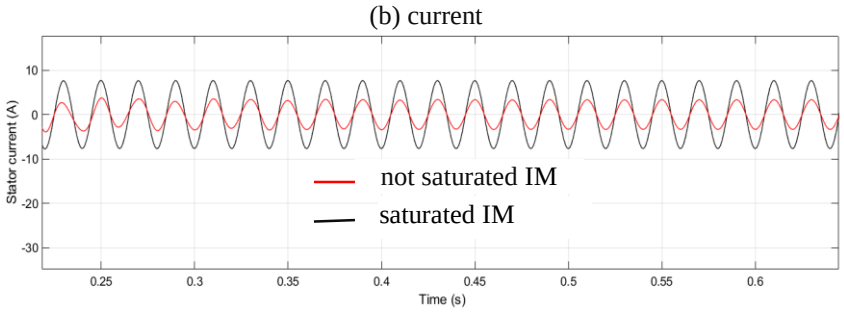
Transient characteristics are simulated for two operating regimes: no-load and rated load. The transient characteristics at no-load for motor speed, current and torque are presented in Fig. 3.



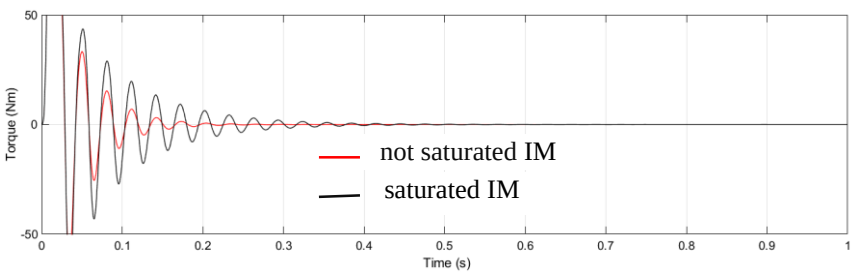
(a) speed



(b) current



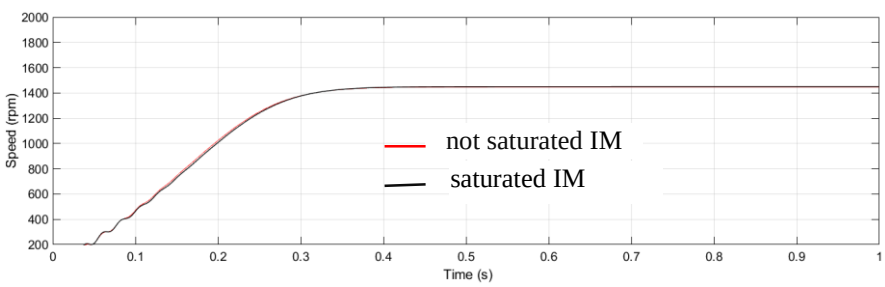
(c) current-detail



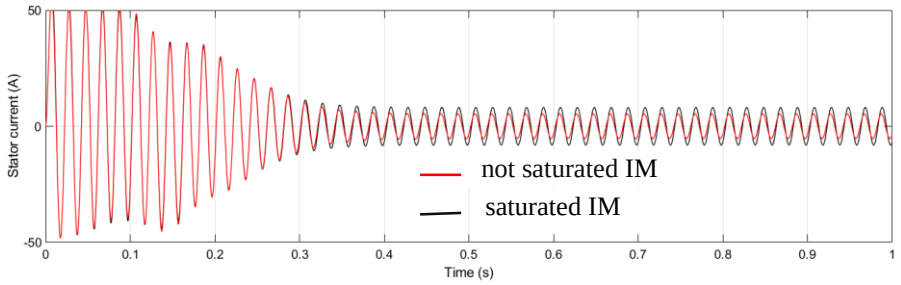
(d) torque

Fig. 3 Transient characteristics at no-load

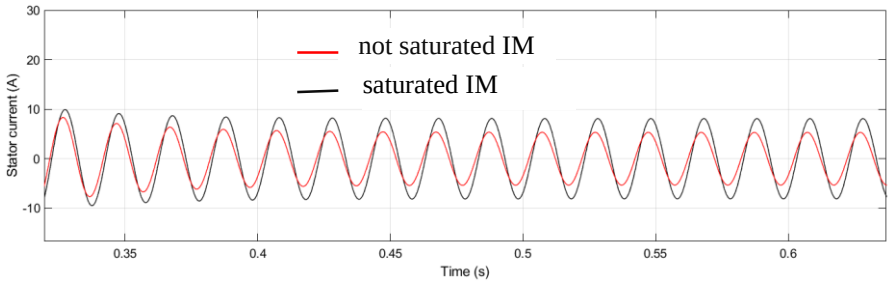
The transient characteristics at rated load for motor speed, current and torque are presented in Fig. 4.



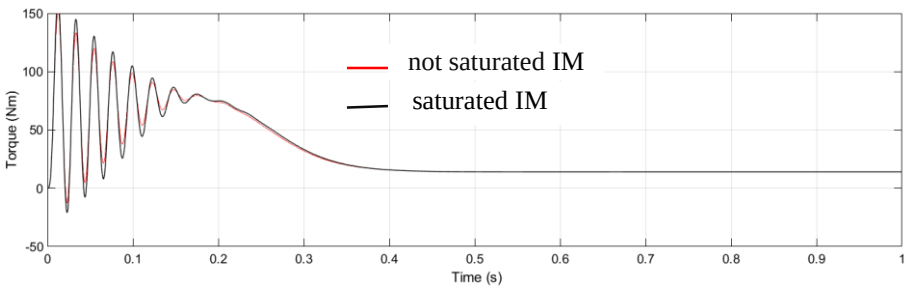
(a) speed



(b) current



(c) current-detail



(d) torque

Fig. 4 Transient characteristics at rated load

The effect of core saturation is enhanced at no-load and evident in transient characteristic of current. No significant impact of core saturation on motor speed and torque can be observed. The presented results of Simulink models are compared with the results and characteristics from the steady state models for their verification.

3. Steady-state and numerical models

The steady-state characteristics of the IM are calculated in Rmxprt, a software module, in Ansys program. The motor is modeled based on its geometry and properties of the materials. The non-linear B-H curve of magnetization of the iron core is input according to the data presented at Fig. 5.

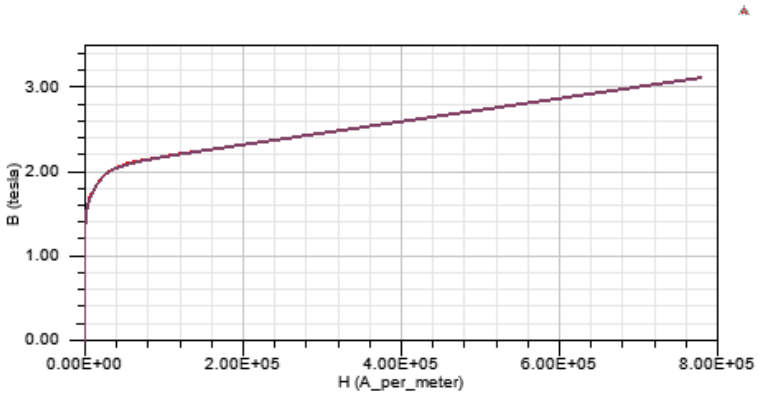
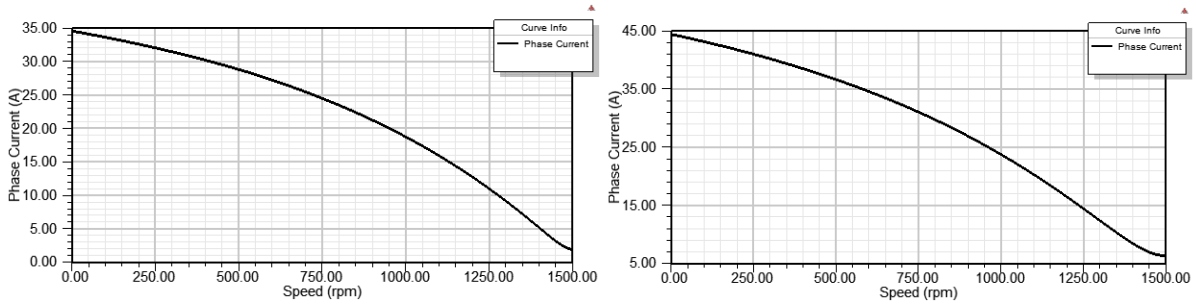


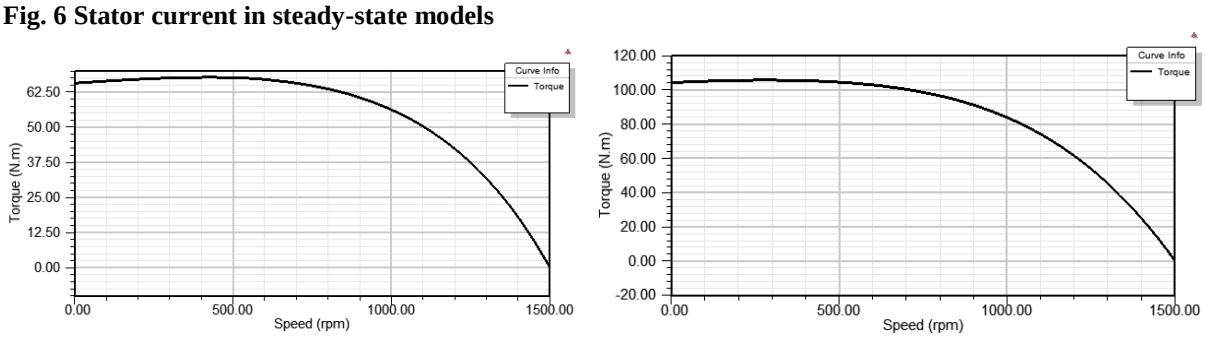
Fig. 5 B-H curve in steady-state models

The core saturation occurs at increased voltage that shifts the operating point above the knee of B-H curve. Therefore, the fifteen percent increased voltage than the rated one, is applied at saturated model in order to study the impact of core saturation on steady state characteristics of current and torque. The core saturation is even more evident in FEM models that present the distribution of magnetic flux density in motor cross-section. In Fig. 6 motor current for saturated and unsaturated machine is presented. In Fig. 7 the motor torque for saturated and unsaturated model is presented. In Fig. 8 the distribution of flux density in motor cross-section for no-load operation is presented. In Fig. 9 the flux density distribution for the rated load operating regime is presented.



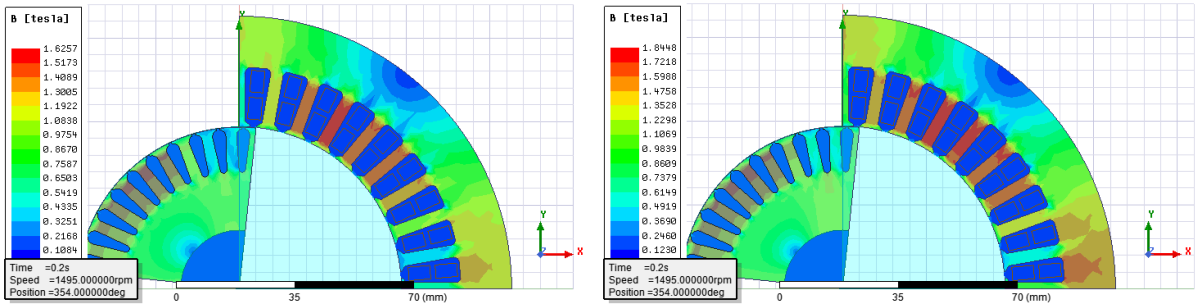
(a) unsaturated model (b) saturated model

Fig. 6 Stator current in steady-state models



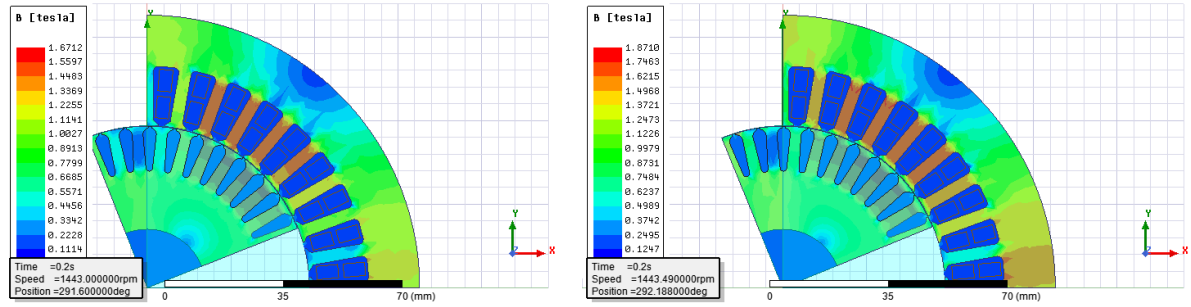
(a) unsaturated model (b) saturated model

Fig. 7 Torque in steady-state models



(a) unsaturated model (b) saturated model

Fig. 8 Flux density distribution at no-load

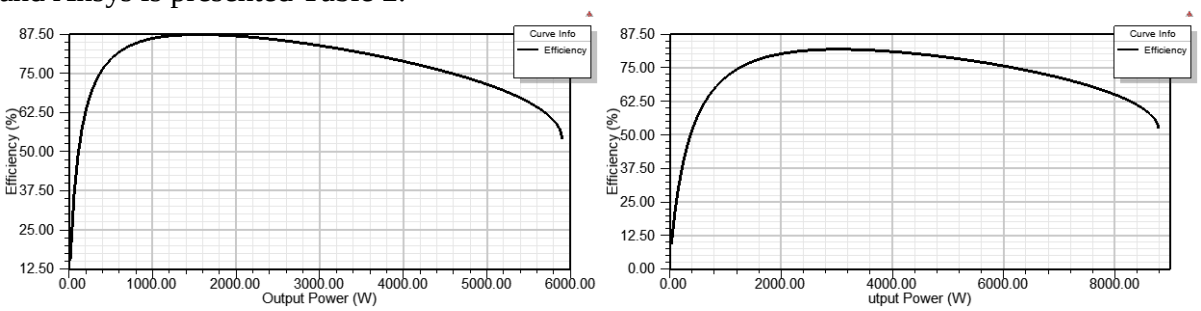


(a) unsaturated model (b) saturated model

Fig. 9 Flux density distribution at rated load

4. Discussion of the results

The Simulink model gives transient characteristics of speed, current and torque for the saturated and unsaturated motor. From the Figs. 3 and 4 it can be observed that effect of the core saturation is more pronounced in stator current which is increased, especially at no-load operating regime. The increased current, increases the motor losses and consequently the efficiency factor of the motor is decreased. In Fig. 10 is presented the steady –state characteristic of the efficiency factor for the saturated and unsaturated model, where it is evident the decrease of the efficiency in saturated model. Moreover, the motor heating is increased and the overall motor performance is deteriorated. The core saturation has no impact on motor speed, acceleration time or the developed torque in both operating regimes: no-load and rated load. The presented results from Simulink models are verified with the results from the steady-state models, modeled in Ansys. They are presented in Figs 6 and 7, where for the specified speed (1495 rpm-no load or 1443 rpm-rated load) the corresponding current and torque can be read it. The comparison between unsaturated and saturated models in Simulink and Ansys is presented Table 2.



(a) unsaturated model (b) saturated model

Fig. 10 Steady-state characteristics of efficiency

Table 2 Comparison between dynamic and steady-state models

Parameter	Simulink		Ansys	
	Unsaturated model	Saturated model	Unsaturated model	Saturated model
Output power [kW]	2.2	2.2	2.2	2.2
Rated torque [Nm]	15	15	14.55	14.55
Rated current [A]	5	6.3	4.4	7
No-load current [A]-rms value	2.1	5.7	1.95	6.4
Efficiency full load [%]	/	/	86.47	80.8
Rated speed [rpm]	1425	1425	1443	1443

From the presented results in Table 2 it is evident the increase of current in saturated model, which worsen the power factor and motor efficiency due to increased copper and core losses. Therefore, the proper design of the motor core is essential for efficient and reliable motor operation. The last step in the analysis was to present the distribution of magnetic flux density in motor cross-section by calculating the magnetic flux density with finite element method. The good design of the induction motor should have cca 1.3-1.4 T in motor yoke and 1.6 to 1.7 T in rotor teethes. Therefore, the FEM models of the saturated and unsaturated motor are calculated, and according to the results, presented in Figs. 8 and 9, the rise of the flux density in stator teethes to cca. 1.89 T in the saturated model is evident, which is the value of the flux density on the knee of characteristic of magnetization or in the beginning of saturated area. The saturation is simulated by increasing the motor voltage which shifts the motor operation point above the knee of characteristic of magnetization in order the effect of core saturation on motor operating characteristics and magnetic flux density distribution to be easily observed. From the results, presented in Figs. 8 and 9, it can be concluded that the initial design of the machine

under normal operating conditions with rated voltage is good, the magnetic core of the motor is properly designed and under these terms, no core saturation is expected to occur. The saturated models serve as an example to present the effect of the core saturation on the motor operating characteristics, transient and steady-state. If under rated operating conditions, the saturation of the magnetic core is observed due to the obtained results from the flux density distribution in the machine cross-section, then the geometry of the motor should be modified i.e. increase of core cross-section is recommended. The new motor design with increased dimensions should again be verified with FEM for the flux density distribution.

Conclusions

The design of the motors is a challenging task involving many different types of parameters from electric, magnetic and geometrical nature that should be successfully combined in order to obtain the good design with satisfactory operating characteristics: high efficiency, good power factor and good overloading capability. Nowadays, the motors efficiency has become of paramount importance in the world that needs more energy with limited resources. Around of the half of the electricity consumption worldwide is attributed to the electrical motors, being the largest electricity consumers. Therefore, the regulations regarding their efficiency, under various standards worldwide, are becoming more and stricter. One of the factors that have impact on motor efficiency is the core saturation. The paper has analyzed and presented the transient and steady-state operating characteristics of the unsaturated and saturated model of the induction motor obtained from software models in Simulink and Ansys. From results, presented throughout the paper, it is evident that core saturation increases the motor current, losses and decreases the motor efficiency. The results from transient and steady-state models have satisfactory similarity which proves the accuracy of the derived models. In general, core saturation deteriorates motor performance due to lower efficiency and power factor, increased losses and heating. The areas of core saturation can be easily detected in the numerical models by the aid of FEM which calculates the flux density distribution in motor cross-section. In the saturated model obtained by FEM and presented in the paper, it is evident the increase of flux density in stator teethes. The core saturation is simulated for increased supply voltage. If such condition occurs during rated operation of the motor, the revision of motor geometry is recommended, until the recommendations regarding the flux density in certain areas of motor cross-section are satisfied.

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PRINCIPLES AND APPLICATIONS OF ORAL ELECTROSURGERY

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Abstract

Electrosurgery is a good alternative to the scalpel or lasers for soft tissue management and would be the method of choice. Oral electrosurgery is widely accepted throughout the world and has a broad spectrum of clinical applications. Once the clinician understands the nature of the different waveforms and how electrosurgical technology relates to clinical results, a comfort level will be achieved making clinical applications safe, predictable and easy. Electrosurgery can be used instead of the scalpel to cut soft tissues, with the goal of reducing hemorrhage. Electrosurgery alludes to the delivery of thermal energy in the form of an alternating current in the radiofrequency range from an electrical generator to the probe tip and the tissues. The heat generated in the tissue depends on the current intensity, the distance from this tissue to the electrode tip, and the period during which the RF energy is delivered. Electrosurgery is the passage of high frequency radio waves (RF energy) into soft tissue resulting in a variety of clinical effects, including cutting, cutting and coagulation at the same time, coagulation or tissue destruction. Because of the resistance offered by the tissue to the incoming RF energy, the tissue heats up. The electrode tip never gets hot. In actuality, the water in the cells is boiled causing the cells to explode. Radiosurgery has also become an unofficial but accepted term referring to electrosurgery instruments that fall into the higher frequency range of 3-4 mHz (3-4 million cycles per second). Study by Maness et al. in 1978 concluded that higher frequency electrosurgical units produce less tissue alteration than those instruments with frequencies under 2 mHz. Higher frequency units produce less lateral heat and, therefore, less tissue alteration. The optimal frequency appears to be in the 3-4 mHz range. There are numerous indications for oral electrosurgery and some include bleeding control, cosmetic elongation of clinical crowns, soft tissue management during crown and bridge procedures, biopsies, frenectomies, pulpotomies, collecting tissue for gingival grafts, incisions or excisions and tissue contouring. The main goal of this study is to highlight the principles and benefits of electrosurgery application. Electrosurgery can never completely replace the scalpel, but it requires more knowledge, skill and complete understanding of the biophysical aspects of the interaction of electrosurgical energy and tissue. Continued research into the field of tissue interaction is promised and potential development of applications of electrosurgery.

Key words:

Electrosurgery, bipolar, incision, hemostasis, coagulation, soft tissue management, wound healing.

Introduction

Electrosurgery is a commonly used technique in oral surgery for various purposes. It involves the use of high-frequency electric current to cut, coagulate, or remove tissue [1] . Here are some applications of oral electrosurgery: 1. Tissue cutting: Electrosurgery can be used to make precise incisions in soft tissues. It is often employed in procedures such as excision of soft tissue lesions, removal of excess gum tissue (gingivectomy), or crown lengthening; 2.

Hemostasis (control of bleeding): One of the significant advantages of electrosurgery is its ability to coagulate blood vessels during surgical procedures. The electric current can effectively seal blood vessels, minimizing bleeding and facilitating a bloodless surgical field; 3. Soft tissue ablation: Electrosurgery can be used to remove or ablate unwanted or diseased soft tissues. It is commonly used for procedures such as removal of oral mucosal lesions, including benign tumors or precancerous lesions; 4. Tissue contouring: In certain cases, electrosurgery is utilized for tissue sculpting or reshaping. It can help in reshaping gingival tissues, removing excess tissue, or creating esthetic gingival margins; 5. Frenectomy: A frenectomy involves the removal or alteration of a frenulum, which is a small fold of tissue that connects the lips, tongue, or cheeks to the underlying structures. Electrosurgery is often to perform frenectomies, allowing for precise tissue removal and minimal bleeding; 6. Biopsies: Electrosurgery can be used to perform incisional or excisional biopsies of oral lesions [2] , [3]. The technique enables the surgeon to obtain a tissue sample for diagnostic purposes while providing hemostasis during the procedure[4].

Electrosurgery offers several advantages in oral surgery, including precise cutting, simultaneous coagulation, and the ability to control bleeding. However, it's important to use the appropriate power settings and techniques to minimize thermal damage to surrounding tissues. The specific application of electrosurgery will depend on the surgical procedure and the surgeon's preference and experience [5]. Electrosurgery is an excellent alternative to the scalpel or lasers for soft tissue management, and in most instances, would be the instrument of choice. Oral electrosurgery is widely accepted throughout the world and has a broad range of clinical applications. For those practitioners that want to incorporate electrosurgery into their routine patient treatment protocols, there is a learning curve that is critical to its implementation. Once the clinician understands the nature of the various waveforms and how electrosurgical technology relates to clinical results, a comfort level will be reached making clinical applications safe, easy and predictable[6]. Electrosurgery is the passage of high frequency radio waves (RF energy) into soft tissue resulting in a variety of clinical effects, including cutting, cutting and coagulation at the same time, coagulation or tissue destruction. Because of the resistance offered by the tissue to the incoming RF energy, the tissue heats up. The electrode tip never gets hot. In actuality, the water in the cells is boiled causing the cells to explode. Dorland’s Medical Dictionary defines radiosurgery as, “surgery in which tissue destruction is performed by means of ionizing radiation rather than surgical incision.” It usually involves implanted radioactive material. However, radiosurgery has also become an unofficial but accepted term referring to electrosurgery instruments that fall into the higher frequency range of 3-4 mHz (3-4 million cycles per second) [7]. Study by Maness et al. in 1978 concluded that higher frequency electrosurgical units produce less tissue alteration than those instruments with frequencies under 2 mHz. To reach a level of confidence and competence, the clinician needs to understand how to control lateral heat. Lateral heat is the build up of heat in the tissue adjacent to the active electrode. The practitioner must learn to guide and control the RF energy entering the tissue so that enough heat is produced to accomplish the task at hand without creating additional heat that will cause tissue alteration or destruction [8]. The control of lateral heat depends on various factors that are depicted in the following formula. As long as the formula is kept in balance and the clinician stays within acceptable parameters, electrosurgery will be safe and effective.

Critical to successful electrosurgery is working with a “tuned” unit. To tune your electrosurgical unit, set it up in the room where it will be routinely used [9].

The appropriate waveform must be chosen and preset by the practitioner depending on the clinical procedure. For some procedures, a combination of waveforms may be utilized. The coagulation wave (partially rectified) produces the most amount of lateral heat. The cut + coag wave (fully rectified) produces less lateral heat, and the cut (filtered) wave produces the least

amount of lateral heat. So, the cut setting would be the waveform of choice when working near bone or implants, when performing biopsies or when tissue shrinkage is of concern.
Frequency is the one factor in the lateral heat formula that is controlled o
nly once by the clinician–when he/she purchases an electrosurgery instrument. The lower frequency electrosurgical units usually seen in a hospital OR (.5 mHz) require that the antenna (passive electrode) contacts the patient's skin with an applied jelly for better conduction. The higher frequency dental units require no skin contact. Higher frequency units produce less lateral heat and, therefore, less tissue alteration. The optimal frequency appears to be in the 3-4 mHz range. Once the practitioner understands radiosurgical instrument and how to control its radio frequency energy, a comfort zone will be reached, and both the patient and dentist will benefit[10].

1.Materials and Methods

Research strategy

For this narrative article review on the use of electrosurgery in oral surgery, a comprehensive search of relevant literature was conducted using electronic databases, including PubMed and Google Scholar. Keywords such as electrosurgery, bipolar, incision, hemostasis, coagulation, soft tissue management, wound healing , were used to identify relevant articles published in peer-reviewed journals. The inclusion criteria encompassed studies, clinical trials, and reviews published in the English language from the past 10 years. Articles focusing on the materials, methods, techniques, and advancements in electrosurgery in the context of oral surgery were prioritized. The retrieved articles were meticulously analyzed, and relevant information was extracted and synthesized to provide a comprehensive overview of the topic. Additionally, textbooks, surgical guidelines, and manufacturer's literature were consulted to supplement the literature findings. The narrative review aims to present a balanced and informative discussion on the methods, advancements, clinical outcomes, and patient benefits associated with the use of electrosurgery in oral surgery.

2.Evaluation and results

The reviewed articles consistently highlighted the widespread usage of electrosurgery in various oral surgery procedures, such as soft tissue surgeries, gingivectomy, frenectomy, and periapical surgery. Electrosurgical system contain electrosurgical unit as a generator with active electrodes (Fig.1) At it's frequency, muscles and nerves are not affected, and heat is created at the cellular level. The heat created is responsible for the cutting and coagulation effect that is experienced.

Fig.1 Electrosurgical unit
Source:www.praxisdienst.com

Electrosurgery was reported to be effective in achieving hemostasis, precise tissue cutting, and coagulation during these procedures. The use of electrosurgery was particularly beneficial in reducing intraoperative bleeding, postoperative edema, and operative time when compared to traditional surgical techniques. The safety of electrosurgery in oral surgery was a major focus in the reviewed studies. Although electrosurgery was generally considered safe, the articles emphasized the importance of proper technique, appropriate power settings, and good clinical judgment to minimize potential complications. The most commonly reported complications included thermal damage to adjacent tissues, delayed wound healing, and postoperative pain. However, these complications were generally mild and manageable with proper postoperative care. Several studies assessed patient satisfaction and postoperative outcomes following oral surgery procedures involving electrosurgery. Overall, patients expressed high levels of satisfaction with the outcomes, reporting minimal postoperative pain, improved healing, and reduced complications compared to conventional techniques. The use of electrosurgery was associated with improved esthetic outcomes, reduced scar formation, and enhanced wound healing. Based on the reviewed literature, electrosurgery is a valuable tool in oral surgery, providing effective hemostasis, precise tissue cutting, and coagulation. Despite potential complications, when used with proper technique and settings, electrosurgery offers advantages in terms of reduced bleeding, shorter operative time, and improved postoperative outcomes. Future research should focus on optimizing electrosurgical techniques, exploring new advancements in technology, and conducting long-term follow-up studies to evaluate the safety and efficacy of electrosurgery in oral surgery procedures.

The authors of the reviewed articles provided valuable insights and discussions regarding the usage of oral electrosurgery. Here are some key points raised by the authors: 1. Effectiveness and Advantages: The authors consistently acknowledged the effectiveness of electrosurgery in achieving hemostasis, precise tissue cutting, and coagulation during various oral surgery procedures. They highlighted the advantages of electrosurgery, such as reduced intraoperative bleeding, improved visibility, shorter operative time, and enhanced postoperative outcomes. The ability to control bleeding and achieve accurate tissue cutting were considered significant benefits of electrosurgery; 2. Safety Measures and Complications: The authors emphasized the importance of adhering to safety measures and proper techniques when using electrosurgery in oral surgery. They highlighted the need for appropriate power settings, good clinical judgment, and adequate training to minimize potential complications. While thermal damage to adjacent tissues, delayed wound healing, and postoperative pain were reported as possible complications, the authors indicated that these complications were generally mild and manageable with proper postoperative care; 3. Patient Satisfaction and Outcomes: The authors discussed patient satisfaction and postoperative outcomes following oral surgery procedures involving electrosurgery. They reported high levels of patient satisfaction, citing minimal postoperative pain, improved healing, reduced complications, and enhanced esthetic outcomes compared to conventional techniques. The authors emphasized the positive impact of electrosurgery on wound healing, scar formation, and overall patient experience; 4. Optimization and Future Research: The authors acknowledged the need for further research to optimize electrosurgical techniques in oral surgery. They called for studies focusing on refining the power settings, exploring new advancements in technology, and conducting long-term follow-up evaluations to assess the safety and efficacy of electrosurgery. The authors highlighted the importance of ongoing research to improve outcomes and address any potential concerns or limitations associated with electrosurgery.

3.Discussion

Although in the scientific literature review there are some articles on oral electrosurgery, its clinical applications are numerous. Electrosurgery is used in many fields of dentistry, and we believe it is appropriate to study in deep its in clinical field. The benefits and better control of intraoperative complications and risks can lead clinicians to increasingly use electrosurgery in everyday clinical practice[11], [12].

In Nixon et al. gingival incisions were performed on 25 adult male guinea pigs. For every animal, an electrosurgical scalpel was used on one side and a conventional scalpel was used on the other side. However, in this study, only one surgical method was applied to each rat in order not to affect wound healing.

Rathofer et al. compared electrosurgery with scalpel for the excision of inflammatory papillary hyperplasia using questionnaires to assess pain and patients' perception of the postoperative period. Most patients did not feel pain during either technique, but the pain and discomfort after the application of electrosurgery lasted longer than with the conventional scalpel.

Sinha et al. reported that limited hemostasis was obtained with the use of conventional scalpel, but buffering with gauze was needed. They also suggested that use of an electrosurgical device provided better hemostasis compared to CO2 laser and conventional scalpel[13].

Kalkwarf et al. showed that lateral heat production adjacent to a fine wire needle electrode emitting fully rectified-filtered current was dependent upon the time of incision. They also demonstrated that three successive incisions into the same site dramatically increased the amount of lateral heat production (8.0 - 48.0oC) at a distance of 1 mm from the electrode. The authors demonstrated that a cooling period of at least 8 seconds between subsequent incisions in the same area is necessary to assure that lateral heat production capable of initiating adverse tissue responses does not occur. The same group, in a separate study, found that an activated loop electrode generated more energy during surgery than a needle electrode. Temperature increases in the adjacent tissue following use of the loop remained for longer periods of time than after use of a needle electrode. They calculated that a cooling interval of 15 seconds was necessary to properly dissipate heat between successive entries into the same area of tissue with a loop electrode. Size and type of active electrodes the thicker the electrode, the greater the amount of lateral heat. In a study of electrosurgical wounds, it was reported that the needle-type electrode, which is used for incisions, creates a 0,12-mm-wide necrosis, and the loop electrode, used for tissue planing, makes a 0.31- mm-wide necrosis. The same report also concluded that large electrodes cause more tissue damage than small ones. Wave form the choice of waveform depends on (1) the required Surgical effect, i.e., whether tissue separation or hemostasis is required, and (2) the proximity of bone to the surgical site. The fully rectified waveform produces excellent tissue separation with the least amount of lateral heat, but it also produces very little hemostasis (Fig.2). The fully rectified, unfiltered waveform produces good tissue separation with effective hemostasis.

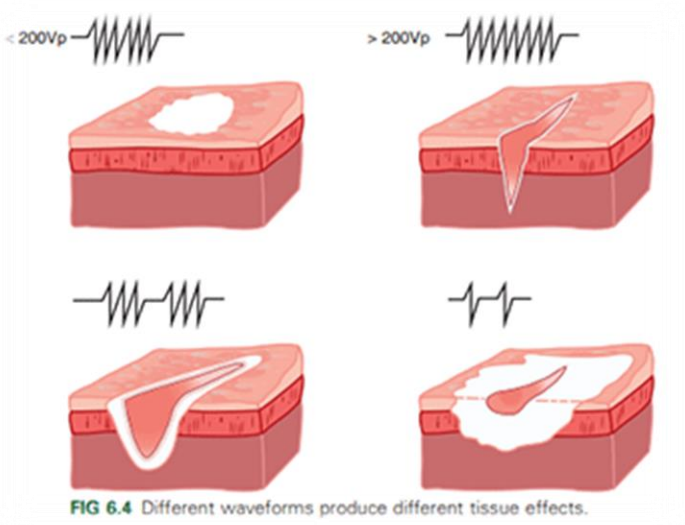

Fig.2 Different waveforms produce different tissue effects
Source://www.steris.com/

The partially rectified waveform produces much more lateral heat than the fully rectified, unfiltered waveform: therefore, it can be used only for the control of hemorrhage in soft tissue ecutting time, The quicker the active electrode is passed over the tissue, the lesser the lateral heat. It has been estimated that to generate an effective incision, while keeping the lateral heat at a minimum level, the electrode must be guided over the tissue at a speed of 7 mm/s. The active electrode must not remain in contact with tissue for more than 1 to 2 seconds at a time and successive applications of the electrode on the same spot must have a 10 to15 seconds interval. This interval allows the heat produced on the wound to dissipate and prevents overheating of the tissue surface before the next application of the electrode. Surface tissue condition. The surface of the tissue must be moist to allow heat dispersal. A dehydrated tissue surface causes sparking, tissue drag, and delayed healing. Therefore, it is desirable for the tissue surface to be wetted with the patient's own saliva or water or saline. Irrigation of the surgical site immediately after ES will also help to minimize lateral heat[14], [15].

Conclusion

Electrosurgery can never completely replace the scalpel, but it requires more knowledge, skill and complete understanding of the biophysical aspects of the interaction of electrosurgical energy and tissue. Continued research into the field of tissue interaction is promised and potential development of applications of electrosurgery. Overall, the authors expressed positive views on the usage of oral electrosurgery, recognizing its effectiveness, advantages, and patient satisfaction. They also emphasized the need for proper techniques, safety measures, and further research to optimize the use of electrosurgery in oral surgery procedures.

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MOLTEN SALT THERMAL ENERGY STORAGE FOR RENEWABLE ENERGY: SYSTEM DESIGN, MATERIALS, AND PERFORMANCE

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Abstract

This research paper thoroughly examines the fundamental principles and design concepts of molten salt thermal energy storage systems, focusing on the critical role of materials selection in choosing the appropriate material for the application. We also discuss the basic design components of these systems when integrated with renewable technology and classify practical systems by their applications.
Based on our analysis, we conclude that solar technologies with molten salt storage systems are particularly promising for practical implementation, and the two-reservoir type system utilizing the sensible heat storage method of molten salt is regarded as the most commercially viable and mature electrothermal storage system available. Solar salt is also considered the best choice for these systems due to its low cost and high energy density. The idea of retrofitting fossil fuel plants with molten salt storage systems is also mentioned. Overall, molten salt thermal energy storage systems have the potential to play a crucial role in future energy systems, and further research and development in this field is essential for maximizing the potential of these systems and achieving a sustainable energy future.

Keywords:

molten salt, thermal energy storage, two-tank sensible heat storage, design concept, material selection, performance evaluation

1. Introduction

As a promising solution for the integration of renewable energy sources into the power grid, molten salt thermal energy storage systems have been of interest to scientists and energy experts alike. In the energy industry, the intermittent nature of renewable energy sources, such as solar and wind power, is a major challenge. This challenge can be overcome by storing excess renewable energy generated during peak periods in molten salt thermal energy storage systems and use it when demand is high. This topic of research has become a crucial issue in recent years as societies worldwide seek to reduce their reliance on fossil fuels.

Molten salt storage systems are a type of thermal energy storage system that utilizes a mixture of salts as the storage medium to store thermal energy at high temperatures. These systems offer several benefits, including high energy density, cost-effective, and non-toxic behavior. They are also highly scalable, making them an excellent option for large-scale renewable energy projects. Additionally, due to their high temperature range and compatibility, molten salt storage systems are an excellent candidate for use with a wide range of solar energy technologies, including concentrated solar power, solar photovoltaics (PV), and hybrid solar thermal electric and PV plants with thermal storage [1] - [6], [8] – [10], [13] – [16], [21]. The use of molten salt thermal energy storage systems enables the electrothermal storage of large amounts of energy ranging from megawatts to gigawatts in the energy industry. At present, the two-reservoir type system utilizing the sensible heat storage method of molten salt is regarded as the most commercially viable and mature electrothermal storage system available. This

concept of thermal energy storage systems that utilize solar energy, depending on the specific solar technology used, the working fluid – heat transfer fluid (HTF) can be molten salt, synthetic oil, water, or steam [4]. In some solar thermal power plants, such as those that use parabolic trough technology, synthetic oil or steam is used as HTF, while in solar tower technology, molten salt is used both as the storage medium and the working fluid (air and steam can also be used as working fluids). In others, such as those that use linear Fresnel technology, steam is used as the working fluid to generate electricity.

The purpose of this paper is to examine the topic of molten salt thermal energy storage for renewable energy, focusing on system design, materials, and performance. We will begin by reviewing the current state of the field and highlighting some of the key challenges and opportunities of these systems. Then, we will discuss molten salt systems in detail, describing their design principles, materials properties, and performance characteristics. In addition, we will explore the factors that influence heat transfer, thermal stability and corrosion resistance. Lastly, the paper will discuss potential future developments in molten salt thermal energy storage systems and their implications for renewable energy.

2. Fundamental Principles

Molten Salt Thermal Energy Storage (MSTES) has emerged as a prominent technology for storing thermal energy derived from renewable energy sources, particularly wind and solar power. The essence of MSTES lies in harnessing the superior heat storage and transfer properties of molten salts, which exhibit an exceptionally high specific heat capacity, enabling them to absorb and dissipate significant quantities of heat while undergoing only minimal temperature fluctuations.

MSTES systems are composed of several key components, including a storage tank, heat exchangers, and a fluid circulation system [3]. During the charging phase, MSTES systems utilizes renewable energy to heat the molten salt in the storage tank. Subsequently, the heated molten salt is transported through heat exchangers, where it transfers heat to a HTF such as water or steam (or other HTF as described previously). This HTF can then be utilized to produce electricity or stored for future use. The discharging phase involves the reverse process, where the HTF is utilized to heat the molten salt, which is then conveyed back to the storage tank [5].

The effectiveness of MSTES systems is influenced by several factors, including the selection of the molten salt, the design of the storage tank and heat exchangers, and the efficiency of the HTF. Among these factors, the thermal characteristics of the molten salt play a crucial role in determining the operating temperature range and the amount of heat that can be stored. The selection of an appropriate molten salt is a critical factor in achieving high efficiency and long-term durability. Factors that must be considered during the selection process include the molten salt's melting point, specific heat capacity, thermal conductivity and corrosiveness [6]. These properties play a crucial role in determining the overall performance of the MSTES system. Furthermore, to achieve optimal performance, it is imperative to design the storage tank and heat exchangers with careful consideration of the heat transfer efficiency and heat loss minimization. A well-designed system can enhance the transfer of heat between the molten salt and the heat exchangers, leading to improved overall efficiency. It is worth noting that the choice of the HTF fluid is an equally critical aspect that cannot be overlooked in the design of MSTES systems. The fluid should exhibit high heat transfer coefficient and low viscosity to facilitate efficient heat transfer between the molten salt and the heat exchangers. By doing so, it is possible to achieve optimal heat transfer performance and maximize the efficiency of the MSTES system.

The selection of appropriate materials is a factor of vital importance that plays a significant role in the design of MSTES systems. It is essential to choose materials that can withstand the high temperatures and corrosive nature of molten salts to ensure the long-term durability and reliability of the system. When selecting materials for the construction of the storage tank and heat exchangers, several factors must be considered, such as thermal stability, corrosion resistance and mechanical strength. Carbon steel, stainless steel, and nickel alloys are some of the materials that have been used in MSTES systems due to their ability to withstand high temperatures and resist corrosion [7]. In addition to material selection, it is also crucial to consider the design of the storage tank and heat exchangers. Proper design can further enhance the durability of the materials by minimizing exposure to corrosive molten salts and optimizing heat transfer efficiency. Overall, material selection is a critical aspect of designing MSTES systems, and careful consideration must be given to ensure the long-term performance and reliability of the system.

While there have been significant advancements in the development of MSTES systems, ongoing research is necessary to address the challenges associated with these systems and identify opportunities for further improvements, ultimately supporting the transition to a more sustainable energy future.

3. The Design Concept of Molten Salt Thermal Energy Storage Systems with Optimal Performance and Durability: The Critical Role of Materials Selection in Choosing the Appropriate Material for the Application

In addition to the concept of storage [8] (Fig. 1), the classification of high-temperature MSTES systems is an important consideration in the design of energy storage systems. These systems can be classified as either active or passive, depending on their mode of operation. Active systems involve the use of external energy inputs to maintain the desired storage temperature, while passive systems rely on the inherent thermal properties of the storage material to maintain the desired temperature. High-temperature MSTES systems can also be classified as direct or indirect, depending on the nature of the heat transfer process. In direct systems, the storage material is in direct contact with the HTF, while in indirect systems, the HTF is separated from the storage material by a heat exchanger. High-temperature thermal storage systems (direct and indirect systems), including molten salt storage systems and concentrated solar power (CSP) technologies are illustrated in Fig. 3 (a) and (b).

MSTES systems are designed to operate in different modes depending on the energy requirements and availability of the system. These systems consist of primary and secondary charge and discharge cycle subsystems, which work in tandem to provide the energy storage capacity of the system. An example is given for the concentrated solar technology. During charging, energy is transferred from the solar receiver (or other solar, and wind technology) to the hot storage tank, while during discharge, energy is extracted from the hot storage tank and transferred to the power block for conversion to electricity. The system is designed to maintain a constant temperature in the hot storage tank, which is achieved by recirculating the molten salt through a heat exchanger. The system also includes a cold storage tank, which stores the cooled molten salt until it is needed for the next charging cycle. The entire process is illustrated in Fig. 2 and is further described below.

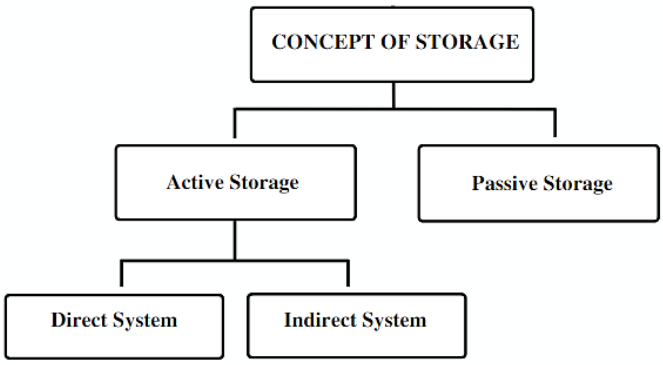

Fig. 1. Classification of storage concept for MSTES systems

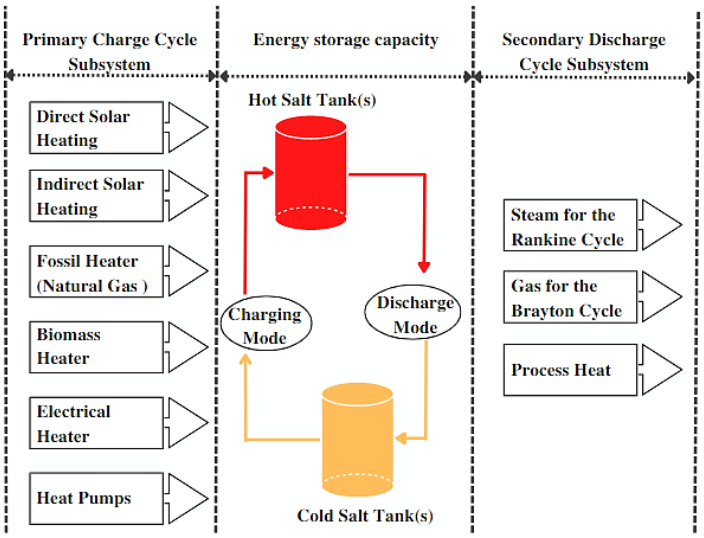

Fig. 2. Construction of subsystems for energy storage and operational mode utilizing MSTES systems

As shown in Fig. 2, MSTES systems are characterized by three modes of operation: charge, storage (standby) and discharge. Carnot batteries [11], [14] is a term commonly used to describe the three operating modes of molten salt energy storage systems.

1. **Charge mode**: during the charge mode, heat is transferred to the molten salt, usually through direct solar heating or indirect heating through thermal oil or steam (or through the other forms listed in the Fig. 3), raising the temperature of the salt and storing heat energy.
2. **Storage mode**: after the molten salt is heated, it is stored in a thermal capacity, a hot tank where it can be kept at a high temperature until it is needed for later use (generation of electricity).
3. **Discharge mode**: When the stored thermal energy is needed, the salt is pumped from the hot reservoir to a cold reservoir and passes through a heat exchanger, transferring the thermal energy to a secondary fluid, such as water, which generates steam and drives the turbine for electricity production.

The third segment of the secondary discharge cycle subsystem in a molten salt energy storage system typically includes a combined thermodynamic cycle that utilizes both the Rankine and Brayton cycles.These two thermodynamic cycles are used to produce electricity supported by heat to energy reconversion processes.

When renewable energy is available, it can be used to power electric heaters, which transfer the salt's energy into heat by a process known as energy-to-heat conversion. When energy is

needed, the heat stored in the salt can be used to generate electricity through the Rankine cycle. It allows the thermal energy stored in the salt to be converted back into electrical energy by reconversion during discharge operation mode.

On the other hand, the reconversion of heat into energy during discharge operation mode is also performed by the Brayton cycle with a closed loop that uses gas under pressure (air as the working fluid). This reconversion process follows the energy to heat conversion process with the use of high temperature heat pumps for efficient conversion of renewable energy to heat in the molten salt in charge mode operation.

Molten salt is a desirable option for sensible heat storage material in high-temperature (>100°C) thermal applications [12]. Its advantages make it a potential candidate for integration into thermal systems together with technologies that are commercial, mature (e.g., CSP, PV) and used to serve services at the power grid level. For a more comprehensive discussion of the thermophysical properties of molten salts as a heat storage media and HTF, further details can be found in [13].

Different types of molten salts that are used are: nitrates, chlorides, carbonates, fluorides, etc. These different types of salts have special properties that make them suitable for specific system designs. Table 1 summarizes some of the important features with an overview of the specific properties and cost of several selected molten salt mixtures. More properties can be found in the literature [14] – [17].

Table 1 Molten salts for high-temperature applications of thermal storage systems

Acronym	Molten Salt Composition [wt%]	T_m [°C]	T_{max} [°C]	C_p [$Jg^{-1} K^{-1}$]	ρ [$g\ cm^{-3}$]	T_{stab} [°C]	Cost ($ kg^{-1})
Solar Salt	KNO3 – NaNO3 (40-60)	220-240	530-565	1.55 [400°C]	~1.84 [400°C]	600	0.5
Hitec	KNO3 – NaNO2 – NaNO3 (53-40-7)	142	450-540	1.54 [400°C]	1.79 [400°C]	535	0.73
HitecXL	Ca (NaNO3)2 – KNO3 – NaNO3 (42-43-15)	130-140	460-500	1.43 [400°C]	1.91 [400°C]	/	1.19
LiNaK carbonates	Li2CO3 – Na2CO3 – K2CO3 (32-33-35)	397	>650	1.85 [700°C]	1.98 [700°C]	800-850	2.5
LiNaK fluorides	KF– LiF– NaF (59-29-12)	454	>700	1.89 [700°C]	2.02 [700°C]	>700	>2
ZnNaK chlorides	ZnCl2 – NaCl – KCl (68.6-7.5-23.9)	204	>700	0.8 [300-600°C]	2.02 [600°C]	850	0.8
MgNaK chlorides	MgCl2 – NaCl – KCl (68.2-14.0-17.8)	380	800	~1.84 [500-800°C]	~1.84 [600°C]	>800	<0.35

Source: Data are based on literature [14] – [17]

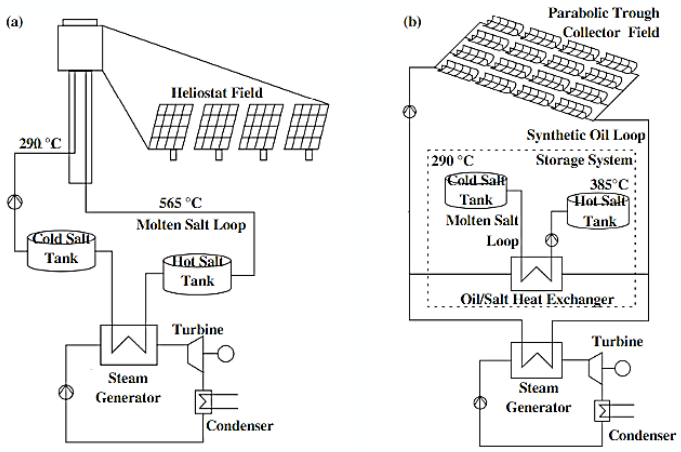

Fig. 3. This schematic illustration displays examples of direct and indirect storage in solar thermal systems that incorporate CSP technology. The direct system depicted in (a) uses molten salt as both the transfer and storage medium, with a solar field comprising heliostats focused on a solar tower. In contrast, the indirect system illustrated in (b) utilizes synthetic thermal oil as the HTF and molten salt as the storage medium. The solar field in this system is composed of parabolic collectors.
Image data has been modified accordingly [9], [10]

The temperature range of the various molten salt compositions (Table 1) shows different temperatures that define the limits of their use. These limits are defined as the melting temperature T_m and the maximum operating temperature T_{max}. The melting temperature for selected molten salts varies from 130-454 °C, depending significantly on the type of anion and cation composition [3]. The T_{max} value is the maximum temperature at which the molten salt composition can withstand certain conditions such as thermal decomposition, high vapor pressure or high corrosion rate [15]. The table also shows values of heat capacity C_p and density ρ, and their product is equal to the volumetric heat capacity which determines the size of the sensible heat storage system. The volumetric heat capacity $C_p \cdot \rho$ varies with values from 2.9 to 3.8 J cm^{-3} K^{-1}, which are important as a characteristic for the transfer heat fluid. The last value in the table is the material price, which is expressed in dollars kg^{-1}, which together with the heat capacity and the temperature difference between charging and discharging $\triangle T$, constitute the specific material investment cost (dollars kWh^{-1}).

A molten salt mixture consisting of 60% by weight of sodium nitrate ($NaNO_3$) and 40% by weight of potassium nitrate (KNO_3), also known as solar salt or nitrate salt [2] – [6], [9], [10], [12], [14] – [17] has emerged as a practical and proven choice especially for solar thermal energy storage systems. Solar salt boasts a low cost and excellent thermal performance, making it an attractive option for thermal applications that use both direct and indirect storage systems, with particular attention to CSP and PV technologies. This molten salt mixture has a melting point in the range of 220-240 °C, depending on the measurement conditions with a temperature stability of ~560 °C.

3.1 Basic Design Components of Molten Salt Thermal Energy Storage Systems Integrated with Renewable Technology

Example Table 2 outlines the main components and description for a MSTES.

Table 2 Main and basic components of a molten salt thermal energy storage system

Component	Description
Storage Tank	Central component of the storage system. Material: Stainless steel (or are lined with insulating materials to minimize heat loss). It is important to follow typical design standards such as API. For cold storage tanks, carbon steel (ASTM A-516 Gr.70) is commonly used, while stainless steel (ASTM A-347H or ASTM A-321H) is used for hot tanks that need to withstand higher operating temperatures [14].
Heat Exchangers	Transfers heat between the molten salt and other components of the thermal energy system. Materials such as nickel alloys or ceramics are often used for this purpose [18].
Pumps	Responsible for circulating the molten salt through the system to transfer heat and store energy. There are typically two types of pumps used in a molten salt storage system. - Charge pumps: These pumps are used to fill the storage tank with molten salt at the beginning of a storage cycle [14]. They are typically centrifugal pumps [19] and are designed to handle the high temperatures and corrosive nature of molten salt. - Circulation pumps [20]: Circulation pumps are utilized to move the molten salt through the system during charging and discharging cycles when the storage tank is filled. These pumps are typically positive displacement pumps and are designed to manage high temperatures and flow rates. Materials such as stainless steel or nickel alloys are typically used for the pumps, and they must be designed to prevent leakage and minimize the risk of corrosion.
Insolation System	Reduces heat loss from the thermal energy storage tank and prevents the molten salt from solidifying. The isolation system typically consists of insulation materials, valves, and expansion joints. Insulation materials such as ceramic fiber or mineral wool are commonly used in molten salt storage systems [21].
Freeze Protection System	The freezing protection system in a molten salt storage tank is crucial to maintain the temperature of the salt above its melting point, which is typically around 220°C to 260°C, depending on the composition of the salt mixture. Below this temperature, the salt can freeze and cause blockages in the system, which can damage the equipment and affect the performance of the molten salt system [14].
Generator Unit	The generator unit is a critical component of a molten salt storage system because it allows the stored thermal energy to be converted into a usable form of energy that can be dispatched to the grid as needed. The generator unit typically consists of a heat exchanger, a turbine, and a generator. The heat exchanger is used to transfer the heat from the molten salt to a working fluid, such as water or steam. The working fluid is then used to drive a turbine, which in turn drives a generator to produce electricity.

In the design and implementation of a molten salt storage system integrated with renewable technology, it is crucial to ensure that the system components and specifications are tailored to the specific needs and requirements of the project. While the main components outlined in the table provide a general guideline, the unique conditions and constraints of each project may require modifications or alternative solutions. To ensure the success of the project, it is recommended to consult with a professional engineer or contractor with expertise in molten

salt thermal energy storage systems. This will help to ensure that the system is designed and installed correctly, and that any potential issues or challenges are identified and addressed early in the process.

4. Applications of Molten Salt Thermal Energy Storage Systems for Various Power System Applications and Classification of Practical Systems

The key characteristics highlighted in Table 3 provide a detailed framework for assessing the capabilities and limitations of molten salt storage systems, considering factors such as power output, cycle life and response time. These metrics are essential for understanding the performance of these systems in various contexts, and for optimizing their design and operation to meet specific application requirements.

Table 3 Key characteristics of molten salt thermal systems for power system applications

Application	Power [MW]	Discharge Time	Cycles [daily]	Response Time
Energy Management	>100	hours to days	0.14 - 0.7	minutes
Support of Renewable Energy Sources	<100 and above	hours	0.5 - 2	minutes
Investment Deferral	~10 - 500	2 – 5 hours	0.75 - 1.25	hours
Black Start	0.1 - 400	hours	< 1 per year	< 1 hour
Load Following	1 – 2,000	15 minutes to 1 day	1 - 29	< 15 minutes
Spinning Reserve/Non-Spinning Reserve	10 – 2,000	15 minutes to 2 hours	0.5 - 2	< 15 minutes
Waste Heat Utilization	1 – 10	12 hours to 1 day	1 - 20	< 10 minutes
Combined Heat and Power	1 - 5	minutes to hours	1 - 10	< 15 minutes

Thermal energy storage systems using molten salt can be classified into several types according to their practical applications [1] – [6], [8] – [10], [13] – [16], [21]. MSTES systems are classified as follows:

- Molten salt thermal energy storage systems with thermal electric parabolic trough collectors.

- Molten salt thermal energy storage systems with thermal electric solar receivers.
- Molten salt thermal energy storage systems with hybrid solar thermal electric and PV plants.
- Systems for pumped-thermal energy storage in molten salt.
- Molten salt thermal energy storage systems for conversion of fossil fuel power plants.

5. Conclusion

In conclusion, molten salt thermal energy storage systems are emerging as a promising solution for renewable energy integration and electrification. With the critical role of materials selection and system design, these systems can achieve optimal performance and durability in various power system applications. The fundamental principles of these systems are based on the unique properties of molten salt, which enable low cost, high energy density, thermal stability, and efficient heat transfer. The design concept of these systems must carefully consider the materials selection, system integration with renewable technology, and practical implementation of different types of systems. Solar technologies with molten salt storage systems are particularly promising for practical implementation, while retrofitting fossil fuel plants can further accelerate the transition to a sustainable energy future. Based on current research and industry trends, the two-reservoir type system with sensible heat storage method using solar salt is currently the most commercially available and mature electrothermal storage system, and it is expected to play a key role in future energy systems.

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ДЕНТАЛНИТЕ ЛАСЕРИ - ПРЕДИЗВИК НА СОВРЕМЕНАТА СТОМАТОЛОГИЈА

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Апстракт

Ласерската технологија станува сè попопуларна во стоматологијата во последните неколку децении. Денталните ласери поседуваат мноштво на индикации кои се изведуваат во секојдневата стоматолошка пракса, вклучувајќи третман на пародонталните заболувања (ласерите може да се користат за отстранување на инфламираното гингивално и пародонтално ткиво и за промовирање на растот на здравото ткиво); отстранување на каризоните лезии (ласерите може да се користат за отстранување на кариесот на забите, без употреба од анестезија); белење на заби (ласерите може да се користат за активирање на средствата за белење и подобрување на ефикасноста на третманите за белење на забите); за изведување на биопсија (ласерите може да се користат за отстранување на мали примероци од ткиво за биопсија); процедури на меките орални ткива(Ласерите може да се користат за преобликување или отстранување на ткивото на непцата за да се подобри изгледот на насмевката). Најважни за споменување се придобивките од употребата на ласери во стоматологијата од кои најзначајни се намалена болка и непријатност кај пациентот, намалено крварење и побрзо време на заздравување. Ласерите исто така можат да бидат попрецизни од традиционалните стоматолошки алатки, што овозможува значително поконзервативен третман.

Клучни зборови:

безболно, ефикасност, прецизност, ласер, третман

1. Вовед

Употребата на светлината во дијагностички и терапевтски процедури датира многу одамна. Древните лекари ја користеле за да ја следат бојата на кожата, да го следат процесот на зараснување на раните и да се изведуваат различни терапевтските активности. Исто така, топлината на сончевата светлина во минатото лекарите ја користеле како тераписки модалитет. Па така, Грците и Римјаните користеле сончеви бањи и солариуми и остатоци од истите може да се најдат во нивните домови во археолошките ископини. Старите народи, како Египќаните, Кинезите и Индијците ја користеле светлината во третманот на псоријаза, рак на кожата, па дури и психоза.

Подоцна, во осумнаесеттиот и деветнаесеттиот век, европските физичари користеле сончева светлина или вештачка светлина за лекување на туберкулоза на кожата, псоријаза, егзематознидерматози и мукозни габични инфекции, [3]
Со користење на ласерската светлина во стоматологијата може да се изведат бројни интервенции на тврдите и меките ткива во усната шуплина. Иако ласерите сè уште не успеале да ги заменат конвенционалните инструменти и техники, нивните бројни предности се причината поради која почнале да се користат почесто, [11]
Стоматолошките интервецнии кои се изведуваат со помош на ласер поседуваат бројни придобивки и за терапевтот и за пациентите. Особено значајно е дека во текот и после изведувањето на стоматолошките интервенции со помош на ласер се постигнува: намалување на постоперативните компликации, скратување на постоперативниот тек, настанува помала траума при интервенцијата и во повеќето случаи ласерските интервенции може да се употребат без користење или пак со минимална количина на анестетички раствор, [4]
Врз основа на претходно наведеното ја поставивме и основната цел на ова истражување да го опишеме настанувањето на ласерскиот зрак, стоматолошките интервенции кои може да се изведат со помош на ласерите. Посебен сегмент е насочен и кон бенефитите од употребата на ласерската светлина во денталната медицина.

2. Материјал и метод

За да се исполнат основните цели на ова истражување направено е литературно пребарување на различните бази на податоци - научни трудови, доминантно на PubMed, во претходно определен период, кој ја опфаќа последната деценија (2013-2023), се со цел да се задржи современоста на темата. Во истражувањето користени се податоци од трудови за кои се смета дека се основни иако потекнуваат од постар датум и се однесувааат само на темата која е цел на ова истражување, како и одредени трудови кои имаат за цел дообјаснување на самата тема.За исполнување на зададената цел изведен е сеопфатен литературен преглед во контекст на бараните информации и примарно се користени студии публикувани на англиски јазик.
Опфатени беа трудовите од разлини типови како: публикуван труд (Journal Article), клиничко испитување (Clinical Trial), рандомизирано контролирано испитување (Randomized Controlled Trial), прегледни трудови (Review), компаративна студија (Comparative study). За правилно насочено пребарување беа користени само соодветни клучни зборови.
Пред да започнеме со описот на најчесто изведуваните стоматолошки интервенции со помош ласер, како и на бенефитите од користењето на истите, ќе биде презентиран краток историски развој и ќе биде опишан и начинот на создавањето на ласерскиот зрак во самите уреди.
Преку исполнување на целите на овој труд сакаме да ги презенираме основните начела на употребата на ласерската светлина во денталната медицина. Тоа се должи пред сè на фактот дека ласерската технологија станува сè попопуларна во стоматологијата во последните неколку децении. Денталните ласери поседуваат мноштво на индикации кои се изведуваат во секојдневата стоматолошка пракса, кои секој стоматолог треба да ги знае, за да може да ги почувствува бенефитите од оваа ултрамодерна алатка.

2.1. Формирање на ласерски зрак

Развитокот на ласерската светлина и можностите за нејзината употреба во дијагностички и тераписки процедури во денталната медицина потекнува од базичните физички истражување на интеракцијата на светлината и материјата од почетокот на 20. век.
Во почетокот на овој дел ќе го дефинираме ласерот како уред и неговите можни примени во секојдневната медицина и стоматологијата.

Ласерот претставува уред преку кој се создава и емитира ласерска светлина низ процесот на засилување на светлината (амплификација) врз основа на стимулирана емисија на електромагнетно зрачење. Ласерот се карактеризира со фокусирана светлина насочена кон мала точка на голема далечина. Токму поради овој факт, со помош на ласерската светлина може да се изведат значително прецизни стоматолошки интервенции, [18]

Особено значајно е да се воочат разликите помеѓу обичната светлина и ласерските зраци. Имено, главната разлика помеѓу ласерската и обичната светлина е во тоа што ласерската светлина е монохроматска, кохерентна и паралелна, за разлика од повеќебојната- обична светлина, чии бранови не се синхронизирани и непаралелни, односно нејзините зраци се прекршени, [27]

Ласерскиот зрак се создава со помош на феноменот означен како стимулирана емисија. Прв услов за фотонска емисија е ласерскиот медиум да содржи енергетски нивоа чија енергија (или енергетска разлика) одговара на енергијата на емитуваните фотони. Втор услов е поголемиот број на атоми да бидат во ексцитирана состојба. Преку надворешно доведена енергија може атомите на ласерскиот медиум да се доведат во возбудена состојба подигнувајќи го енергетското ниво. Кога електроните спонтано ќе се вратат во својата нормална енергетска состојба се емитираат фотони, по пат на спонтана емисија, во разни насоки. Тие фотони понатаму може да се апсорбираат од невозбудените атоми и на тој начин настанува стимулирана емисија на преостанатите возбудени атоми, [29]

Во текот на описот на формирањето на ласерскиот зрак неминовно е да се напомене и терминот популациска инверзија на атомите во ласерскиот медиium состојба во која бројот на атомите во возбудена состојба мора да биде поголем од бројот на атоми во нормалната, основна состоба. Инверзната населеност се постигнува со доведување на средината во една термодинамичка нерамнотежа со помош на некој надворешен причинител поради што поголем број од атомите од основна состојба преминуваат во возбудена, [5]

Она што е исто така значајно е дека за да настане стимулирана емисија во активната средина, доволен е само еден надворешен фотон да навлезе во неа. Тој ќе индуцира создавање на уште еден фотон. Понатаму, двата заедно, ќе индуцираат уште четири такви и на таков начин процесот брзо ќе се прошири низ средината. Бројот на апсорбираните фотони ќе зависи од бројот на атомите во основното ниво, а бројот на емитуваните фотони по пат на спонтана и стимулирана емисија од бројот на атомите во повисокото енергетско ниво. На тој начин при излегување на зраците од таквата средина интензитетот ќе биде засилен, [20]

2.2. Употреба на ласерската технологија во денталната медицина

Напредокот во дизајнот и инженерството на денталните ласери се зголеми експоненцијално во последните неколку децении. Сепак, ласерската светлина не се користи само во стоматологијата. Се користи и во многу други гранки како во индустријата за прецизно сечење, оптички инструменти, ласерски печатачи, баркодови, ласерска хирургија, телекомуникации, мерење на лунарното растојание итн, [8]

Денес сите достапни стоматолошки ласери се во рамките на брановите должини од 500 nm до 10,600 nm, односно може да се најдат во видливиот или во невидливиот дел од електромагнетниот спектар. Во суштина денталните ласери емитуваат зраци со бранова должина која се наоѓа во нејонизирачкиот спектар. Дентални ласерски инструменти кои емитуваат ласерсски зраци во рамките на видливата светлина се: аргон ласерите со бранова должина од 488 nm и 514 nm (денеска веќе не се произведуваат), Nd:YAG ласерите со бранова должина од 532 nm, ниско енергетските ласери за фотобиомодулација со бранова должина од 635 nm и ласерите за кариес детекција со бранова должина од 655 nm. Преостанатите дентални ласери емитуваат невидлива

ласерска светлина и тоа од блискиот, средниот и далечниот дел од инфрацрвениот електромагнетен спектар, [27]

Бројни се индикациите за употребата на денталните ласери во секојдневата стоматолошка пракса, кој лесно може да се групираат во следниве постапки:

- третман на пародонталните заболувања. Значајно е дека ласерите може да се користат за отстранување на инфламираното гингивално и пародонтално ткиво и за промовирање на растот на здравото ткиво, [7,22]
- отстранување на каризоните лезии. Ласерите може да се користат за отстранување на кариесот на забите, без употреба од анестезија, [12,26]
- белење на заби. Па така во секојдневната стоматолошка пракса ласерите може да се користат за активирање на средствата за белење и подобрување на ефикасноста на третманите за белење на забите, [2]
- за изведување на биопсија. Ласерите може да се користат за отстранување на мали примероци од ткиво за биопсија, што е особено значајно поради исклучително минорната траума на околните ткива, [13]
- процедури на меките орални ткива. Ласерите може да се користат за преобликување или отстранување на ткивото на гингивата за да се подобри изгледот на насмевката, [25]
- третман на пулпините и периапикалните промени. Ласерите поради нивниот антисептичен ефект вршат неутрализација на бактериите со што нивниот квантум се намалува, [9]
- третман на фиксиран френулум на јазикот или усните, [25]
- Третман на афтозни и херпетични лезии. [13]

Минималната инвазивност во текот на ласерскиот третман на кариозните лезии се базира на фактот - колку поголема содржина на вода има во ткивото, толку полесно ласерите ќе го отстранат кариес-распаднатото ткиво. Затоа, многу заболеното забно ткиво (со зголемен квантум на вода) ќе се отстранува многу полесно и со помалку енергија-од помалку кариозно распаднатите ткива. Стапката на аблација на забните тврди ткива е во корелација со количината на ласерски енергија доставена до ткивото, ефектите на бранова должина, пулсното времетраење , обликот на пулсот, стапката на повторување, густина на моќноста, термичкото релаксационо времето на ткивото и начинот на испорака. Ласерската препарација на кариозните кавитети се базира на „минималистички" пристап при што се врши отстранување само на заболеното ткиво и и при тоа се употребуваат композитно-смолести реставративни материјали.

При ласерското белење се „активираат" елементите на средствата за белење со користење на многу ефикасен извор на светлосна енергија - ласер. Со употребата на ласерот, однсоно преку фотоните, на специфична бранова должина која е приближна на спектарот на апсорпција на избелувачкото средство, наместо користење на извор на светлина кој емитува повеќе бранови должини, хемиската реакција се изведува побрзо, а со тоа се редуцира времето на изложеност на средството за белење. Со тоа можноста за компликации значително се минимизира.

Со помош ласерите може да се обезбеди безбедна, ефикасна нехемиска алтернатива во текот на изведувањето на ендодонтскиот третман. Оттука може да се каже дека ласерите се ефикасна алтернатива за лекување на пулпата, со дополнителен бенефит во обезбедување на адекватна пулпина терапија, без косристење на хемикалии, [14]

Со помош на стоматолошките ласери може да се изведе и третман на афтозните лезии и на херпес лабиалис. Третман на овие лезии обично се изведува со ласери со ниска енергија со дефокусиран зрак. Целта е да не се оштети ткивото, но при тоа да се делува на епителот околу лезијата. Исто така кога херпетиформните лезиите се третираат при иницијалните знаци на инфекција, лезиите лесно може да се отстранат. При третманот потребно е третираната област да ја вклучува целата лезија, како и најмалку 3-5 мм странично од еритематозниот ореол кој ја означува границата на оваа лезија, [17]

Во современата стоматологија, употребата на денталните ласери е од особена корист во подобрувањето на третманот, како во хируршката, така и во постхируршката и протетската фаза во денталната имплантологија. Паралелно со зголемување на застапеноста на денталните импланти како тераписка опција, се подобруваат и перформансите на денталните ласери. Ласерите понатаму можат да бидат особено корисни во справувањето со различните компликации од имплантната терапија и во третман на воспалително периимплантно ткиво. Различните бранови должини на ласерите кои ни се на располагање, имаат уникатни карактеристики кои го олеснуваат пристапот на стоматологот до имплантите, како и удобноста на пациентите. Денталните ласери им овозможува на клиничарите подобра визуелизација на хируршкото поле со намалување на крварењето и намалување на времетраењето на дадената процедура. Со создавање стерилни услови со помош на денталните ласери, за време и по изведувањето на хируршката интервенција, значително се намалуваат можните компликации и инфекции, [15,16]

2.3. Бенефити од користењето на денталните ласери

Многубројните предности од користењето на ласерската светлина тешко можат да се игнорираат, како што се прецизноста, леснотијата на користење и поголем успех во терапијата од конвенционалните терапевтски процедури во современата стоматологија. Сепак, целосното познавање на оваа терапевтска алатка е императив за да се избегнат несаканите ефекти и да се добијат сите посакувани бенефити во текот на работата.
Она што е од иклучително значење е дека со помош на ласерските зраци настанува лесно отстранување на патолошки променетото ткиво без крварење, оток или постоперативна болка е огромна предност за стоматологот и за пациентот.
Ласерите се одлично решение за проблемот со контаминација на хируршкото поле. Тоа се должи на фактот дека сите ласери се бактерицидни. Стоматологот треба да го изложи хируршкото поле, неколку секунди на ласерската енергија, а при тоа бактерицидните ефекти се длабоки и речиси моментални, и со тоа хируршкото поле се стерилизира. Пред остеотомијата, мекото ткиво може да се стерилизира многу поефикасно со ласер отколку преку класичните методи со плакнење на устата со помош на антисептични средства. Брановите должинини на ербиум и неодимиом ласерите може да постигнат деконтаминација пред се поради тоа што ласерскиот зрак физички го озрачува секој квадратен милиметар од работната површина, [1]
Мора да се напомене дека ербиумовата група на ласери не се толку ефикасни како другите бранови должини во обезбедувањето хемостаза. Но тоа претставува и значителен бенефит при користењето на овој ласер бидејќи овозможува површинско крварење на коскените структури, со што се подобрува коскеното заздравување, без разлика дали е вметнат имплант или графтинг материјал, или едноставно алвеолаата се остава да се наполни со коагулум и да започне да се случува заздравување на раната, [2]
При работата во меки ткива особено значајна е адаптацијата кон дебелината на ткивата. Акоткивото е релативно тенко (1-2 mm), секоја бранова должина е прифатлива за работа. Ако ткивото е подебело, користењето на диодни или Nd: YAG ласерите може да потрае неколку минути наспроти неколку секунди со при употребата на ербиумовите и CO_2 ласерите. Со брзо и ефикасно сечење низ ткивото и создавање оптимална видливост за хирургот, времетраењето на процедурата може успешно да се намали во споредба со конвенционалните техники, [28]
Оттука може да се забележи дека употребата на ласерската светлина при изведувањето на стоматолошките интервении има бројни предности. Примарно, со помош на ласерите се изведува стерилна инцизија со минимална веројатност да биде инфицирана. Ласерот го сече ткивото без да предизвика каскада на настани што доведуваат до едем и воспаление. Бидејќи ласерите декулаваат и на лимфните садцо, односно вршат нивно

запечатување постои клинички мерливо намалување на болката, отокот и другите постоперативни компликации, [21]
При употребата на ласерите, потребни се послаби аналгетични средства и антибиотици (кои ќе доведат до помалку интеракции и компликации) бидејќи пациентите доживуваат значително помалку трауматски постоперативен тек. Ова се однесува и на минорни но и на големи орално-хируршки процедури.
Друга предност на ласерите е нивната употреба кај пациенти на антикоагулантна терапија со употреба на лекови како што се аспирин и антикоагуланси. Некои пациенти користат и хербални лекови кои можат значително да го променат времето на коагулација. Но сепак доколку постои и минимална дилема во однос на можноста за пролонгирани крварење кај пациентот, треба да се направат соодветни лабораториски анализи. Ласерите имаат одлични хемостатички својства што доведуваат до намалено крварење, такашто контролирањето на интраоперативното крварење не е проблем, [6,10]
Од се претходно наведено, може да се забележи дека бројни се бенефитите од третманот со ласери на меките и тврдите ткива. Па така при интервенциите на меките ткива постои:

- Можност за сечење, коагулација, аблација и вапоризација на елементите од целните ткива;
- Коагулација на малите крвни садови (што овозможува суво работно поле во хируршки интервенции);
- Коагулација на мали лимфатични садови (што води до редуцирање на пост-оперативен едем);
- Стерилизација на ткивата (поради топлината настанува деструкција на бактериските мембрани);
- Намалување на појавата на постоперативни лузни. [19]

Исто така бројни се и бенефитите од употребата на ласерската светлина на тврдите ткива кои учествуваат во градбата на стоматогнатниот систем и тоа постои:

- Можност за селективна аблација на кариозно променетото ткиво (побрза аблација настанува при поголемо присуство на вода во кариозно променетите забни ткива);
- Редуцирани периоперативни напукнувања на забни супстанции во компарација со ротирачки инструменти;
- Можност за минимално инвазивни интервенции кај почетни кариозни лезии;
- Редуцирање на термичко оштетување на пулпата;
- Стерилизација на кавитетите. [23,24]

3. Заклучок

Денталните ласери, како една современа алатка, поседуваат бројни индикации во секојдневната стоматолошка пракса. Исто така, бројните предности што ги поседува ласерот како алатка треба да бидат причина за неговата се поголема употреба при иведувањето на различни видови стоматолошки интервенции. Сепак, употреба на ласери е сведена на мал број интервенции што е поврзано со знаењето и рутината на клиничарот. Со воведување современи образовни програми, како и дополнителна едукација оваа состојба може да се подобри.

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ANALYSIS OF DEVELOPING NATIVE ANDROID APPLICATIONS USING XML AND JETPACK COMPOSE

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Abstract

Native mobile applications have been the first choice for companies and independent developers to build software that utilizes device hardware and functionality. For Android development, this means using Java/Kotlin for the program logic and XML files for the user interfaces. Recently, Jetpack Compose has gained significant attention in building user interfaces for Android applications. This paper aims to analyze the benefits and limitations of these two technologies. An intensive literature review is conducted and presented to identify the benefits and limitations of XML and Jetpack Compose. In order to compare their development processes and code complexity, we also developed the same application using both technologies. Analysis of the code used in each technology provides an insight into how they uniquely solve the same problem, helping us to identify which one is better suited from a developer's perspective. The results of the study indicate that both XML and Jetpack Compose have their respective strengths and weaknesses. XML provides a structured approach to UI development, fully respecting the separation of concerns between the view (what is being displayed on the screen) and the controller (which data is being sent to the view). On the other hand, Jetpack Compose simplifies the UI development process by offering a declarative approach, which leads to more readable and maintainable code. This study identified the advantages and disadvantages of using XML and Jetpack Compose in the development of native Android applications and recommended criteria for choosing one of these tools for new users, as well as switching to a new tool for experienced users.

Key words

Android, Compose, XML, comparison, analysis, code

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ENSURING INFORMATION SECURITY IN THE DIGITAL AGE

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Abstract

In the digital age, information security has become increasingly important as the amount of sensitive data being stored and transmitted electronically continues to grow. Information security refers to the practice of protecting information from unauthorized access, use, disclosure, disruption, modification, or destruction. Ensuring information security in the digital age involves implementing a variety of security measures to ensure the confidentiality, integrity, and availability of information. One important aspect of information security is the protection of sensitive information, such as personal information, financial data, and trade secrets. This can be achieved through the use of encryption, secure communication protocols, and access controls. Additionally, network security is crucial in protecting information systems and networks from cyber-attacks. This can be done through the use of firewalls, intrusion detection and prevention systems, and regular security audits. Another element of information security is incident response and management, including planning for and responding to security breaches. This can involve activating incident response teams, conducting forensic investigations, and implementing recovery plans to restore normal operations. A comprehensive information security program also includes employee education and awareness, security policy, and compliance with relevant regulations and standards such as PCI-DSS, HIPAA, and ISO 27001. Overall, information security is a constantly evolving field as new technologies and attack methods are developed. It requires ongoing monitoring, testing, and updating of security measures to ensure the ongoing protection of information in the digital age.

Key words

Digital age, information security, protection of sensitive information, network security and cyber-attacks.

Introduction

In today's digital age, information security has become a critical concern for individuals, businesses, and governments. With the increasing amount of sensitive data being stored and transmitted electronically, the potential for unauthorized access, use, disclosure, disruption, modification, or destruction of this information has grown. As a result, ensuring information security has become a top priority for organizations of all sizes and industries. Information security, also known as cybersecurity or IT security, involves the implementation of a variety of security measures to protect information from cyber threats. These threats can include hacking, malware, phishing, and other forms of cyber-attacks. In addition to protecting sensitive information, information security also aims to ensure the availability and integrity of information systems and networks.

One important aspect of information security is the protection of sensitive information, such as personal information, financial data, and trade secrets. This can be achieved through the use of encryption, secure communication protocols, and access controls. Additionally, network security is crucial in protecting information systems and networks from cyber-attacks. This can be done through the use of firewalls, intrusion detection and prevention systems, and regular security audits.

Another element of information security is incident response and management, including planning for and responding to security breaches. This can involve activating incident response

teams, conducting forensic investigations, and implementing recovery plans to restore normal operations. A comprehensive information security program also includes employee education and awareness, security policy, and compliance with relevant regulations and standards such as PCI-DSS, HIPAA, and ISO 27001. Information security is a constantly evolving field, with new technologies and attack methods being developed all the time. This means that organizations must stay vigilant and keep their security measures up to date in order to effectively protect their information. In addition, organizations must also be prepared for the possibility of a security breach and have incident response plans in place to minimize the impact of any security incident.

The rise of cloud computing, Internet of Things (IoT), and mobile devices has also led to new security challenges. The use of cloud computing services and mobile devices has increased the amount of data stored and transmitted over the internet. This has led to an increase in the number of potential entry points for cyber attackers. Furthermore, the growing number of IoT devices connected to the internet has created new opportunities for cyber attackers to gain access to sensitive information. To ensure information security in the digital age, organizations must adopt a proactive approach. This includes regular risk assessments, penetration testing, and security audits to identify vulnerabilities and potential threats. Additionally, organizations should invest in advanced security technologies such as artificial intelligence (AI) and machine learning (ML) to help detect and respond to cyber threats in real-time [1 – 6].

1. Related Work

Information security is a complex and multifaceted field that has been the subject of much research in recent years. A variety of approaches and techniques have been proposed to ensure the confidentiality, integrity, and availability of information in the digital age. This section will provide an overview of some of the most relevant research in the field of information security, focusing on areas such as encryption, network security, incident response, and compliance.

Encryption is a widely used technique for protecting sensitive information from unauthorized access. A number of encryption algorithms have been proposed and studied, including the Advanced Encryption Standard (AES) and the Rivest-Shamir-Adleman (RSA) algorithm. Research in this area has focused on the development of more secure and efficient encryption algorithms, as well as the study of potential weaknesses in existing algorithms [1 – 3].

Network security is another important aspect of information security. Firewalls, intrusion detection and prevention systems, and virtual private networks (VPNs) are commonly used to protect networks from cyber-attacks. Research in this area has focused on the development of more advanced security technologies, such as intrusion detection systems that use artificial intelligence (AI) and machine learning (ML), as well as the study of new types of cyber-attacks and vulnerabilities.

Incident response and management is also an important aspect of information security. This includes planning for and responding to security breaches, as well as conducting forensic investigations and implementing recovery plans. Research in this area has focused on the development of incident response frameworks, as well as the study of best practices for incident response and management.

Compliance with regulations and standards is also an important aspect of information security. The Payment Card Industry Data Security Standard (PCI-DSS), the Health Insurance Portability and Accountability Act (HIPAA), and the International Organization for Standardization (ISO) 27001 standard are examples of regulations and standards that organizations must comply with to ensure information security. Research in this area has focused on the development of compliance frameworks, as well as the study of best practices for compliance [4 – 6].

The research in information security also covers the security of cloud computing, Internet of Things (IoT), and mobile devices, which has become increasingly important in recent years. The use of cloud computing services and mobile devices has increased the amount of data stored and transmitted over the internet. This has led to an increase in the number of potential entry points for cyber attackers. Furthermore, the growing number of IoT devices connected to the internet has created new opportunities for cyber attackers to gain access to sensitive information.

To ensure information security in the digital age, organizations must adopt a proactive approach. This includes regular risk assessments, penetration testing, and security audits to identify vulnerabilities and potential threats. Additionally, organizations should invest in advanced security technologies such as AI and ML to help detect and respond to cyber threats in real-time [1 – 6].

1.1. Challenges and opportunities

Ensuring information security in the digital age is a complex and challenging task, as new technologies and attack methods are constantly emerging. This section will discuss some of the challenges and opportunities that organizations face in ensuring information security in the digital age. One of the major challenges of information security is the ever-increasing number of cyber threats. The rise of the internet and the proliferation of connected devices have led to an increase in the number of potential entry points for cyber attackers. Additionally, cybercriminals are becoming increasingly sophisticated, using advanced tactics such as social engineering and malware to gain access to sensitive information. This makes it difficult for organizations to keep pace with the changing threat landscape and protect themselves from cyber threats [1 – 6].

Another challenge is the lack of security expertise. As the field of information security continues to evolve, organizations may struggle to find and retain security professionals with the necessary skills and knowledge. This can make it difficult for organizations to implement effective security measures and stay up to date with the latest threats and technologies.

The rise of cloud computing and mobile devices has also presented new security challenges. The use of cloud computing services and mobile devices has increased the amount of data stored and transmitted over the internet. This has led to an increase in the number of potential entry points for cyber attackers. Furthermore, the growing number of Internet of Things (IoT) devices connected to the internet has created new opportunities for cyber attackers to gain access to sensitive information.

However, despite these challenges, there are also many opportunities for organizations to improve their information security in the digital age. One opportunity is the use of advanced security technologies such as artificial intelligence (AI) and machine learning (ML). These technologies can help organizations detect and respond to cyber threats in real-time and can also be used to automate security tasks such as incident response and compliance.

Another opportunity is the development of new security standards and regulations. Organizations can use these standards and regulations as a guide to improve their security practices and ensure compliance. For example, the Payment Card Industry Data Security Standard (PCI-DSS), the Health Insurance Portability and Accountability Act (HIPAA), and the International Organization for Standardization (ISO) 27001 standard are examples of regulations and standards that organizations must comply with to ensure information security.

Additionally, organizations can also improve their security by implementing incident response and management plans. This includes planning for and responding to security breaches, as well as conducting forensic investigations and implementing recovery plans. By having incident response plans in place, organizations can minimize the impact of a security incident and return to normal operations more quickly [1 – 6].

1.2. The future of Information Security

Information security is an ever-evolving field, with new technologies and attack methods constantly emerging. As such, it is important for organizations to stay informed about the future of information security in order to effectively protect themselves from cyber threats. This section will discuss some of the key trends and developments that are likely to shape the future of information security. One trend that is expected to continue in the future is the increasing use of artificial intelligence (AI) and machine learning (ML) in information security. These technologies can help organizations detect and respond to cyber threats in real-time and can also be used to automate security tasks such as incident response and compliance. Additionally, AI and ML can also be used to analyze large amounts of data to identify patterns and anomalies that may indicate a cyber-attack [1 – 6].

Another trend that is expected to continue in the future is the increasing use of cloud computing and edge computing. Cloud computing can provide organizations with a cost-effective and scalable way to store and process data. However, this has led to an increase in the number of potential entry points for cyber attackers. Edge computing, on the other hand, brings computing power closer to the data source to reduce network traffic and improve response times.

The Internet of Things (IoT) is also expected to play an increasingly important role in the future of information security. As more and more devices become connected to the internet, the number of potential entry points for cyber attackers will continue to grow. As such, it is important for organizations to ensure that their IoT devices are secure and to implement security measures to protect them from cyber threats. Another trend that is expected to shape the future of information security is the increasing importance of compliance. Organizations must comply with a variety of regulations and standards to ensure information security, such as the Payment Card Industry Data Security Standard (PCI-DSS), the Health Insurance Portability and Accountability Act (HIPAA), and the International Organization for Standardization (ISO) 27001 standard. As such, organizations will need to keep up to date with the latest regulations and standards to ensure compliance [1 – 4].

Finally, the future of information security will be shaped by the increasing importance of user education and awareness. As cyber threats become more sophisticated, it is important for users to understand how to identify and respond to these threats. Organizations will need to invest in user education and awareness programs to ensure that their employees are well-informed about the latest cyber threats and how to protect themselves [1 – 6].

Conclusions

In conclusion, ensuring information security in the digital age is a complex and challenging task that requires a holistic approach. Organizations must prioritize the protection of sensitive information, while also ensuring the availability and integrity of information systems and networks. Additionally, they must stay up to date with the latest technologies and attack

methods and be prepared for the possibility of a security breach. One of the key aspects of information security is the protection of sensitive information, such as personal information, financial data, and trade secrets. This can be achieved through the use of encryption, secure communication protocols, and access controls. Additionally, network security is crucial in protecting information systems and networks from cyber-attacks. This can be done through the use of firewalls, intrusion detection and prevention systems, and regular security audits.

Another important aspect of information security is incident response and management, including planning for and responding to security breaches. This can involve activating incident response teams, conducting forensic investigations, and implementing recovery plans to restore normal operations. A comprehensive information security program also includes employee education and awareness, security policy, and compliance with relevant regulations and standards such as PCI-DSS, HIPAA, and ISO 27001.

The rise of cloud computing, Internet of Things (IoT), and mobile devices has also led to new security challenges. The use of cloud computing services and mobile devices has increased the amount of data stored and transmitted over the internet. This has led to an increase in the number of potential entry points for cyber attackers. Furthermore, the growing number of IoT devices connected to the internet has created new opportunities for cyber attackers to gain access to sensitive information. To ensure information security in the digital age, organizations must adopt a proactive approach. This includes regular risk assessments, penetration testing, and security audits to identify vulnerabilities and potential threats. Additionally, organizations should invest in advanced security technologies such as artificial intelligence (AI) and machine learning (ML) to help detect and respond to cyber threats in real-time.

In the future, organizations should expect the increasing use of AI and ML in information security, cloud computing, IoT and mobile devices to present new security challenges, compliance to be a major concern and user education and awareness to be a key aspect of ensuring information security.

Overall, ensuring information security in the digital age is a continuous effort that requires ongoing monitoring, testing, and updating of security measures to ensure the ongoing protection of information. By staying informed and taking a proactive approach, organizations can better protect themselves against cyber threats and ensure the security of their information in the digital age.

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CLOUD COMPUTING AND VIRTUALIZATION: CAN CLOUD COMPUTING EXIST SEPARATELY FROM VIRTUALIZATION?

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Abstract

Virtualization is a software technique that emulates the operation of the entire computer. Depending on the needs and the powers of the physical computer, several virtual machines can be installed at the same time. The resources of physical computers will be shared between all virtual machines and because of that, virtual machines will be working slower. A virtual machine uses a combination of software and an existing computer to provide additional computer machines, all in one physical device. Cloud computing involves delivering hosted services and cloud applications over the internet and enables users to obtain a shared pool of data from remote physical servers, databases, and computers. Although virtualization and cloud computing are seen as two different techniques, they are interconnected and cannot exist without each other. Virtualization in cloud computing can prevent the IT system from failing and can protect the IT environment from bugs and viruses. In IT infrastructure, cloud computing and virtualization are used together to build a cloud infrastructure. The aim of this study is to define and analyze what virtualization and cloud computing are. Then through a comparison to show how these techniques are related to each other and consequently a conclusion will be drawn.

Key words

software technique, services, IT infrastructure

Introduction

Virtualization can be defined as a software technique that emulates the operation of the entire computer. Depending on the needs and the powers of the physical computer, several virtual machines can be installed at the same time on one computer. A virtual machine uses a combination of software and an existing computer to provide additional computer machines, all in one physical device. Like any other program, programs for creating virtual machines need to be installed and then configured. The installation and configuration of this programs are a simple procedure, consisting of number of steps that need to be performed for the virtual machine to be properly used. Once the program has been installed on the hard drive and configuration has been performed, we can start creating virtual layers and installing operating systems. With this, we can work using more than one operating system on a single computer.
On the other hand, Cloud computing in these days is one of the most used technologies because of the major issues such as reducing costs, and its scalability and flexibility in computer services. Cloud computing allows using different pool of resources anywhere and anytime via Internet. It generally provides on demand IT services and products. This technology allows consumers and businesses to use applications without installation and access their personal files

at any computer only with using of internet access. Cloud computing also allows much more efficient computing by centralizing storage, memory, processing, and bandwidth [11]-[17].

1. Virtualization

Virtualization is a technology that combines hardware and software. It allows the same computer to run several different operating systems that share common resources. In this way, the system is divided into several separate virtual entities that act as independent computer systems. More precisely, virtualization is the possibility of using multiple operating systems on the same physical computer. There are existing various kind of virtualization: OS virtualization (Xen, VMware), storage virtualization (NAS, SAN), database virtualization and software virtualization (Apache Tomcat, Oracle App Server ...) [11].

Fig. 1 Architecture with virtualization

A virtual machine is a computing resource that uses software instead of a physical computer to run programs and deploy applications. Basically, it is a virtual environment in which we can install an operating system that can be used on the main operating system that is on the computer. These environments manage to mimic the hardware that the computer has, so that it behaves as if we are on a completely different computer with a different operating system installed. The main feature is that there are two users of the computer, namely:

- Host machine - the machine that represents the physical equipment and the main operating system.
- Guest machine - our installed virtual machine, running an operating system that corresponds to it.

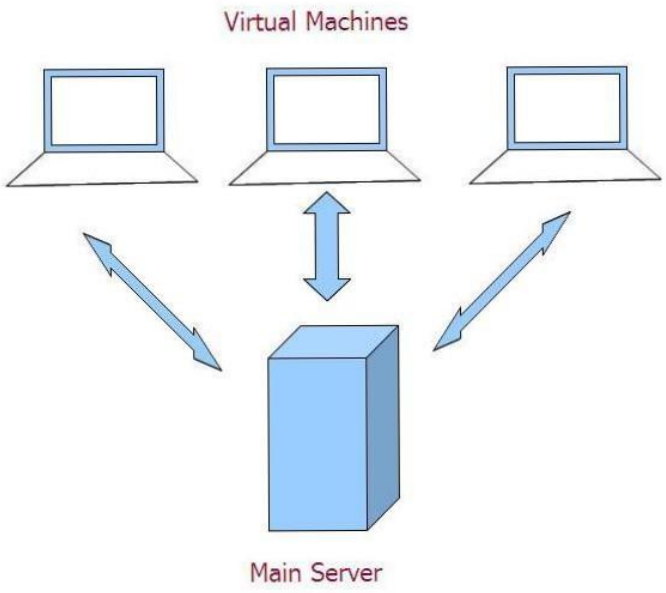

Fig. 2 Virtual environment

There are two different types of virtual machines, each with different functions:

- System virtual machines or also known as full virtualization virtual machines. They provide a replacement for a real machine. This virtual machine makes it possible to represent the physics between several virtual machines, using software called a hypervisor. A hypervisor allows multiple environments to be isolated from each other but still exist on the same physical machine. Modern hypervisors use virtualization-specific hardware, primarily from the host processor.
- Virtual machines processes designed to run computer programs in a platform-independent environment [1]-[10].

Advantages of virtual machines

- We have different operating systems that can exist simultaneously on the same machine, separated from each other.
- A virtual machine has a simpler instruction architecture than a real computer.
- It can be portable, as it can be used on any computer in a secure way.
- At the business level, they cause economic savings and space savings.
- Since there is no physical hardware, there is no need to worry about the damage that can be caused when installing a program.
- Different types of applications can be tried and if they are not right, we can just delete them.

Disadvantages of virtual machines

- Virtual machines are slower.
- They can consume a lot of resources.
- When there is a need to access the hardware, it is not very efficient.
- When multiple virtual machines are running at the same time, unstable performance occurs, depending on the scale of the system [1]-[10].

2. Cloud computing

Cloud computing helps to reduce IT costs, to improve agility and time to value and to scale more easily and economically [14, 17]. Cloud computing is some kind of Internet-based computing where application, storage and servers are given via internet connection. Cloud based services are ideal for companies that involve continuous network connectivity and bandwidth. Cloud Computing consists of several services: Infrastructure as a Service (IaaS), Software as a Service (SaaS) and Platform as a Service (PaaS) [17].

- SaaS: Users can get and use software with less money than buying and installing it. It offers web reliability and security using SSL (secure socket layer).
- IaaS: Infrastructure can be scaled up or down based on the requirement. Virtualization as service allows clients to run the virtual machines. Network as a service includes hardware for firewalls, routers, and load balancing.
- PaaS: Provides greater flexibility, speed and agility to the development process and it reduces server storage costs [13].

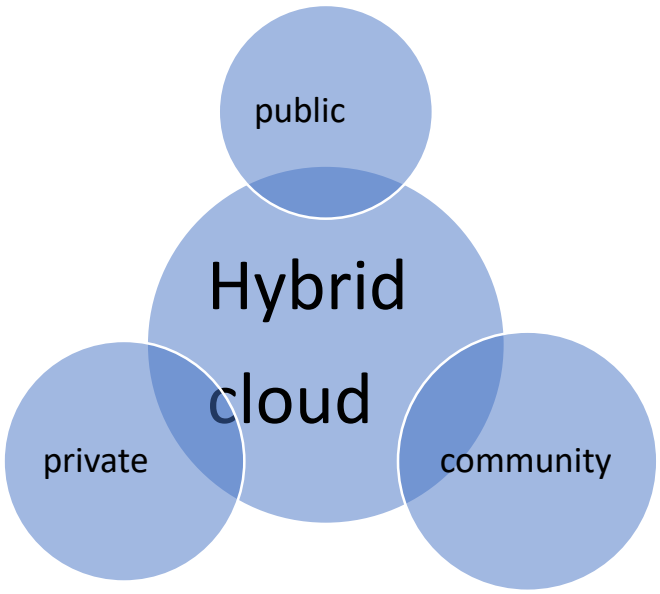

Fig. 3 Deployment models of Cloud computing

It represents an association of several terms like Application Service Provider, Grid Computing, Server Hosting, Virtualization and Utility Computing [13, 17].
There are four deployment models of Cloud computing: public cloud, private cloud, community cloud and hybrid cloud.

- Private cloud is aimed for businesses and used by single organization.
- Public cloud is aimed for software development and projects.
- Hybrid cloud is combination of two clouds (private, public or community) and is aimed for big businesses.
- Community cloud is collaborative platform used by more organizations for sharing same applications.

Cloud computing services first were offered by Amazon, Google, Microsoft, but now exist many more. These services are used in many areas like software industries, government sectors, health care sectors...
Architecture of cloud computing from the point of virtualization is given in Fig.4 [11].

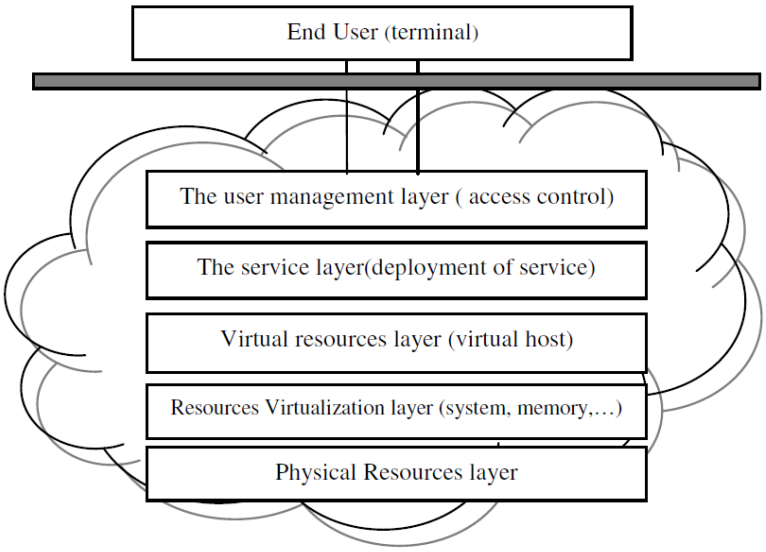

Fig. 4 Architecture of cloud computing

According to the paper [11] end users get service anywhere and anytime through terminal using computer or mobile phone.

- The user management layer is the relationship between user and cloud, and the user access "clouds" through it.
- The service layer converts the cloud resources into the services (such as storage, software as a service, platform, and services) which look after the end users.
- Virtual resources layer combines and handles virtualized resources.
- The second last layer handles the virtualization of all kinds of computing resources and ensures that users do not have to deal with problems such as the actual physical location of the machine, maintenance, and so on.
- The last layer is the base of the entire platform for cloud computing, storage of real physical resources.

3. Virtualization in cloud computing

Virtualization in Cloud Computing creates a virtual framework of the server operating system and storage devices. This will allow the same resource to be shared among multiple users at the same time. Cloud virtualizations reduce computational work and deliver a virtual environment in the cloud that can be software hardware or any other thing [17].
Main gains of virtualization in cloud are:

- Security (security is by means of firewalls that help keep data private. It can also virtualize the entire data store and can back up a server where the data can be stored),
- Flexible operations (technical errors can be resolved in physical systems. It eliminates the problem of recovering data from crashed or destroyed devices and thus saves time),
- Economical (saving money on physical systems, data is stored on a virtual server which is a much cheaper investment and reduces electricity and maintenance costs),
- Eliminates the risk of system failure (the system can stop working at any time and thus cause a disaster to the business. Therefore, data stored in the cloud can be retrieved at any time with any device),
- Flexible transfers of data (the data is located on a virtual server and no time is wasted to find it because it is easily accessible),
- Utilization of hardware efficiently (Cloud vendors deliver physical services without deploying any physical hardware system),
- Availability increases with Virtualization (Data migration from one server to another is safe. Also, we can access data from any location and at any time from any device),

- Disaster Recovery is efficient and easy (there is real time data recovery, backup of data and duplicate, data damage is impossible),
- Virtualization saves Energy,
- Quick and easy setup,
- Cloud Migration becomes easy [17].

Virtualization is the key component of cloud computing. With the introduction of virtualization, cloud computing enables users to not have to worry about the maintenance of the physical host, the problem of management and optimization [11]. With the use of virtualization, cloud computing brings not only benefits of convenience and efficiency, but also great challenges in data security and privacy protection. Virtualization is important in cloud computing because it abstracts compute resources and enables rapid scaling of resources [18].

Conclusions

Virtualization of computer systems is an old idea in a new edition. With the advancement of computer technology and the development of hardware-assisted virtualization technology, as well as the increase in power of today's computers, virtualization has taken a new dimension. It destroys the "one computer - one operating system" concept. As we have seen so far, a virtual machine is a computer within a computer.

Virtual machine can be used for everyday use even by people who do not have extensive knowledge of information services. But, of course, they also have a huge impact on IT companies, so they improve their IT efficiencies. Many IT departments spend more than half of their time managing routine administrative tasks, but with the help of virtualization, it is possible to split a single physical server into several virtual machines. So, administrators can manage multiple operating systems at once from a single physical server. They are independent of each other, making them hardware independent. So, when we need to use multiple applications and operating systems at the same time, the only thing to do is to properly install and configure the virtual machine and then work with it flawlessly for a long time.

Cloud computing helps to get over the problems of losing data, accessing data whenever needed and data security. This technology is mainly service oriented and focuses on cost reduction, hardware reduction and only service pay.

Virtualization in cloud computing is creating a virtual image of the storage devices (servers or network resources) so that they can be used on multiple machines at the same time [14]. Virtualization makes cloud computing environment easier to manage the resources.

With the many advantages and possibilities provided by these two technologies, we can say that these technologies will continue to reorganize and modify many fields of human venture for years to come [15].

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THE IMPACT OF ONLINE TEACHING ON THE DENTAL STUDENTS' EXAM SUCCESS

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Abstract

COVID-19 epidemic has changed a number of aspects in various life activities. The epidemic had the greatest impact on the education process itself. Pupils and students from classical teaching in their classrooms and lecture halls have switched to online teaching. At the same time, a significant effort was made by the teaching staff to adapt to the newly created situation. Aiming to assess the impact/influence of the online teaching on the success of students, we set the main goal of this research to make a comparative analysis of students' grades in the same courses in the period before the epidemic and during the implementation of online teaching.
In order to fulfil the purpose of our research, an analysis was made of the grades for three courses of the study program in dental medicine - preclinical periodontology, periodontology 1 and periodontology 2 in the academic year 2018/2019 when the teaching was carried out with physical presence, 2019/2020 when the teaching it was entirely online and for 2020/2021 when a hybrid type of teaching was conducted. The pass rate of the exams and the average grades for the three most important exam sessions - June, September and February are presented.
The results that we obtained within the research showed that there is significant change in terms of the pass rate of the students, as well as the average grade regarding the three courses. The pass rate has shown significant decrease, while the average grade regarding the courses increased during those years. This is solid ground for comparisons to be made with other courses, modules, faculties, even universities, towards locating the reasons for this reality. One possible and very reliable reason can be found in the fact that the change of the teaching type from classic to online and than hybrid is big and fast change for the students, that led to decrease of the pass rate, but most probably the students who passed the exam mastered the material better.

Key words

Epidemic, students, Covid-19

Introduction

The COVID-19 epidemic has changed a number of aspects in various life activities. The epidemic had the greatest impact on the education process itself. Pupils and students from classical teaching in their classrooms and lecture halls have switched to online teaching. at the same time, there was a significant effort by the teaching staff to adapt to the newly created situation.

Millions of college students from all around the world were forced into virtual learning due to the pandemic in 2020. One year later, many colleges in our country, as well as in Europe and United States of America were ready to welcome back students as the new academic year begins, but there was still a lot of uncertainty about having the old good close communication within the classrooms. This has led (at least, until now) to a declineof the classical teaching and surely, for many institutions like our university, will undoubtedly be solid ground to continue offering hybrid and/or online classes and teaching methods in general. Simultaneously, low immunization rates, new Covid variations, and travel limitations will also affect the shape of education in future.

It must be stated that in the United States, students' colleges experiences increasingly rely on online courses. Even before the Covid-19 pandemic forced faculties to switch to distance learning urgently, many students were taking classes online. For instance, in 2016, more than 30% of all undergraduate students took online courses.[15]
The availability of the basic literature for learning the material and further, passing the exams is of great importance in the success of passing the various exams. Two of the teaching courses (preclinical periodontology and periodontology 1) that are taken in this research have corresponding textbooks that are published on the electronic library of the university, while for the third course - periodontology 2, students receive appropriate text from different authors. Also, for the course of preclinical periodontology there is an appropriate practicum for the practical exercises.
What needs to be emphasized is that although there are separate e-courses created for all the three courses within tne university's e-learning platform where all the materials are to be attached and available for the enrolled students, there is no presentation is attached within the e-courses. Those e-courses were the place where e-colloquiums were conducted. However, it must be noted that during the periods when there was online learning, students could download presentations that were uploaded to Microsoft Teams. This was (and still is) one of the most popular and used e-tools within the teaching process.
In accordance with the rules for studying on the first cycle of University Goce Delcev,[18] several elements are important to be considered within the continuous assessment of the student during the semester. The presence and/or activity on the theoretical teaching is valued up to ten points, the presence and/or activity on the practical exercises is valued also with 10 points maximmum, the semester's project (project task) is also valued with 10 points maximmum and there are two continuous assessments of the knowledge - colloquiums that are conducted during the esemester, one in the middle and one at the end, each with 20 points maximmum. The final exam for each course is valued with 30 points. Each of the subjects carries one grade independent of eachother. It should be especially noted that the scoring of the practical teaching is carried out according to the following criterion - 0.3 points for attendance and 0.7 points for previous theoretical preparation and success in working with patients.
Online courses and training are very popular nowadays and more and more institutions and companies are offering courses online. The most important advantage about online learning is that individuals can take courses from the comfort of their office or home.When online teaching is present, students do not interact directly with professors and teaching assistants. One of the most frequently cited difficulties by students is the fact that they feel difficulties to ask their online teacher questions as the communication is often very impersonal (everybody are on channel).However,most of the online courses often offer alternatives, such as online forums,email,andchatrooms in order to remove this negativity. These alternatives can help individuals to get answers to their questions.
Classical teaching primarily helps students and teachers to get to know each other in a better manner. This allows teachers to know the students and evaluate their strengths and weaknesses better, act as mentors, and guide students in their career possibilities. In a traditional classroom, students can directly share their views and clarify their own queries with the teacher, thus getting their questions answered right away.For the most students, also books and notes from the classroom are very helpful for studying and passing exams.
Numerous published studies indicate that, in comparison to traditional face-to-face teaching and learning, near-term valorization of student's learning and performance, such as course completion, grades, and success in subsequent courses, are slightly lower in online conditions.When compared to on-campus programs, bachelor's degree students in online programs perform worse on nearly all test score measures.
According to Fischer et al [8], when compared to students who take the courses required for their major in person, online students have a slightly shorter time for degree completion and are more likely to graduate in four years.

Prior to the transition to distance education as a result of the Coronavirus pandemic, online courses have opened up for postsecondary education, and a significant number of students have taken classes online. [1, 15] For instance, McFarland et al [15], in the fall of 2016, an estimated 5.2 million undergraduates in the United States, or 31% of all undergraduates, were enrolled in at least one online course. There is a number of factors at the department and student levels that are contributing to the increasing availability of online classes and the rising number of students enrolling in them.

According to some studies, there has been significant pressure on university students, but the effects have varied depending on socioeconomic status The most adversely affected students by the confinement were those who lacked adequate computer equipment, access to networks, or a private room where they could take telematic classes. [17]

According to Jamal [12] the following are some of the main benefits of online education: (1) access from any online computer at any time; (2) takes into account busy schedules; (3) course content is better understood and retained, according to some researches; (4) presence of more important discussions; (5) focus on writing, technology, and life skills like time management, independence, and self-control; (6) increased interaction and discussion between students and teachers; (7) a learning environment that is more student-centered; (8)presence of more active learning and less passive listening; (9) a greater sense of synergy and connection; (10) increased creativity and variety in educational activities; (11) adaptation to a variety of learning styles; (12) ability to manage grading online and to document interactions over the internet; (13) make room for more students; (14) reduce the burden on the limited infrastructure of the campus; (15) offer options to students; (16) reach new markets for students; (17) increase enrollment by appealing to existing students.

Also, students while on-line teaching may be able to enroll in courses that they otherwise would not have been able to because of departmental scheduling constraints or over-enrollment in those courses. [9, 14] Students can enroll in additional classes by meeting their individual needs to avoid travel and by assisting students in avoiding scheduling conflicts with jobs, internships, and other out-of-class commitments. [6, 11]

There has been little research done on the significant but cumulative effects of the COVID-19 pandemic on students' academic performance. Aiming to assess the impact of online teaching on the success of students, we set the main goal of this research to make a comparative analysis of students' grades in the same subjects in the period before the epidemic and during the implementation of online teaching.

1. Material, method and essential information about the courses

During this research, an analysis has been conducted regarding the grades for three courses of the study program dental medicine, first cycle of studies, faculty of medical sciences, University Goce Delcev in Stip, Republic of North Macedonia:

- Preclinical periodontology,
- Periodontology 1, and
- Periodontology 2,

The grades that were matter of the analysis were obtained as finals of the teaching of those courses that was carried oud during:

- Academic year 2018/2019, when the teaching was completely carried out with physical presence,
- Academic year 2019/2020, when the teaching was entirely online and
- Academic year 2020/2021, when there was a hybrid type of teaching.

The data were generated from the students' information system of the university – e-index. It is a complex software solution that integrates and automates the administration of the student completely. In terms of academic year, exam sessions in September, February and June are taken into consideration respectively each academic year, with no difference whether it is regular or non-regular exam session.

Periodontology is a science that refers to the periodontium, i.e. the supporting tissues of the tooth. After caries, periodontal diseases are the most common oral disease. Up to 90% of the population has some form of periodontal disease.The pathological processes that occur during different periodontal diseases lead to a gradual but progressive loss of teeth.

Within the curriculum for studies in dental medicine, there are three courses covering the field of periodontology: preclinical periodontology – compulsory course in 8^{th} semester, periodontology 1 in 9^{th} semester and periodontology 2 in 10^{th} semester of the study program. Each of these courses is designed according to the curriculum and consists of lectures and exercises. During the teaching of periodontology 1 and 2, the exercises are clinical practice, and the students work on real patients, participating in the diagnosis and treatment of periodontal diseases.

The skills that the students are expected to acquire with studying and passing the exam for preclinical periodontology course aim to familiarize the students with the anatomy, histology, and physiology of the supporting tissues of the tooth, with the classification and epidemiology of periodontal diseases, with the risk factors and determinants of the disease, as well as with the etiology of the disease. Competencies that students should have after passing the periodontology 1 course are relateted on the occurrence of periodontal disease, clinical signs and symptoms of periodontal diseases, occlusal influences, as well as working with patients in field of periodontology.In the last semester of studying this area is covered with in the periodontology 2 course, where students are trained for the therapy of periodontal diseases.

One assistant professor from the field of periodontology and oral pathology participates in the theoretical teaching of the given courses, while in the practical teaching, an external associate-master of dental sciences participates is also engaged to deliver the necessary material to the students.

2. Results and discussion

The data from the students' information system, related to the prerequisites listed earlier are shown below.

Table 1. Pass rate through the years

Academic year	Course	P/F	Number	Number of passed	Percentage
2018/2019	Preclinical periodontology	Passed	21	57	95,00%
		Failed	2		
	Periodontology 1	Passed	16		
		Failed	1		
	Periodontology 2	Passed	20		
		Failed	0		
2019/2020	Preclinical periodontology	Passed	30	83	89,25%
		Failed	9		
	Periodontology 1	Passed	23		
		Failed	1		
	Periodontology 2	Passed	30		
		Failed	0		

2020/2021	Preclinical periodontology	Passed	13	48	71,64%
		Failed	16		
	Periodontology 1	Passed	18		
		Failed	2		
	Periodontology 2	Passed	17		
		Failed	1		

Source: E-index, University Goce Delcev in Stip

Summary, over the years, the decrease of the pass rate is pretty obvious (Figure 1).

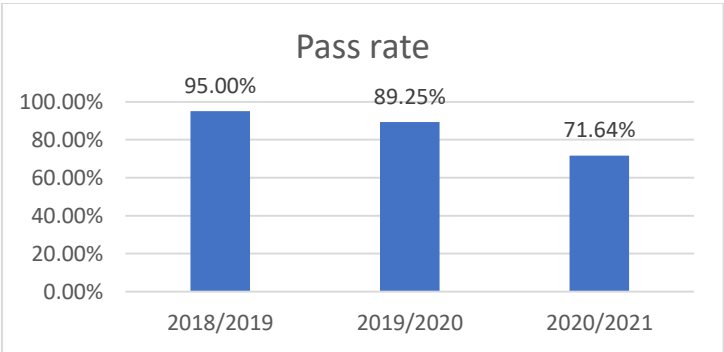

Fig. 1. Pass rate through the years
Source: E-index, University Goce Delcev in Stip

The tendency of the decrease of the pass rate is pretty significant, especially for the last academic year 2020/2021, where 71% of the students that applied for final exam has passed it. Regarding the average grades related to the courses through the academic years, that indicates how much students have learned from the material, based only of the sample of the students that have passed the exam, the results are below. We assume that higher grade means higher quality of learning and understanding of the material from the student (it is pretty general in this research).

Table 2. Grades average by courses and academic year

Academic year	Course	Average	Average by academic year
2018/2019	Preclinical periodontology	6,17	6,34
	Periodontology 1	6,40	
	Periodontology 2	6,44	
2019/2020	Preclinical periodontology	6,78	6,46
	Periodontology 1	6,33	
	Periodontology 2	6,24	
2020/2021	Preclinical periodontology	6,40	7,16
	Periodontology 1	7,63	
	Periodontology 2	7,30	

Source: E-index, University Goce Delcev in Stip

Average grades show tendency of increase through the years (figure 2).

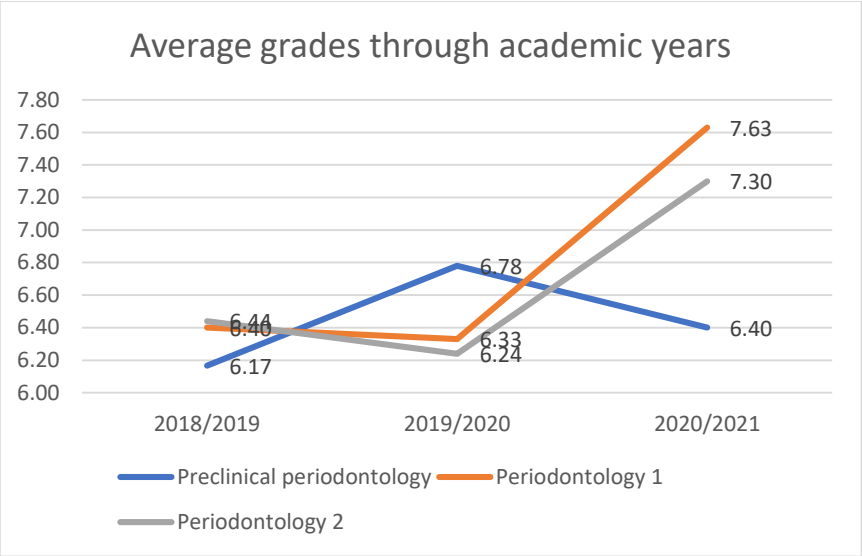

Fig. 2. Average grades through the academic years by courses
Source: E-index, University Goce Delcev in Stip

It is clear that there was a tendency of increase of the grades' average in general, even though it is not the case with all the courses.

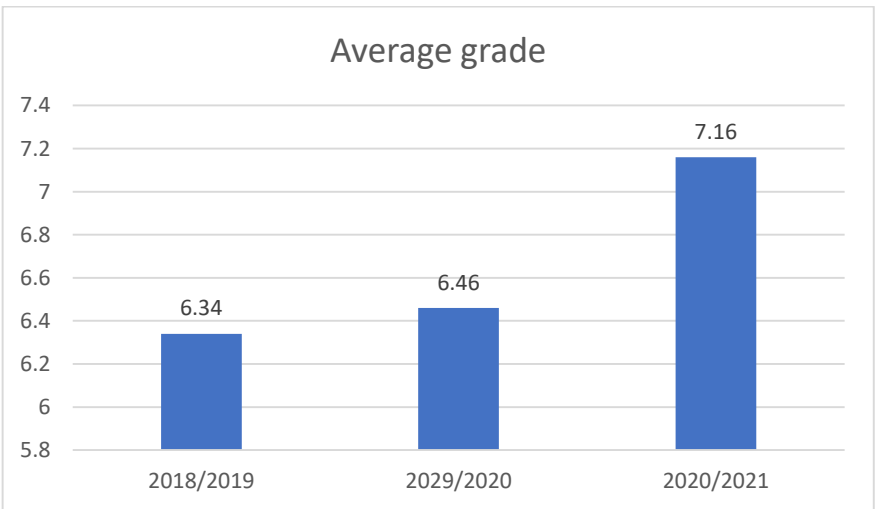

Fig. 3. Average grade through the academic years
Source: E-index, University Goce Delcev in Stip

The difference is particularly noteworthy during the year when everything was hybrid, with highest grade average of 7,16.
In contrast to the results of our study, Bashir et al [3] indicated that students achieved higher grades with online assessments.
Even after adjusting for the effects of additional variables that may contribute to the differences, the findings indicate that the pandemic has a small but significant impact on grades in higher education. The highest grade increasing effect ever reported in the literature, 9.21%, was found by Karadag in 2021.[13]
Online and distance learning are a part of higher education. From this point of view, a higher priority should be given to educators' abilities for teaching online. Grades in mandatory courses, according to Carter and Lara [5] should be assigned as successful/unsuccessful and these courses should not be counted toward the general weighted grade point average without increasing the existing online education capacities of higher education institutions and online

education competencies of educators. It is advisable to write guides on effective assessment and evaluation procedures for online learning.

Working independently in an online course may have advantages and disadvantages, despite Berry's [4] research suggesting that students do not view it as ideal. Students found online learning to be more flexible than traditional face-to-face learning, according to Hass and Mathew's [10] study comparing traditional face-to-face courses to online courses.

The majority of online and hybrid courses offer students access to a wide range of educational resources. The researchers discovered in a previous study that students with the highest access rates also had the highest academic achievement.[16]

Due to its complexity, the term "academic performance" is frequently disputed. However, it is widely acknowledged that the best measure of a student's academic performance is their grades in the university-level courses they take.[2] According to these studies, the COVID-19 lockout has had negative effects on students' stress levels, schools' and universities' lack of adaptability, students' and teachers' lack of knowledge of the technologies and implementation methodologies.[7]

At the and we have to note that we are aware that our study has some limitations. It is challenging to extrapolate our results to other universities worldwide. Also, the sample size we have available is poor. Despite this drawback, our findings demonstrate the detrimental impact of the digital learning on the educational outcomes for students. Access to reliable internet is essential for students' academic success, especially institutions—like our university—integrate online learning to combat the effects of the Covid19 pandemic.

Conclusions

Based on the processed data, we can notice that the pandemic and online teaching in the given academic years significantly affect the pass rate of the exams, while it decreases over the years. On the contrary, it has been observed that in the year in which there is hybrid teaching (combined teaching) there is a significant improvement in the average grade for the examined subjects. We think that this phenomenon is due to the lower passing of the exams, but also to the fact that those who passed the exam mastered the learning material better.

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КОМПАРАТИВНА АНАЛИЗА НА СТАНДАРДИ И МЕТОДОЛОГИИ ЗА УПРАВУВАЊЕ СО ИНФОРМАЦИСКО-БЕЗБЕДНОСНИ РИЗИЦИ НА ТЕХНИЧКИТЕ И ЕЛЕКТРОНСКИТЕ СИСТЕМИ ОД КРИТИЧНАТА ИНФРАСТРУКТУРА

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Abstract

Information security is a priority at the national and world level, which results with the need to define certain security violations with the ultimate goal of successfully preventing information breaches, and with that quickly and successfully remediating the consequences. In a cyber war scenario, the energy and financial sectors are considered as the most critical to national security. The identification of key weaknesses, risks and potential exposure to cyber threats in energy systems, as well as the creators of cyber incidents, can be performed based on the perception of possible cyber attack scenarios. At the world level, there are several models for assessing and managing security risk (ISO/IEC 27001, NIST 800-53, COBIT, OCTAVE Allegro, etc.) and therefore the main goal of this research is to sublimate and compare the values of the most frequently used methodologies, which will enable the selection of the best model for the successful prevention of information breaches and the quick and successful remediation of the consequences. This paper analyze the application of current standards and methodologies for managing information-security risks in the elements of CI, assessment of the level of application of standards and methodologies in the institutions, which are part of CI, as well as determining a way to improve the management of current information security risks.

Keywords:

security risk assessment methodology, security risk management, ICT-Infrastructure, cloud system,

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УЧЕЊЕ СО ПОМОШ НА МОБИЛНИ УРЕДИ – ПРИДОБИВКИ И ПРЕДИЗВИЦИ НА НОВОТО ВРЕМЕ

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Апстракт

Денес информацискатa и комуникацискатa технологија се речиси насекаде, па и во образованието. Учениците учат со употреба на компјутери и технологија и со нивна помош секојдневно развиваат нови вештини. Воведена е нова генерација на едукативни алатки со користење на мобилни уреди. Мобилната настава е за планирање и извршување на учење преку мобилни уреди. Овој начин на учење може да влијае и на професорите (предавачите), и на студентите. Ова учење е овозможено и преку Интернет кој помага да се создадат современи методи кога се интегрирани со педагошката настава. Целта на оваа студија е да ги разгледа придобивките и перспективата на мобилните уреди во образованието, како и предизвиците за универзитетите, професорите и студентите во нејзиното спроведување.

Клучни зборови:

ИКТ, мобилни уреди, мобилна настава

Вовед

Образованието е главна развојна алка во општествениот синџир на секоја држава. Без образование, но и со лошо конципирано и менаџирано образование нема напредок и развој, нема иднина. Затоа велиме дека од образованието зависи иднината и опстанокот на секоја држава. Колку е подобро конципирано и поставено на здрави основи, колку подобро се спроведува и менаџира образованието толку повеќе државата се развива во вистинска насока.

Во 18-тиот и 19-тиот век, образованието беше привилегија на богатите кои се образуваа дома. Учителите доаѓаа во нивните домови да ги подучат и им ги носеа потребните книги. Но, државите увидоа дека образованието е важно за секоја индивидуа и претставува е развојна компонента на општеството, затоа тоа претрпе промени во поглед на местото и начинот на негово спроведување. Во минатиот 20-ти век, образованието се организираше и спроведуваше во училиштата како главни места за учење, а учебниците им беа нивен составен дел. Учениците и студентите во секој степен на образованиот процес учеа од учебници, кои беа идентични и задолжителни во секое училиште. По учебници се одвиваше целиот процес, без слободен простор на учителите. Домашното подучување не се практикуваше, а училиштето се сметаше за главна образовна, социјална и општествена средина, која беше темел на учењето и развојот на младата индивидуа. Сепак, ако некој ученик имаше задача или самоиницијативно сакаше да истражува или да прочита нешто повеќе од она што беше во базичниот учебник тогаш

тој требаше да помине часови и часови во библиотека и да прочита многу книги, бидејќи содржината на секоја книга не може да даде секогаш прецизна информација за она што читателот го бара. Затоа, беше неопходно да се прочитаат многу книги.
На крајот од 20-тиот век постепено се воведуваа компјутерите како помошна алатка во процесот на учењето во училиштата. Започна ерата на дигитализација во училиштата и воопшто во образованието. Развојот на компјутерите одеше мошне брзо и тие се повеќе и повеќе стануваа неразделив дел од образовниот систем. Во тоа придонесоа и појавата и развивањето на мобилните телефони и другите мобилни уреди, кои на некој начин дадоа поттик да се научи по нешто и надвор од училиштето. Но, многу брзо овие уреди го заменија одењето и седењето во библиотеките, бидејќи пребарувањето со нив беше поефективно и побрзо, но и фондот на книги многу поголем отколку што може физички да биде опремена една библиотека. Сепак, образованието постепено се дигитализираше, се менуваше и прилагодуваше со некое темпо, кое им одговараше на сите негови чинители. Училиштето сè уште беше незаменливо во спроведувањето на образовниот процес, независно од развојот на техниката, технологијата, а и достапноста до сите тие технички ресурси.
Во 2020-та ни се случи Ковид-19, пандемија во светски размери. Пандемија која стави клуч на училиштата и наставниот процес во него. Начинот на учење и се она што значеше образование до тогаш замина во историјата. Сите мислеа дека ова ќе биде еден лош и краток период од нашите животи, кој ќе го пребродиме брзо и успешно. Но, сепак не беше така, а учениците мораа да продолжат да учат и образовниот процес не можеше да биде прекинат со месеци. Затоа, сите држави во светот започнаа да бараат нови начини за спроведување на образованието од далечина. Се бараа брзи и одржливи промени за учење од дома. Истовремено тие мораа да бидат и подеднакво ефективни. Образованието мораше за кратко време да се прилагоди на новите предизвици, иако ништо не беше исто како пред тоа. Компјутерите и останатите мобилни уреди беа најповикани за ваков вид на образование и станаа незаменлива алатка во образовниот процес. Дигитализацијата на образованието мораше да се случи брзо и веднаш. Немаше време за одложување и тестирање на компјутерските платформи од далечина. Училиштата низ целиот свет започнаа да користат различни платформи за далечинско учење како што се Microsoft Teams и Zoom во зависност од нивната проценка за добро и корисно. Не постоеја препораки, согледувања и резултати од ваков тип на образование. Целиот образовен систем во секоја држава беше и сеуште е еден глобален тест за далечинско учење.
Сепак, образованието не е нешто што се дефинира еднаш и како такво се спроведува и раководи секогаш на идентичен начин. Тоа е процес кој постојано треба да се менува и развива соочувајќи се со временските предизвици, големината на човечките и техничките ресурси во самата држава. Бидејќи ниту една држава не е изолирана од другите држави околу неа, нејзиното образование треба да ги следи и да се прилагоди на образовните процеси на државите околу неа, државите во регионот, па и глобално во светот. Образованието е процес кој неминовно се развива во нормални услови, каков што беше животот пред појавата на мобилните уреди и нивната употреба во рамките на образованието.

1. Мобилно учење

Денес информацискатa и комуникацискатa технологија се речиси насекаде, па и во образованието. Образованието е процес со кој мудроста, знаењето и вештините на една генерација се пренесуваат на следната. Денес постојат две форми на образование: конвенционално образование и образование на далечина. Во денешено време, нашите паметни телефони ги користиме буквално за сè. Комуникација со пријатлите и семејството, онлајн шопинг, нарачување храна, играње игри и за многу други работи. Дали треба да користиме и паметни телефони за учење?

Воведена е нова генерација на едукативни алатки со користење на мобилните уреди. Мобилното учење, или „м-учење'', нуди модерни начини за поддршка на процесот на учење преку мобилни уреди. Мобилните уреди ја вклучуваат секоја преносliва и лесна за користење технологија, како што се основните мобилни телефони, паметни телефони, е-читачи, нет букс, таблети, iPad и компјутери [1]. Тие даваат брз и лесен пристап до мноштво на ресурси. Мобилните уреди доведуваат до нов образовен модел наречен мобилно учење [2].

Мобилното учење е потреба, а не желба. Се верува дека со дозволување на учениците да користат мобилни уреди во училниците, мотивацијата за учење и постигнување на резултати се зголемува [3]. Студентите сакаат информациските и комуникациските технологии да го подобрат нивното универзитетско искуство, како и да обезбедат искуства кои се преносливи на сите аспекти од нивниот живот [4]. Студентите сакаат да бидат во чекор со новите технологии за да имаат подобра и поуспешна кариера.

2. Разлики помеѓу електронско (е-учење) и мобилно (м-учење) учење

Често мобилното учење се поистоветува со електронското учење. Но, тие не се едно, па исто и нивните разлики се сумирани во дадената табела.

Табела 1 Разлики помеѓу електронското и мобилното учење

Е-учење	***М-учење***
	
Дефиниција Електронско учење е форма на образование каде учењето и наставата се одвиваат преку интернет, користејќи електронски уреди.	***Дефиниција*** Мобилното учење е форма на учење и настава што вклучува мобилни уреди.
Пристап Иако може да се пристапи со WBT, статично е.	***Пристап*** Пристапено од каде било во секое време.
Уреди Електронското учење се одвива преку компјутери и лаптопи, вклучува оперативни системи како Windows, Linux и Mac.	***Уреди*** Мобилното учење се одвива преку мобилни уреди како паметни телефони и таблети и вклучува оперативни системи како iOS и Android.

Дизајн	***Дизајн***
Курсевите за е-учење може да користат сложени и поголеми дизајни и модули.	Курсевите за м-учење не треба да вклучуваат посложени графици и детални информации. Покрај тоа, треба да бидат дизјанирани со едноставни екрани и едноставна навигација.
Времетраење	***Времетраење***
Подолги и пошироки курсеви од м-учење. Препорачано: 20 минути до 1час.	Кратки модули со препорачана големина: 3-15 минути.
Цел	***Цел***
Ги учи студентите на специфични вештини или пренесува длабинско знаење за некоја тема. Две клучни цели за учење: Разбирање и задржување.	Пристап до информации во моментот кога е потребно. За поддршка на тековниот процес на учење каде што на ученикот му треба брз пристап до делови од информации, обично во движење.

3. Предизвици со кои се соочуваме при мобилното учење

Професорите и студентите имаат истовремено позитивни и негативни размислувања за користење мобилни уреди во образовниот процес. Професорите повеќе се плашат од користењето на нови технологии и методи во учењето за разлика од студентите. Професорите сметаат дека методот е добар за учениците - не им требаат книги, тетратки, само уред, но исто така се грижат и за здравјето на учениците - користењето на уреди може да влијае на нивните очи, глава (главоболка), како и се плашат да не го изгубат традиционалниот начин на учење со книги, училници, креда, табли и најважно, со ученици во предавалните / училниците [8].
Според професорите, мобилните уреди позитивно ќе влијаат на мотивацијата на студентите, инспирацијата, желбата да научат повеќе, комуникацијата, тимската работа, соработката и способноста за истражување, домашните работа и проектите. Но, според нив има и доста предизвици со кои студентите ќе мора да се соочат, како што се:

- проблемите со приватноста и безбедноста,
- расеаноста е исто така еден голем предизвик за професорите,
- постои мислење дека учениците ќе ги користат уредите за комуникација со пријателите и за играње игри, а не за корисни работи,
- раководството во образовните институции (универзитетите) мора да преземе одговорност да блокира одредени апликации или веб-страници; а професорите и асистентите треба да се движат низ класот за да ја контролираат и надгледуваат употребата на такви уреди од страна на учениците,
- не сите студенти имаат пристап до модерна технологија (некои семејства се сиромашни, а некои студенти живеат во рурални средини),
- На некои ученици им е тешко да напишат долги текстуални одговори на уредот поради недостаток на тастатури. Употребата на посебни тастатури ја ослабува моќноста и ја намалува преносливоста,

- нема пристап до различни дигитални книги, универзитетите треба да им обезбедат на студентите повеќе опции,
- читањето на голема количина текст на малиот екран на мобилните уреди е тешко и може да ги замори и оштети очите,
- загубата е доста голема ако уредите се оштетат или скршат, а постои и можност за кражба на уредите на факултетите или на други места каде што се користи уредот,
- не сите студенти се компетентни за користење на мобилни уреди и можеби се фрустрирани и можеби не сакаат да ги истражуваат можностите.

Професорите знаат дека со континуирани обуки, работилници и секојдневна работа ќе ги надминат предизвиците за употреба на мобилните уреди при учење и изведување на настава [5]. Знаат и дека учениците ќе се прилагодат и побрзо ќе го прифатат овој тип на учење во споредба со нив.

За користење на мобилни уреди за настава и учење на универзитетите и високообразовните институции, потребна е интернет конекција со прокси-сервер. Во исто време, раководството на институцијата мора да го ограничи пристапот до интернет за да се избегне несоодветна употреба. Интернет-врската мора да биде со профил за секој ученик со зададено корисничко име и лозинка.

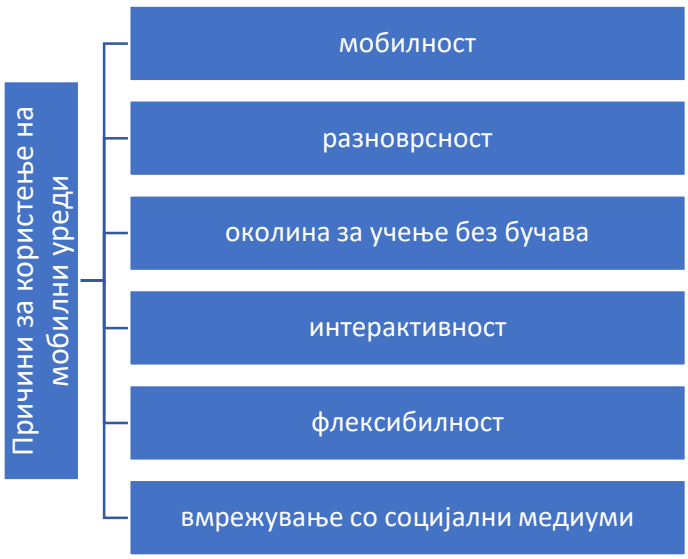
4. Придобивки од мобилното учење

Мобилните уреди се важни за нас бидејќи ни овозможуваат да соработуваме, да комуницираме, да пристапуваме до информации, да конструираме нови информации, да се поврзуваме со други.... Тие се неверојатно достапни [8]. Исто така со нивна помош можеме да го користиме Google за истражување, насекаде и во секое време; да користиме апликации за читање; да имаме пристап до виртуелни библиотеки, музеи, мрежи; да ја користиме Microsoft Teams платформа за настава; овозможуваат учење базирано на игри и учење базирано на проекти; споделувањето на датотеки може да се направи брзо и без никакви проблеми, студентите можат да планираат како да го поминуваат своето време како што сакаат и претпочитаат; студентите можат да имаат избор во однос на апликации, платформи, социјални канали, стил на оценување и така натаму; слушалките, бубиците и другите сродни периферни уреди стануваат сè повообичаени и корисни; може да функционира како центар за продуктивност за учење - потсетници, списоци со задачи, ажурирања на календарот, пораки на социјалните мрежи, е-пошта итн.; може да се користи за правење квиз во реално време и за давање резултати на професорите од брзите тестови; може да се користи како калкулатор...

Овие уреди имаат голем потенцијал за трансформирање на учењето. Некои дополнителни причини [4], [6], [7] кои се сметаат за поважни при користење на мобилни уреди во училницата кога станува збор за наставниот дизајн и инфраструктура се:

- Мобилност: нуди услови за учење во движење, алатки за комуникација надвор од училницата, неколку активности во училницата преку Интернет алатки додека не можат физички да присуствуваат на училницата,
- Разноврсност: мултитаскинг (алатки за учење онлајн, запишување белешки, посетување активности во училницата во реално време, MS Office алатка за работа со документи, алатки за уредување слики), забрзување на процесот на учење,
- Околина за учење без бучава: iPad и паметен телефон обезбедуваат опција за екран на допир (наспроти компјутер, бидејќи со компјутер користиме тастатури и глувци кои се гласни кога претискаме на нив),
- Интерактивност: учење преку аудио/видео медиуми, учење на интерактивен начин користејќи визуелни елементи како графикони и слики
- Флексибилност: адаптивна средина за учење користејќи различни апликации,

- Вмрежување со социјални медиуми: комуникација преку веб-страници за социјални медиуми како Фејсбук и Твитер. Овие страници им овозможуваат на студентите да комуницираат со нивните колеги, да споделуваат знаења, вести и видеа, да добиваат одговори за секоја задача и прашања од нивните професори и постари колеги од универзитетот.



Слика 3 Причини при користење на мобилни уреди во училницата [6], [8]

5. Заклучок

Од трудот можеме да забележеме дека придобивките од користењето на мобилни уреди ги засенуваат предизвиците. Знаејќи го фактот дека повеќе европски земји воведоа ваков вид на учење, професорите се надеваат дека овој вид на учење ќе се прошири и кај нас и ќе ја разбуди желбата кај учениците да се истакнат во учењето пред своите врсници и да се стремат да напредуваат во животот и кариерата. Целта на секој студент и човек е да биде успешен и да остави нешто зад себе. Се надеваме дека како институција ќе го интегрираме мобилното учење и ќе ги следиме новите трендови ширум светот.

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TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION METHOD IN PATIENTS WITH XEROSTOMIA

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Abstract

Patients with salivary gland hypofunction typically complain of dry mouth, difficulty chewing, swallowing and/or speaking; they hardly tolerate spicy, acidic, and crunchy food and often times report taste changes or difficulty wearing dentures. It can also increase the chance of developing dental decay, demineralization of teeth, tooth sensitivity, and oral infections. The goals of treating xerostomia include identifying the possible causes, relieving discomfort, and preventing complications. In this study, we investigate the most effective frequency to increase salivary secretion, without side effects on the skin and orofacial structures. Transcutaneous electric nerve stimulation (TENS) is a simple, inexpensive, and non-invasive modality that uses electric current to activate nerves for therapeutic reasons. It is a non-pharmacological method of pain management for which it is widely used. Application of electric impulses to one or more of the three components of the salivary reflex arch should theoretically improve salivary secretion and lessen the various long-term effects of hyposalivation. For this study were analyzed totally 23 published studies in the last 10 years. The study is made on narrative review of published articles that were go into the related subject, evaluation of the impact of a transcutaneous electrical nerve stimulation (TENS) system on patients' dry mouth and salivary flow rates. The TENS unit was effective in increasing the quantity of stimulated saliva and was also found to be more effective in increasing saliva in diabetic individuals. From the results of the study, it can be concluded that TENS was effective in increasing the salivary flow rate in hyposalivatory patients with residual saliva.

Key words

Salivary glands, xerostomia, saliva flow rate, dry mouth therapy, TENS, hyposalivation treatment.

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БИОТЕХНОЛОШКА ПРОЦЕДУРА НА ДОБИВАЊЕ НА АВТОЛОГЕН ДЕНТИНСКИ ГРАФТ ЗА СТОМАТОЛОШКИ И МЕДИЦИНСКИ ЦЕЛИ

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Апстракт

Екстрахираните заби сè уште се сметаат за клинички отпаден материјал и како такви се сметат за неупотребливи. Меѓутоа во денешно време со примената на специјалниот апарат-SDG од екстрахираните заби се добива автологен дентински графт.

Главната цел на трудот е да се претстави новиот протокол и новата процедура на добивање на минерализиран автологен дентински графт користејќи свежо екстрахирани заби, конкретно во овој труд применет за презервација на алвеоларен гребен и со можност на употреба во пополнување на дефекти во виличните коски и целокупниот скелетен систем. Исто така целта е насочена кон докажување на високиот потенцијал на автологниот дентински графт (ADG) во регенерирање на коскените и мекоткивните структури во виличните коски, зачувувајќи ги притоа вертикалните и хоризонталните димензии на алвеоларниот гребен. Користена е апаратурата наречена Smart Dentin Grinder (SDG) која овозможува за краток временски период од 3 секунди да се сомели екстрахираниот заб во дентински зрнца со големина од 300 до 1000 μ. Добиените дентински партикли подлегнуваат на хемиска обработка со помош на употребените хемиски реагенси. Целата процедура е изведена по протоколот на Itzhak Binderman (2014 год). Добиениот ADG претставува солиден и прочистен графт материјал со задоволителна количина за потребите во оралнохируршките интревенции. Се употребува имедијатно и економски е поприфатлив за пациентите. Дентинските честички кои се користат како графт материјал, треба да се сметаат за златен стандард поради остеогенетскиот, остеоиндуктивениот и остеокондуктивниот потенцијал. Добиениот и подготвен ADG може да се користи за водена коскена регенерација во различни области од медицината и стоматологијата.

Клучни зборови*:*

автологен минерализиран дентински графт (АМДГ), Smart Dentin Grinder (SDG), коскена регенерација, презервација на алвеоларен гребен, автологни коскени графтови

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PHYSIODISPENSER – AND ITS USE IN DENTAL MEDICINE

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Abstract:

A physiodispenser is a specialized dental drill that is designed to prepare the implant site in the jawbone during the dental implant placement procedure. The use of a physiodispenser is important because it ensures that the implant site is properly prepared and the implant is placed with precision and accuracy. It cut bone very efficiently with controlled torch, speed and gear. There is constant saline irrigation system which washed away wash the bone debris and blood and also act as coolant. So after surgery patient will not get pain and swelling. It has very low noise, comfortable for patient. The physiodispenser is key technology in implant dentistry. The Physio-Dispenser is a device enabling us to embed the implants into the bone. Its main advantage is that, compared to standard dental sets of instruments, almost every part of the dispenser can be sterilized, which prevents spreading of infection into the operation wound. It allows bone surgery at low speed becomes extremely safe and patients will typically not get any swelling after surgery. It uses a combination of high-speed rotary motion and gentle oscillation to create precise, controlled channels in the bone for the dental implant to be placed. The oscillation feature helps to minimize damage to the surrounding bone tissue and increase the accuracy of the implant placement.

Key words:

comfort, control, drill, implant, physiodispenser

1. Introduction

A physiodispenser is indeed a medical device used in dentistry. It is designed specifically for drilling during dental procedures, allowing for precise and controlled movements.
A physiodispenser typically has adjustable speed settings to accommodate different drilling needs during dental procedures. The speed can be controlled by the dentist or technician operating the device.
Regarding the drill itself, it is usually a specially designed bur or bit that is used for drilling into the bone during dental implant placement. These drills are typically made of high-quality materials and come in various sizes to accommodate different implant sizes.
In this study we will show you some different types of physiodispensers and advantages and disadvantages of using the physiodispenser, also the specifics about it.

In dental implantology, a physiodispenser is commonly used to prepare the site where the dental implant will be placed. It allows for precise and controlled drilling into the bone, ensuring the implant is securely and accurately positioned. The use of a physiodispenser helps minimize trauma to the surrounding tissues and promotes faster healing.

2. Advanteges

The surgical handpiece is like a superhero, swooping in to save the day, and its precision and power. It allows dentist to perform implant procedures with ease and accuracy, ensuring that those implants go in just right. One of the main benefits of surgical handpiece is versatility. It can be used of a variety of tasks during the implant procedure, from drilling the pilot hole to shaping the bone. It's like have the Swiss army knife in the dentist's hand.
Another advantage is the speed and the efficiency. It brings to the table. With the surgical handpiece, dentists can complete the procedures in a fraction of the time compared to the traditional manual methods.

2.1. Disadvantages

Like any superhero, the surgical handpiece has its kryptonite. One of the main concerns is the heat generated during the drilling process. This heat has potentially damaged the surrounding tissue if not managed properly. So dentists need to be mindful and take precautions to prevent any unwanted heat-related complications.
Another drawback is the noise. The sound of a dental handpiece can be a bit unnerving for some patients. It's like a dental symphony but not everyone is a fan of that particular tune, (14)

2.2. Types of physiodispensers

There are several types of physiodispensers used in dental implantology, each with its own features and advantages. Here are a few examples:

1. Surgical Handpiece: This is the most common type of physiodispenser. It is a handheld device that connects to the dental unit and is used to prepare the implant site by drilling into the bone.

2. Piezoelectric Handpiece: This type of physiodispenser uses ultrasonic vibrations to cut through the bone. It is particularly useful in delicate procedures where precision is crucial, as it minimizes trauma to the surrounding tissues.

3. Electric Handpiece: These physiodispensers are powered by an electric motor, allowing for more controlled and precise drilling. They often come with adjustable speed settings to accommodate different surgical needs.

4. Implant Motors: Implant motors are more advanced physiodispensers that offer a range of features. They typically provide torque control, speed adjustment, and preset drilling protocols. Some models even have integrated cooling systems to reduce heat generation during surgery.

The main difference between these physiodispensers lies in their power source and functionality. While all of them serve the purpose of drilling the implant site, their specific features cater to different clinical demands and preferences.
We've got electric ones, the air-driven ones, and eve the ultrasonic ones. It's like a dental tool extravaganza. The electronic physiodispensers are the Energizer bunnies of the dental world. The keep going and going, providing the consistent and reliable power source for those implant procedures.no need to worry about running out of juice mid-operation. On the other hand we have the air-driven physiodispensers. These are like the dental equivalent of a turbocharged engine. The deliver high speed rotation, making implant procedures a breeze.
And let's not forget the ultrasonic physiodispensers. These futuristic tools use ultrasonic vibrations to create precise and controlled movements. It's like they're preforming the dental symphony.

Now when it come for advantages for these physiodispensers it's all about efficiency and accuracy. The make the implant process faster and more precise, ensuring that your pearly whites are in good hands. With their different features, these physiodisopensers allow dentist to customize their approach based on a patient's needs. It's like having a dental toolbox with all the right tools for the job, (3)

2.3. Specifics for some physiodispensers

1.The Surgic Pro2

Wireless pedal control

Bluetooth connectivity allows you to choose the optimal position without worrying about the length of the cable. The foot control is 400 g lighter than the previous model (including the hangar), which makes it easier to set up. You can focus on healing.
"Coolant Flow Volume Button", "Program Button" and "Forward / Reverse Button" can be customized with 3 installed buttons that allow the operator to select the desired operation mode. In the energy-efficient power supply, 3 AAA batteries are used, which last about 6 months. A signal light shows when the batteries are running low.
Connectable to the ultrasound system "VarioSurg 3"

The Surgic Pro2 can easily be connected to the NSK VariosSurg 3 ultrasound surgical system by adding our Bluetooth connection module. Using the NSK connection stand, two units can be safely stacked to save space.
One foot control
You can easily switch between Surgic Pro2 and VarioSurg 3 for improved flexibility and workflow.
Compatible with iPad

Installing a dedicated app and connecting an iPad to the control unit allows detailed procedural data to be displayed in real-time, such as rotational speed and torque range.
Process data can also be saved. Data can also be displayed and saved when connected to the Osseo 100+. Data management on the traceability of procedural details allows tailoring of implant treatment to individual patients.
Visibility is significantly improved by the high-resolution color LED

The use of a high-resolution color LED screen allows the blood and gums to be seen as if they were naturally lit, providing increased visibility during treatment. The LED light source generates a minimal amount of heat and has an excellent life expectancy.

2.Surgic pro'2
Technology and functions
• LCD touch screen
• Visibility is guaranteed by the large, high-contrast LCD screen with backlight.
• The screen can be adjusted in 10 brightness levels. Intuitive and easy-to-understand screen icons enable smooth operation.
Simple interface and clean screen
• Touchpad sensitivity can be adjusted to reliably respond when using surgical gloves and surgical barriers.
• Extremely narrow screen bezel makes cleaning easier.
• The new design takes into account the latest requirements for the treatment and control of cross-infections.

Quiet and smooth irrigation pump

The irrigation pump provides a consistent and constant flow that works quietly in the background. Setting up the irrigation tubing is quick and easy, and the pump fits seamlessly into the Surgic Pro2's compact and elegant design, (2)

3. Conclusion

When it comes to physiodispenser, these nifty gadgets play a crucial role in dental implant procedures. Think of them as the superheroes of the dental world, swooping in to save the day with the features and advantages. The use of a physiodispenser is important because it ensures that the implant site is properly prepared and the implant is placed with precision and accuracy. It cut bone very efficiently with controlled torch, speed and gear. There is constant saline irrigation system which washed away wash the bone debris and blood and also act as coolant. So after surgery patient will not get pain and swelling. It has very low noise, comfortable for patient. The physiodispenser is key technology in implant dentistry.

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BIOMECHANICAL BEHAVIOR OF ENDOSONICS

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Abstract

Endosonics is used for root canal instrumentation and disinfection. An endosonics insert is designed to shaping and allow the traditional endodontic irrigant, sodium hypochlorite, to pass through and along the endo-sonic files. The irrigant is activated by the ultrasonic energy imparted from the energized instruments and the root canal becomes an ultrasonic bath. The ultrasonic tip vibrates at a high frequency and produces acoustic streaming and cavitation, which helps to dislodge and remove the organic and inorganic part of the smear layer and gram+ and gram – bacteria from endodontic system. This review of the literature aims at presenting the biomechanical work of endosonic in endo cavity and its clinical applications in a modern-day endodontic practice.
The following electronic databases were searched: Pubmed, Web of Sciences, Embase, Medscape, Web of Science and Cochrane Library. This study is based on review on published articles written in English language, reporting results related to biomechanical work of endosonics. The articles are full reading text, with no publication date restriction. After implementation of inclusion and exclusion criteria, from the total 104 articles, 82 articles were discarded and only 22 articles were taken for detailed analysis. A number of researchers have shown that ultrasonically assisted irrigation improves the cleaning efficiency in root canal treatments. In the study of Joyce et al., specially made endosonic dies and diamond instruments are energized by means of a Cavitron ultrasound generator (above 20 kHz frequency). Piezoelectric units have some advantages compared with earlier magnetostrictive units because they offer more cycles per second, 40 versus 24 kHz.
In summary, endosonics is a valuable tool in the field of endodontics, as it helps to improve the effectiveness of root canal treatment while reducing the need for invasive procedures. The use of endosonics in endodontics provides several benefits, including improved cleaning and shaping of the root canal system, reduced treatment time and improved treatment outcomes. Additionally, endosonics is minimally invasive and can help preserve more of the natural tooth structure, reducing the need for more extensive dental procedure. As well as explaining the endosonics biomechanical work, the work provides a basis for the further development and optimisation of the design of endosonic files.

Key words

endodontics, endosonics, ultrasonics

Introduction

Acoustic cavitation is a well-known phenomenon in the field of ultrasound [1]. It can increase mixing and fluid motion in a system, form reactive intermediates which accelerate chemical

reactions and aid in cleaning processes [2], [3]. Root canal treatment has application of ultrasound in endodontics. Here, ultrasound is applied to a narrow file which is placed within the root canal to improve the dissolution and removal of infected tissues and abscess from an infected root canal [4].

Endosonics is a particularly useful in cases where traditional endodontic techniques are not effective, such as in cases of calcified canals of root canal retreatment. It is also useful in cases where the root canal system is complex or has many branches. Endosonics in endodontics involves the use of ultrasonic energy to clean and shape the root canal system. After accessing the root canal, the ultrasonic tip is inserted into the canal system. Then the ultrasonic tip is activated. When ultrasonic nickel-titanium tip is activated, the tip vibrates at a high frequency, producing ultrasonic energy. The energy creates acoustic streaming and cavitation within the root canal, which helps to dislodge and remove debris and bacteria. Parallel to this function is irrigating the root canal. During the ultrasonic procedure, an irrigating solution is used to flush out debris and bacteria flush the root canal system. In the end, the dentist evaluate the canal, using x-rays or other imaging techniques to entire root canal system. [5], [6]

Objective: This review of the literature aims at presenting the biomechanical work of endosonic in endo cavity and its clinical applications in a modern-day endodontic practice.

Materials and methods: To reach the aim of this study, was conducted electronic research of some literature bases.

Search strategy

This review of literature was performed with analyzing 104 articles. The survey was based on electronic research of literature bases: Pubmed, Web of Sciences, Embase, Medscape, Web of Science and Cochrane Library. The articles that were reviewed are those that report results related to the ultrasonic shaping and irrigation of endodontic cavity and about our objective: biomechanical work of endosonic in endo cavity and its clinical applications in a modern-day endodontic practice.

For the search were used the following key words: ultrasonic endodontic shaping, ultrasonic endodontic irrigation, endodontics, endosonics, ultrasonics.

Criteria of inclusion and exclusion

This study is based on implementation of inclusion and exclusion criteria. Inclusion criteria were: published articles written in English language, articles reporting results related to use and biomechanical work of endosonics, articles that are full reading text, with no publication date restriction. Exclusion criteria were: duplicate articles and articles with references that are not proven.

After implementation of inclusion and exclusion criteria, from the total 104 articles, 82 articles were discarded and only 22 articles were taken for detailed analysis.

Results and discussion:

In the study of Joyce et al., specially made endosonic dies and diamond instruments are energized by means of a Cavitron ultrasound generator (above 20 kHz frequency). An endosonic insert is designed to allow the traditional endodontic irrigant, sodium hypochlorite, to pass through and along the endo-sonic files. The irrigant is activated by the ultrasonic energy imparted from the energized instruments and the root canal becomes an ultrasonic bath. Thus, endosonics is a synergistic system. The ultrasonic energy makes the files vibrate and oscillate,

facilitating the instrumentation of the root canal and, in addition, activates the irrigant for canal disinfection.

A number of researchers have shown that ultrasonically assisted irrigation improves the cleaning efficiency in root canal treatments [7]–[9]. Some argued that this was due to enhanced acoustic streaming [10]–[12] while others suggested that it could be due to the physical effects caused by cavitation [13], [14].

Table 1 Comparation of articles that have higher cleaning with different methods of biomechanical work of the endosonics

Author	Year	Higher cleaning efficiency with endosonics	Higher cleaning efficiency with acousting streaming of endosonics	Higher cleaning efficiency with cavitation of endosonics
Lee et al.	2004	✓		
Van Der Sluis et al.	2007	✓		
Violich et al.	2010	✓		
Ahmad et al.	2009		✓	
Walmsley et al.	1988		✓	
Lumley et al.	2008		✓	
Lea et al.				✓
Tiong et al.				✓

The oscillation profiles of endosonic files (i.e. files used during endodontic treatments that involve ultrasonic vibrations) have been measured to investigate correlations between the oscillation profiles and the cleaning effectiveness [15], [16]. The areas of cavitation activity around the instruments were assessed by the detection of sonochemiluminescence (SCL). Although it was reported that SCL tended to appear around the vibration antinodes of the oscillating files, there was no clear relation between the vibration amplitudes and the SCL emission [5], [6]. Furthermore, it was also reported that there was no correlation between the lengths of the endosonic files and the oscillation profiles [17]. Endosonics is an ultrasonic synergistic system of root canal instrumentation and disinfection. An endosonics is designed to allow the traditional endodontic irrigant, sodium hypochlorite, to pass through and along the endo-sonic files. The irrigant is activated by the ultrasonic energy imparted from the energized instruments and the root canal becomes an ultrasonic bath.

The term endosonics was coined by Martin and Cunningham [18], [19] and was defined as the ultrasonic and synergistic system of root canal instrumentation and disinfection. Ultrasound is

sound energy with a frequency above the range of human hearing, which is 20 kHz. The range of frequencies employed in the original ultrasonic units was between 25 and 40 kHz [20]. Subsequently the so-called low-frequency ultrasonic hand pieces operating from 1 to 8 kHz were developed [21] - [26], which produce lower shear stresses [27], thus causing less alteration to the tooth surface [28]. There are two basic methods of producing ultrasound [29] –[31]. The first is magnetostriction, which converts electromagnetic energy into mechanical energy. A stack of magnetostrictive metal strips in a handpiece is subjected to a standing and alternating magnetic field, as a result of vibrations. The second method is based on the piezoelectric principle, in which a crystal is used that changes dimension when an electrical charge is applied. Deformation of this crystal is converted into mechanical oscillation without producing heat [20]. Piezoelectric units have some advantages compared with earlier magnetostrictive units because they offer more cycles per second, 40 versus 24 kHz. The tips of these units work in a linear, back-and-forth motion, which is ideal for endodontics. Some authors [27] demonstrated that the position of nodes and antinodes of an unconstrained and unloaded endosonic file activated by a 30-kHz piezon generator was along the file length. As a result the file vibration displacement amplitude does not increase linearly with increasing generator power. This applies in particular finding the hidden canals or when removing posts and separated instruments. In addition, this motion is ideal in surgical endodontics when creating a preparation for a retrograde filling. A magnetostrictive unit, on the other hand, creates more of a figure eight elliptical motion, which is not ideal for either surgical or nonsurgical endodontic use. Themagnetostrictive units also have the disadvantage that the stack generates heat, thus requiring adequate cooling [20].

Conclusions:

In summary, endosonics is a valuable tool in the field of endodontics, as it helps to improve the effectiveness of root canal treatment while reducing the need for invasive procedures. The use of endosonics provides several benefits, including improved cleaning and shaping of the root canal system, reduced treatment time and improved treatment outcomes. Additionally, endosonics is minimally invasive and can help preserve more of the natural tooth structure, reducing the need for more extensive dental procedure. As well as explaining the endosonics biomechanical work, the work provides a basis for the further development and optimisation of the design of endosonic files.

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ДИГИТАЛНИ ОТПЕЧАТОЦИ-СОВРЕМЕН ТРЕНД НА ДЕНЕШНИЦАТА

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Апстракт

Земањето на отпечаток претставува најбитна процедура во секојдневната стоматолошка пракса. Целта на земањето на точен и прецизен отпечаток е да се прикаже димензиски стабилен негатив кој ја претставува моменталната ситуација од усната празнина. За изработка на адекватни протетски изработки најбитно е што е можно поточно репродуцирање на интраоралната состојба, и особено значајно е дека при присутна грешка може да се добие неквалитетна конечна изработка.
Современите дентални отпечаточни материјали се прецизни, хидрофилни и димензионално стабилни и можат автоматски да се замешуваат. Компаративно со развојот на конвенционалните отпечаточни материјали доаѓа до појава на интраорални скенери за дигитално отпечатување на различните структури во усната празнина. Интраоралните скенери се дигитални апарати кој во стоматолошката ординација се користат за дигитално земање на отпечатоци и прикажување на реалната состојба од усната празнина на пациентот и на пазарот и во секојдневната стоматолошка пракса се појавуваат во осумдесетите години на минатиот век.
Механизмот на нивната работа се темели на емитирање на структурирана светлосна мрежа или ласерски зрак кој доаѓа во контакт со површината која се скенира. За време на контактот со површината зраците се деформираат и се враќаат во камерата која го праќа применият сигнал во софтверот. Софтверот ги комбинира сите примени слики од снимените разни агли, земајќи ги во предвид движењата на скенерот како и оддалеченоста на објектите кои се скенираат, и на тој начин се реконструира скенираниот објект.
Денес на пазарот постојат разни интраорални скенери базирани на разни оптички компоненти и извори на светлина. Се разликуваат скенери базирани на активно произведување на бранова должина (True Definition Scanner, 3M), паралелна конфокална микроскопија (3Shape) и на оптичка триангулација (Sirona CEREC Omnicam). Покрај наведените постојат скенери кои користат и вештачка интелегенција како по секое скенирање имаат повеќе информации и податоци во врска со природните заби.
Најзначајните предности при употребата на дигиталните отпечатоци се однесуваат на тоа дека со нивната примена се скратува времетраењето на самите интервенции, има помала непријатност кај пациентите, станува збор за едноставна процедура, постои можност за електронски трансфер на самите податоци и се добива значително попрецизна и поточна презентација на состојбите од усната празнина на самите пациенти.

Клучни зборови:

дигитално отпечатување, интраорални скенери, отпечаток, отпечаточни материјали

Вовед

Денталното отпечатување има тенденција да стане рутинска постапка во секојдневната стоматолошка пракса. Најчесто отпечатувањето се изведува преку конвенционалната постапка која вклучува употреба на отпечаточни маси и лажици за отпечатување. Главната цел на отпечатувањето е да се регистрира оралната структура во негатив и како дефинитивен продукт се добива отпечаток. Излевањето на отпечатокот со материјалите за добивање на модели даваат позитивна репродукција на состојбата од усната празнина

на пациентот, а моделите подоцна ни служат за дијагностика, планирање и спроведување на план за третман,[8] па поради тоа прецизноста и димензионална стабилност на отпечаточните материјали се од исклучителна важност за да се добие прецизен и точен модел за изработка на самите протетски изработки.[9] Со традиционалните постапки се бележи долгогодишен клинички успех, но забрзаниот развој на тродимензионалната технологија последните десетина години овозможуваат работа со интраорални скенери кои овозможуваат изработка на тродимензионален дигитален модел и на тој начин да се намали можноста за појава на грешки.[2]

Тежнеењето да се поедностави постапката како и да се заштеди времето за целокупната тераписка постапка, но потребата за поголема прецизност како и поголема пријатност при интервенциите на самите пациенти, се една од предностите за кои дигиталната технологија сè повеќе наоѓа место во секојдневната клиничка пракса.

Како што напоменавме, конвенционалното отпечатување подразбира употреба на конфекциски или индивидуални лажици како и соодветен отпечаточен материјал за земање на отпечаток, а самата постапка за земање на истиот се изведува така што отпечаточната маса со соодветна коезистенција се поставува во лажица и со помош на ротационо движење се внесува во усната празнина на пациентот. Отпечаточната маса за време на внесување во устата е во течна или пак со пластична коезистенција, а по стврднувањето на истата, се вади од устата на пациентот, се дезинфицира и се праќа во лабораторија каде што техничарот го излева отпечатокот и се добива модел- кои е верна репродукција на она што се наоѓа во усната празнина.[8] Се со цел да имаме колку што е можно подобар модел потребно е отпечатокот да биде земен доста прецизно. Квалитетот на отпечатокот зависи од самите својства на отпечаточниот материјал, начинот на ракување со истиот, својствата на матерјалите за излевање на моделите, како и од вештината на самиот терапевт.[2] Прецизноста на отпечатокот покрај претходно наведеното зависи и од начинот на дезинфекција на отпечатокот,[17] начинот на транспорт до изведувањето на постапката на излевање,[9] одбирањето на соодветната техника на отпечатување,[10] како и од времето кое е поминато од стврднувањето до излевањето на материјалот.[16] Секој чекор од избор на лажица и отпечаточен материјал, па се до земање и излевање на отпечатокот, даваат можност за појава на грешка.[22]

Дигиталното отпечатување во денталната медицина се воведува во осумдесетите години на минатиот век, со развојот на технологијата, класичната дводимензионална дијагностика и терапија се заменува со напредна тродимензионална технологија.[20] Со новите материјали и технологии се подобрува ефикасноста, точноста, содржината а со тоа и предвидливоста на резултатите.[19] Три големи чекори во конвенционалната работата во стоматолошките ординации се дигитализирани. Прв чекор е собирање на податоци од пациентот и внесување на истите во дигитален облик, вториот чекор дава можност за планирање на рехабилитацијата на пациентот при што истата е потпомогната со дигитално планирање и симулација на екранот (ang. Computer Aided Design – CAD), додека третиот чекор овозможува користење на компјутерски изработки (ang. Computer Aided Manufacturing – CAM).[20]

Благодарејќи на бројните предности интраоралните скенери се користат во дијагностички цели и помагаат во планирањето на терапијата во разни гранки од денталната медицина. Во стоматолошката протетика се користи за изработка на дефинитивни реставрации како што се инлеи, онлеи, коронки и мостови, успешно се користат и за снимање на положбата на денталните импланти, додека пак во ортодонцијата најчесто служат за планирање на терапијата со помош на aligner и нивната изработка. [4, 11]

Денталните скенери се делат на интраорални и екстраорални (лабараториски) скенери.

- Интраоралните скенери се користат исклучително во ординација, а во состав на CAD/CAM системите служат за директно скенирање на интраоралните структури.[5]
- Лабораториските скенери се користат во заботехнички лаборатории и со нив се скенираат отпечатоци, кои се добиени со конвенционални методи за земање на отпечаток или пак за скенирање на веќе добиени излеани модели.[5]

И покрај тоа што се смета за тривијална и едноставна процедура, земањето на отпечатоци и излевањето на модели, без разлика дали е физички или виртуелен, се клучни чекори кои влијаат на добра дијагноза, планирање и спроведување на терапијата, затоа е неопходно да се обрне внимание на деталите и точните техники на отпечатоци за веродостојна репродукција на забните структури. [4]

Врз основа на фактот дека дигитализација во стоматологијата е несомнена, ја поставивме и основната цел на ова истражување да го опишеме методот на дигиталното отпечатување, начинот на создавање на дигаталните отпечатоци и предностите и нестостатоците на дигиталните отпечатоци.

Материјал и метод

Сѐ со цел да се исполнат основните цели, направено е литературно пребарување во интернет-базите со научни трудови, доминантно на PubMed, во претходно определен временски период, кој ја опфаќа последната деценија (2013-2023), пред се поради современоста на темата. Во делови од трудот се искористени и податоци од трудови кои се од постар датум, но истите се сметаат за базични. За комплетно исполнување на зададената цел изведен е сеопфатен литературен преглед и користени се податоци кои се публикувани на англиски јазик. За соодветно насочено пребарување беа користени само соодветни клучни зборови.

Беа користени трудови кои припаѓаат на категоријата: публикуван труд (Journal Article), клиничко испитување (Clinical Trial), рандомизирано контролирано испитување (Randomized Controlled Trial), прегледни трудови (Review), компаративна студија (Comparative study).

Преку исполнување на целите на овој труд сакаме да ги презентираме основните карактеристики на употребата на дигиталните отпечатоци во денталната медицина. Тоа се должи пред сѐ на фактот дека дигитализацијта во стоматологијата е сѐ попопуларна во последниве години. Дигиталното отпечатување како постапка поседува мноштво на индикации поради што сметаме дека ќе стане незаменлива алатка во секојдневата стоматолошка пракса.

Дентални скенери- иднина на стоматологијата

Врз основа на горенаведеното може да се напомене дка земањето прецизен отпечаток е една од најважните процедури во стоматолошката пракса. Важно е да се прикаже интраоралната состојба што е можно попрецизно, бидејќи грешките може да доведат до неквалитетен финален резултат- протетска изработка. Конвенционалниот метод на отпечатоци сѐ уште се смета за златен стандард за реплицирање на интраорални структури, но поради неговите бројни недостатоци, се наметнува потребата да се применуваат дигитални отпечатоци.[3] Стекнувањето на тродимензионални слики на оралните структури овозможуваат виртуелна дијагностика, планирање на терапија како и дизајнирање на самите конструкции со помош на глодање/печатење на завршните конструкции.[6]

Како што напоменавме, дигиталниот отпечаток се зема на два начина - со индиректен метод, со скенирање на конвенционален отпечаток или пак со скенирање на моделот во гипс, и со директен метод, со печатење на дентогингивалните ткива за да се добие

дигитален тридимензионален модел.[18] Оптичките отпечатоци даваат бројни предности како што се намалена непријатност кај самите пациенти, поедноставување на клиничката процедура, непосредна размена на податоци со лабораторијата, заштеда на време и можност за складирање на дигитални модели без потреба од лиење на физичкиот модели.[12]

Со цел да се подобри прецизноста и точноста на отпечатокот, заедно со сеопфатната дигитализација, стоматолошките скенери започнуваат да се развиваат во средината на осумдесетите години. Најпрво се користеле во стоматолошките лаборатории, а денес се повеќе наоѓаат примена во секојдневната пракса во стоматолошките ординации како интраорални скенери.[14]

Денталните скенери се една од трите главни компоненти на компјутерски потпомогнатиот дизајн/компјутерски потпомогнато производство, односно CAD/CAM системот (анг. Computer Aided Design / Computer Aided Manufacturing). Составните делови на овој систем се:

- Скенер – уред кој собира податоци за површината подготвена за отпечатување во три димензии и ги претвора во дигитална форма.
- Софтвер - се користи за анализа на податоци кои можат да се складираат во различни формати. Најчесто тоа е STL формат (Surface Tesselation Language и STereoLithography).
- Фреза – машина со која ја добиваме посакуваната форма со помош на фреза и алат за брусење. [13]

Развојот на CAD/CAM системот започнува уште во педесетите години на минатиот век, а првиот систем кој влезе во секојдневна употреба во стоматолошката медицина е создаден во 1987 година со развојот на CEREC 1 од компанијата Сирона, Италија.[13] Д-р Моерман и неговите колеги потоа развиваат систем кои е за употреба во канцеларија (eng. in-office), таканаречен систем “chairside“, каде што имаме директна техника за изработка на протеза во ординација и тоа во само една посета.[5] Сите компоненти на CAD/CAM системот се сместени во самата ординација, така што нема потреба од дополнителна соработка со заботехничка лабораторија.[15]

Покрај техниката “chairside“, постојат уште две CAD/CAM техники. Едната од нив е интегрирана ординациско-лабораториска техника која бара две посети, во првата посета се врши скенирање на самата ситуација во усната празнина на пациентот, додека во втората посета имаме предавање на претходно изработената конструкција во лабораторија со помош на CAD/CAM системот. Стоматологот во ординацијата може да ја потисне препарацијата со скенирање или да користи една од конвенционалните процедури со кои се зема отпечаток и се добива модел и потоа истиот се скенира во лабораторија. Третата техника е централизирано производство во центарот за глодање. Кај оваа техника „сателитските скенери“ во лабораторијата се поврзани преку интернет со центрите за глодање. Готовите податоци за обликуваните конструкции од лабораторијата се испраќаат до глодачкиот центар, а готовата реставрација од истиот се враќа во лабораторијата каде што техничарот дополнително ја дообликува самата конструкција.[13]

Денес на пазарот се достапни екстраоралните стоматолошки скенери кои скенираат веќе испечатени отпечатоци или излеани модели и интраорални скенери кои ги скенираат интраорални структури.[14]

Десктоп дигиталните скенери овозможуваат исклучително висококвалитетна дијагностика, анализа, планирање и споредба на дигитални отпечатоци и модели. Со него управува техничар кој ја дизајнира идната конструкција и потоа ги испраќа овие информации до машината што ја произведува самата конструкција.[14]

Интраоралните скенери денес стануваат сè попопуларни. Тие го поедноставуваат процесот на земање на отпечаток бидејќи состојбата на пациентот директно се

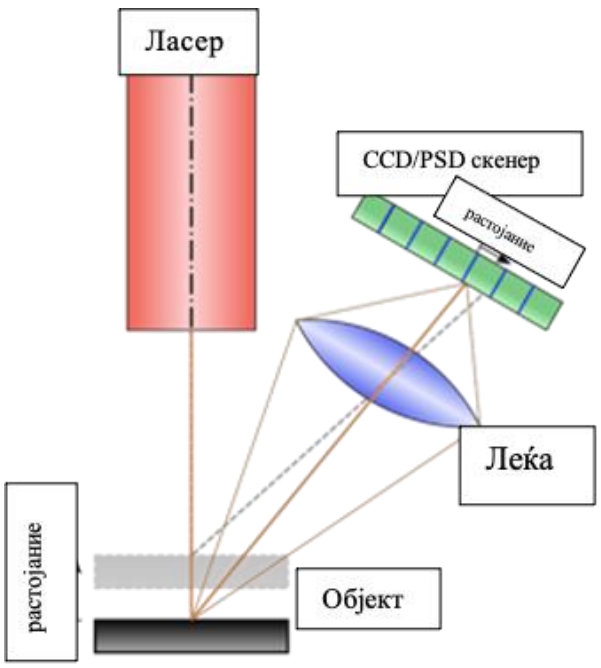
пренесува на екранот со помош на сензорот од камерата која се поставува во усната празнина на пациентот, а снимените слики се обработуваат во софтвер. Резултатот кои се добива со овие скенери е 3D модел, виртуелна алтернатива на традиционалниот работен модел.[12] Со оглед на тоа што не постои конвенционален начин на земање на отпечаток и излевање на модел, помала е и можноста за појава на грешка.[14]

Поделба на итраоралните скенери

Интраоралните скенери може да се поделат на неколку начини:

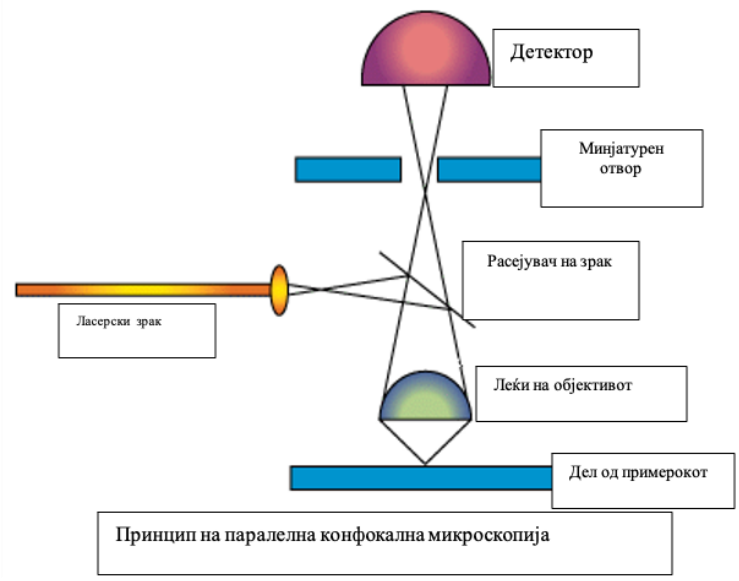
1. Разликуваме скенери кои бараат кондиционирање на скенираната површина со прашок или спреј, на пример прашок од титаниум диоксид или црно-бел прав, со цел да се постигне рамномерна рефлектирачка површина за соодветно тродимензионално скенирање и оние каде што не е потребно кондиционирање, таканаречените скенери „без прав“(powder-free). Системите кои не бараат кондиционирање на површината се значително попрецизни, имајќи предвид дека начинот на нанесување на правот може да влијае на квалитетот на отпечатувањето.[12,21]
2. Според методот на работа, скенерите можат да се поделат на три основни системи – оптичка триангулација, паралелна конфокална техника и активно земање на примероци од брановидни примероци.

2.1 Оптичка триангулација – оптички скенер каде изворот на светлина е ласерски зрак или бела светлина.[13] Главата на камерата испушта светлина под одреден агол на површината. Кога ќе го погоди предметот што се снима, тој се рефлектира според текстурата на површината под одреден агол назад кон единицата што прима. Таму се открива од чип што е чувствителен на светлина и врз основа на аголот на отклон помеѓу емитирана и рефлектирана светлина, се пресметува обликот на снимениот објект.[21] Растојанието на објектот се мери без допирање, со точност од неколку милиметри до неколку микрони. Триангуларните сензори се корисни каде што е потребно брзо собирање податоци, кога се гледаат чувствителни меки и влажни ткива, и таму каде што контактот е непожелен .[19] (Слика 1).



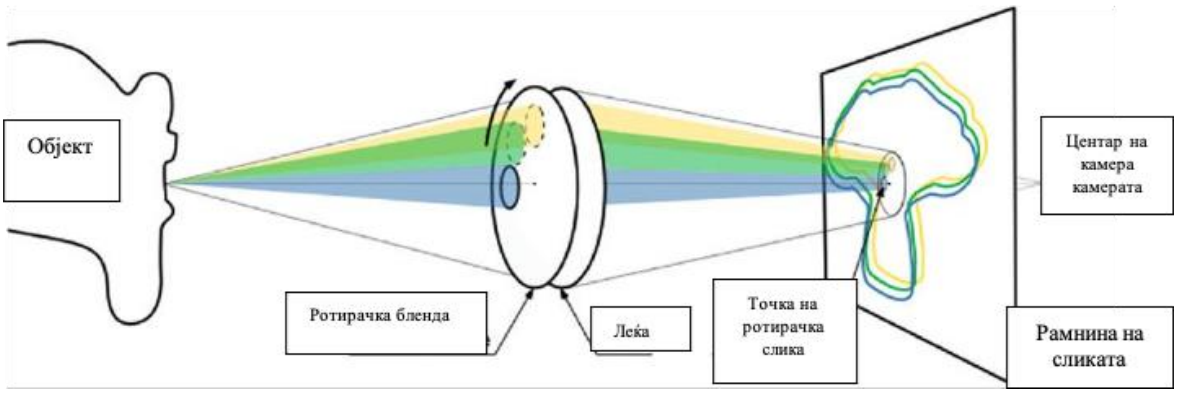
Слика 1. Шематски приказ на дигитализација по принцип на оптичка триангуација
преземено од 3D scanning. Wikiwand [cited 2019]; Available from: https://www.wikiwand.com/en/3D_scanning

2.2 Паралелна конфокална микроскопија (анг. Confocal Laser Scanner Microscopy) – кај овој метод се емитуваат паралелни зраци на светлина кои се рефлектираат од површината на предметот што се скенира по истата патека на зракот и паѓаат на фотосензитивниот сензор. 3D сликата се реконструира со помош на компјутер, а не преку окулар (леќа). Добиената слика може да се подели на делови со висока резолуција со верно прикажување на длабочината на објектот. Положбата на светлосниот зрак на сензорот дава информации за сагиталната, фронталната и трансверзална рамнина.[21] Можно е и просторно филтрирање, кое се користи за отстранување на рефлексии надвор од фокусот или за отстранување на позадината. (Слика 2).[19]



Слика 2. Принцип на работа на апарати со дигитализација на принцип на паралелна конфокална микроскопија
Преземено од Sason, Gursharan Kaur, et al. "A comparative evaluation of intraoral and extraoral digital impressions: An in vivo study." *The Journal of the Indian Prosthodontic Society* 18.2, 2018, pp. 108.

2.3 Активно земање примероци од брановидни површини - бара само една оптичка патека на модулот AWS и една камера за да се добијат информации за длабочината (9). Секоја снимена точка на површината се прикажува во однос на движењето во различни времиња на различни позиции на сензорот како пиксел. Врз основа на просторното и временското поместување на истиот пиксел во различни времиња, може да се пресмета тродимензионалната форма на објектот.[21] (Слика 3).



Слика 3. Принцип на работа на интраоралните скенери врз база на Active Wavefront Sampling
Преземено од Mangano, Alessandro, et al. "Suppl-1, M8: conventional vs digital impressions: acceptability, treatment comfort and stress among young orthodontic patients." *The open dentistry journal* 12, 2018, p.118.

3. Во однос на компатибилноста скенерите ги делиме на отворен и затворен состав. Кај отворенниот состав скенираните податоци можат слободно да се експортираат и да се обработуваат во програм за дизајнирање и планирање на други произведувачи. Достапни се режачи, 3D принтери и тн. независно од произведувачот. Универазалниот јазик на CAD/CAM системот кој ги поддржува повеќето интраорални скенери е STL форматот. Предноста на таквиот систем е добрата поврзаност со сите произведувачи, од наједноставните програми за дизајнирање до најпрецизните произведени единици, но потребно е исклучителна добра координација на сите чекори, а конверзијата на отворените формати може да предизвика губење на квалитетот на моделот. Од друга страна кај затворениот систем сите компоненти на произведениот ланец меѓусебно се оптимално координирани така што потенцијалните грешки лесно се елиминираат чекор по чекор. Некој затворени системи нудат комплетен дигитален тек на работата и нудат оптимално решение. Лимит за таквиот состав се додатни трошоци за отклучување.[12,19]

Компарација на конвенционална и дигитална отпечаточна техника

Најчесто споменуваната разлика помеѓу конвенционалните и дигиталните техники за отпечатување е времетраењето на самата процедура. Конвенционалниот метод на отпечаток бара многу чекори: избор на соодветна лажица, нанесување на атхезивно средство, нанесување на отпечаточен материјал, внесување на лажицата во устата на пациентот, стврднување на отпечаточниот материјал, дезинфекција, регистрирање на меѓувиличните односи, испраќање на отпечатокот во лабораторија, излевање на моделот од отпечатокот, испраќање на моделот назад во ординација, складирање на моделот итн. Интраоралните скенери значително го намалуваат бројот на потребни чекори и ја сведуваат процедурата на внесување на податоците за пациентот, за многу по краток временски период, внесување на инструкции за постапките кои треба да се изведат во лабораторијата како и останатите фази на скенирање на двете вилици и меѓувиличните односи.

Времето потребно за отпечатување со еден од стандардните методи е во просек 10 минути, додека времетраењето на процедурата со помош на интраорални скенери се намалува на околу 4 минути. Потребни се околу 4 минути за да се земе отпечаток од спротивната вилица со помош на конвенционалниот метод, и околу 90 секунди за да се регистрираат меѓувиличните односи. Техниката за дигитален отпечаток бара во просек 90 секунди за да се отпечати спротивната вилица и само 15 секунди за да се регистрираат меѓувиличните односи.[22]

Употребата на интраорални скенери овозможува подобра комуникација со самите пациенти. Протетската конструкција изработена во CAD/CAM системот може да се заврши во една посета, а дополнително може да се направи и високо естетска привремена работа која може да го отслика изгледот на идната конечна реставрација со неговата форма, боја и големина. Привремените изработки служат како шаблон за пациентот да се навикне на идната конструкција и врз истата да ги изрази своите желби и потенцијални промени. Од друга страна, доколку пациентот е задоволен од привремената протетска конструкција, податоците за креирање на дефинитивната конструкција се складираат и служат како шаблон за создавање на истата.[12,21] Исто така, дигитализацијата представува моќно средство за комуникација што сугерира можни терапевтски опции, а исто така е можно да се споредат.[7]

Недостатокот на интраоралните скенери се јавува при прикажување на маргиналниот раб на субгингивалните препарации. Потребата од субгингивална препарација особено се однесува на предните делови на забниот лак, каде што е неопходно да се постигне естетски задоволителна изработка. Изворот на светлина на интраоралните

скенери не може да го одвои мекото ткиво, па затоа не може да стигне ниту до самиот раб на самата препарација.[12]
Се смета дека дигитализацијата ги намалува трошоците за целата постапка при самата терапија.Како предности на дигиталните отпечатоци се вбројува релативно краткото време на отпечатувањето, чувството на пријатност на самиот пациент, подобрата комуникација на стоматологот со самиот забен техничар, поедноставена клиничка процедура, пренос на податоците преку интернет, намалена потреба од физичко слкадирање, едноставно повторување, подминираните делови не претставуваат никаков проблем при самата постапка на отпечатувањето, снимање на сегменти од подрачјето за кое имаме потреба како и приказ во стварно време, додека како недостатоци на дигиталните отпечатоци се вбројуваат трошоците за набавка и одржувањето на самиот скенер, тешкотии при отпечатувањето на длабоки маргинални препарации, дополнителна едукација за земање на отпечаток.[12,21]

Заклучок

Трендот во денешницата е модернизирање на земањето на отпечатоците во секојдневната пракса, потребно е колку што е можно повеќе да се намали времето на работа, а да се зголеми продуктивноста и добивањето на добри резултати. Интраоралните скенери денес во секојдневната пракса наоѓаат сè поголема примена и земаат сè поголем замав со стоматолошката протетика.

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DESIGN AND IMPLEMENTATION OF SCADA SYSTEMS

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Abstract

This paper discusses SCADA systems, their planning and projecting, and their increasing implementation in industry. SCADA are used for 24-hour supervision and management in systems and processes.
Industry requires daily supervision and management of processes, and technology advancements enable more efficient and creative management. SCADA systems enable control and supervision of complex systems, and also enabling employees to be more creative and productive. SCADA systems enable the management of subsystems in different locations, enhancing overall efficiency and productivity.

Key words

SCADA systems, contoling, proceses, sensors, PLC controller

1. Introduction

In the industry, there is a daily need for supervision and management of various processes. As technology develops, so do the possibilities for supervision and management of various processes. Everything that used to be done manually in industry now can be done automatically. For example, in the past, if a certain room had to have a set temperature, the employees had to go to the thermometer itself and look at the temperature in the building. With the development of technology, this process is not only facilitated, but it is also possible to monitor the data from a distance, so the employee does not need to go to the room to find out what the temperature is. This alone saves time that the employee would have spent, and the company itself becomes more productive.

The implementation of modern technologies in the industry will not only make employees more productive, but the same results can be achieved with a smaller number of employees. The implementation of new technologies and the automation of processes are the future for all companies. More and more companies have a lack of manpower, so where the process can be automated, it will be done, and the human factor, which is less and less available, will be used only in places where it is necessary, in places where the automated processes will be managed.

For the simplest case of process management, the process itself should be equipped with measuring instruments that correspond to the purpose for which the management is carried out and a certain type of control device. If a certain process meets these conditions, then it can be controlled through a system that will meet the needs of the user. Usually, the needs of the industry are to control different subsystems that are in different locations. To enable such control and supervision, computer-supported systems known as SCADA (Supervisory Control and Data Acquisition) systems are used. These systems are particularly suitable where 24-hour supervision and control of the processes being carried out are required.

2. SCADA systems

SCADA (Supervisory Control And Data Acquisition) is a system that is used to automate general processes. It is used to collect data from sensors and instruments located at remote stations and transmit and display that data at the central station for monitoring or management.

SCADA involves collecting, transferring, analyzing, and controlling information at a central site and displaying it on operator screens or displays. Control actions are then conveyed back to the process [1].

SCADA systems are computerized systems that are widely distributed. These systems are primarily used for remote management and monitoring of processes or plants with central locations. Almost any industrial automation system includes sensors for the detection of the various "states" of the controlled manufacturing process and actuators as outputs for real-time acting and achieving the desired behavior of the production procedure.[3] This means that the data is collected and sent to the headquarters (dispatch center), the necessary analysis is performed, and, if necessary, management is generated. At the end, a graphic display of the processed data is made, and this display is displayed on an operator terminal, which, depending on the complexity of the process, is displayed in the form of one or more monitor screens. Figure 1 shows a simple SCADA system for drinking water distribution.

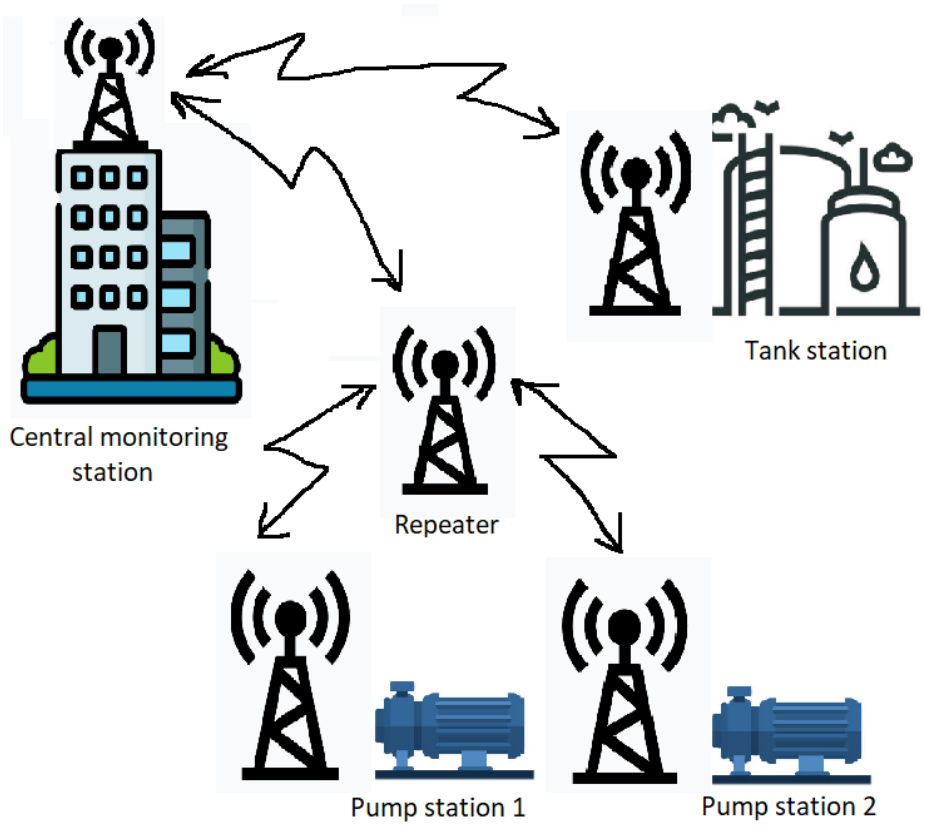

Fig. 1 SCADA system for drinking water distribution.

The main goals of SCADA systems are:

1. Carrying out supervision;
2. Establishing the management of the system in order to ensure the functioning of the system as expected from it;
3. Reduction of the need for human labor by applying process automation;
4. Storage of system behavior data;
5. Provision of information about the functioning of the system;

6. Establishing efficient functioning of the system without the need to go physically to the place where the process takes place;
7. Provision of a management system that will enable certain activities to be carried out remotely;
8. Provision of an alarm system that will enable the improper operation of the system to be monitored early and saved from the central location, from where it would be possible to stop the process, which would avoid major damages and accidents.

SCADA systems, in addition to being suitable for monitoring and managing processes that are carried out in remote locations, also are suitable for applications in processes that are dangerous to the lives of workers. The SCADA system does not always have to be implemented in the monitoring of processes that take place in geographically distant locations from each other; it can also be implemented in the monitoring of processes that are located in the same place, for example, in a factory plant. With the help of SCADA systems, the same functions can be realized across processes, regardless of whether they take place in the same location or are geographically distant.

In general, SCADA systems consist of several functionally connected units. The basic elements of SCADA systems are:

1. Measuring and regulation equipment;
2. Remote stations;
3. Communication system;
4. Supervisory -control center.

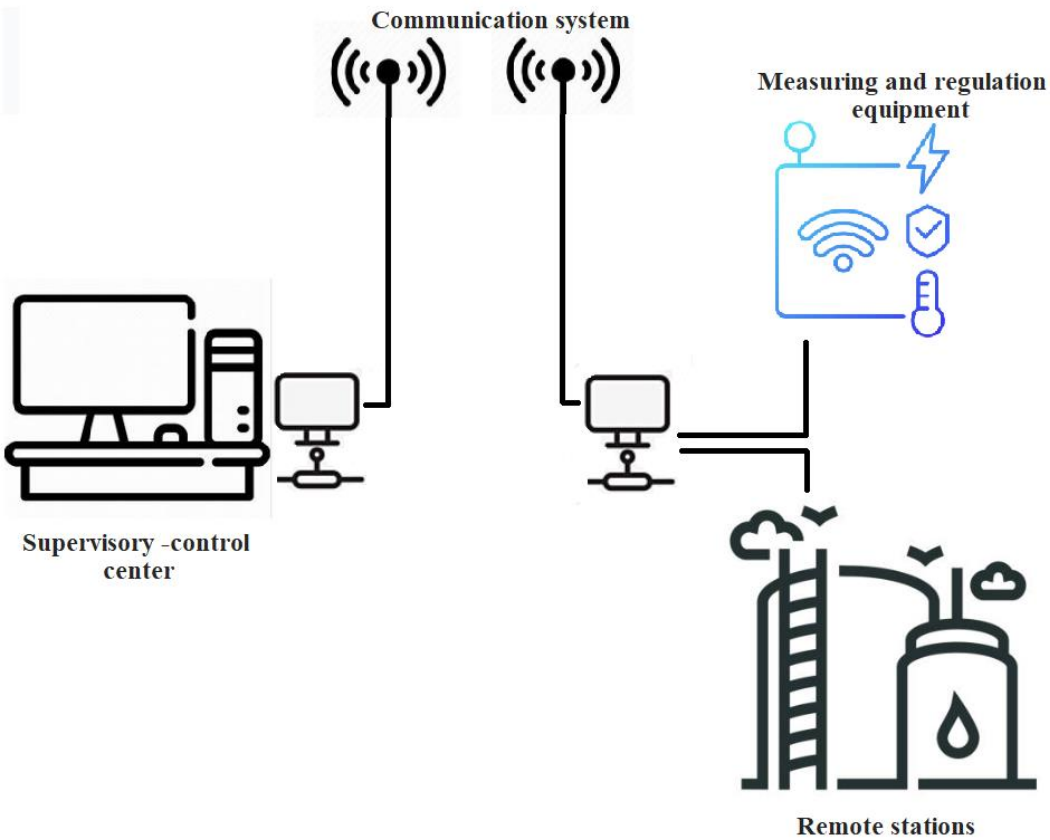

Fig. 2 Simple example of a SCADA system

Data collection is possible with the help of remote stations that scan the input devices, that is, the measuring equipment connected to the PLC devices. Then the central control unit scans the PLC devices in the SCADA system itself with the help of the communication system. The

received data is processed due to the detection of the set alarms; if inappropriate data is detected or a value does not correspond to the set limit, an alarm is activated that is visible to the operators themselves. Operators are notified of the alarm by graphic and sound signaling at the operator stations themselves. Operators can react and remove the reasons for which the alarm appears, which would prevent greater damage to the process. [2]

All processed data (process parameters, alarms, etc.) is stored in a database that is usually located on a computer that has the role of a server; access to data from the server is done using a specialized server.

Finally, with the help of specialized software, it is possible for the operator to give appropriate commands (through the communication system) as a suitable action for the events in the process, and it is possible for the software itself to generate suitable management actions. The control actions are defined by the central computer, and usually it is data that is sent to the PLC devices, which further perform the appropriate action.

The software used by operators and other responsible parties provides a wide range of possibilities, which can be split into two groups: [5]

- The possibility to monitor the data - Data that can be monitored in real time include the position of the alcove's components (busbar, line, earthing, circuit breaker), values for each phase's current and voltage, as well as information on active power, reactive power, apparent power, energy, power factor, frequency, relay parameters, and more.

- Ability to command (control) - Circuit breakers and protective relays are examples of equipment that can be remotely operated. Thus, it is possible to remotely turn on and off the circuit breakers. Operators stationed at the control center will be notified in real time the instant a feeder ceases to function as a result of any breakdown or problem.

When the SCADA system is implemented into the technological processes, it should be allowed for its upgrade to additional functions, either due to the development of the process itself or due to the improvement of management. SCADA systems should be built as an open system, and this is made possible by the fact that this system is based on information, so upgrades in its functionalities are possible. Therefore, open systems are a method of evolution for a control system based on nonproprietary and common software and hardware interfaces that enables future updates to be offered from various vendors at reduced cost and incorporated with comparatively little risk. [6]

3. Planning and designing of SCADA system

Automation is the process of replacing human decision-making and manual command-response tasks with logical programming commands and automated machinery. [4]

The future of every company is the implementation of SCADA systems and the automation of the processes that are carried out in the company itself. The automation itself would speed up the action of the process itself because all the things that the employees do manually, if it is possible to do them automatically, would save time and human resources for the execution of the process.

A growing number of companies in our country and around the world are facing a lack of labor force, so exactly the companies that will reduce the need for labor force will be more competitive in the market. It would be much easier to manage the processes themselves, and they would be executed in a shorter time interval if the human factor was reduced to a minimum.

Each company should first consider several factors that are key to deciding whether to introduce a SCADA system into its operations. It is necessary to pay attention to and analyze the following questions:

1. Can the processes that are performed in the company be automated?
2. What would be the advantage of automating the process?
3. Finding a company that will submit an offer for automation
4. Analysis of the offer in order to see the profitability of the investment.

In the following, we will use a Decision tree model, which should be used by every company that plans to introduce a SCADA system into its operations.
A decision tree is a decision-making model that is similar to a tree, hence its name. Decision tree models are used in the exploration of possibilities, especially in decision-making, to help achieve a specific goal.

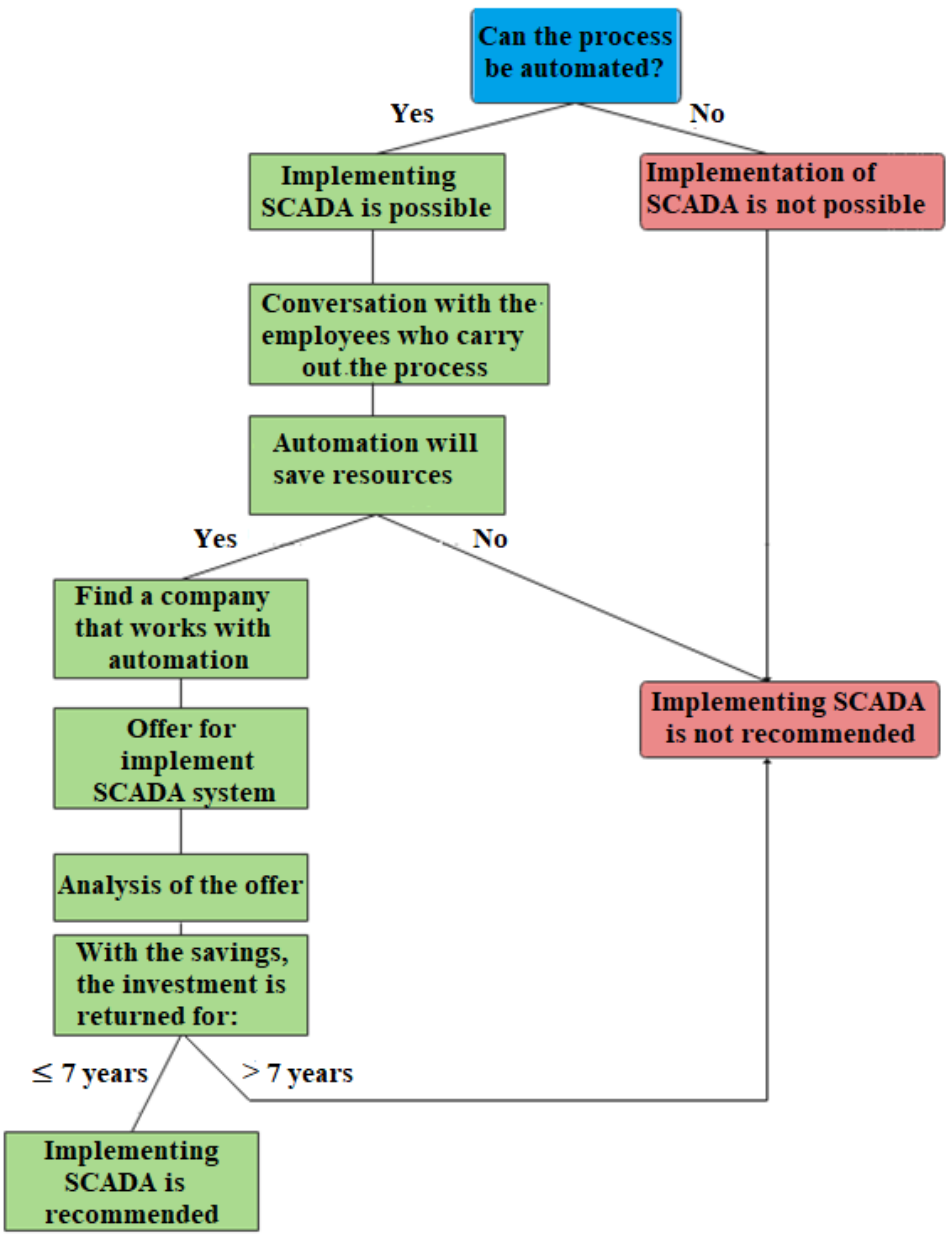

Fig. 3 Decision tree model for implementing a SCADA system

When designing a SCADA system, the processes that the system performs should be defined first. After defining the processes in the system, an analysis is made as to whether they can be

automated. There are cases in which some of the processes can be automated and some cannot. So an additional analysis is needed to determine whether, by automating part of the processes, some benefit would be obtained from the implementation of a SCADA system.

If the benefits obtained are minimal or the processes in the system cannot be automated, then the implementation of a SCADA system is not recommended.

If by automating part of the processes that are carried out in the system or by automating the entire system, there are possible benefits, such as faster execution of processes, reduced need for the human factor, increased reliability, and faster reaction for damage prevention, then it is necessary to continue with additional analysis that will lead us to the decision whether to implement a SCADA system or not.

First of all, an analysis is made of what would be gained by implementing the SCADA system: whether the number of employees hired to perform a certain process would be reduced, whether the duration of the process could be reduced, whether alarms could be introduced, and whether limit values of the process parameters could be introduced in order to prevent unwanted actions and damages that would occur if the process did not move according to the defined directions.

If we think that by implementing a SCADA system we can fulfill some of the above advantages, then it is necessary to contact a company that deals with automating processes.

The company itself, in a conversation with the employees who have activities on a given process, defines which part of the process could be automated and which hardware needs to be incorporated.

The automation company submits an offer that specifies the equipment and, of course, the investment that the company needs to make to automate the process.

With the savings that the company would have with the automation, reducing the number of employees who perform the process and reducing other resources needed to perform the process would cover part of the investment required for the automation of the process, so the company should make an appropriate analysis. The analysis consists of how long the company implementing a SCADA system would need to cover the funds invested in installing the system. If the investment can be recovered with the savings from the introduction of automation in 7 years or less, then this investment is worthwhile, and the company should implement a SCADA system. If the investment made by the company cannot be returned in more than 7 years, then it is an investment that is not profitable, so the recommendation is to not invest in the installation of a SCADA system.

4.Conclusions

Implementing a SCADA (Supervisory Control and Data Acquisition) system in an organization or industry can bring several advantages. SCADA systems enable centralized monitoring and control of various processes, allowing operators to streamline operations and improve efficiency. Real-time data acquisition and analysis help identify bottlenecks, optimize workflows, and reduce downtime, leading to increased productivity. SCADA systems provide operators with accurate and timely data on process performance, equipment status, and environmental conditions. This data empowers decision-makers to make informed choices, respond quickly to issues, and implement strategies for process optimization and resource allocation. SCADA systems allow operators to remotely monitor and control processes, even from off-site locations. This capability enables 24/7 monitoring, reduces the need for on-site personnel, and facilitates rapid response to emergencies or equipment failures. By optimizing processes, reducing downtime, and enabling predictive maintenance, SCADA systems can lead

to significant cost savings. They minimize manual intervention, prevent costly equipment failures, optimize energy consumption, and improve resource allocation, resulting in reduced operational expenses. Implementing a SCADA system can provide organizations with operational advantages, increased safety, improved decision-making, and cost savings, ultimately contributing to their overall success and competitiveness.

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ПРЕДНОСТИ И НЕДОСТАТОЦИ ПРИ ИЗВЕДУВАЊЕ ONLINE НАСТАВА ПО МАТЕМАТИКА

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Апстракт

Наставниот процес и начинот на изведување и одржување на наставата се најважни за продуцирање на образовани, таленирани и способни експерти во која и да било област. Доста време наставата во универзитетите и училиштата се одвиваше на класичен начин во предавална, амфитеатар или училница. Новини кои се воведува со тек на годините беа дигитализацијата, примената на интернетот, користење на платформата е-учење и слично. Ковид 19 пандемијата наложи целосна промена на тој класичен начин на спроведување на наставата т.е. ја донесе потребата од воведување и спроведување на online настава. Целта на оваа студија е да се согледат придобивките и недостатоците од реализрање online настава по Математика во образовните инситуции.

Клучни зборови:

online настава, дигитализација, интернет

Вовед

Под поимот наставен процес или настава се подразбира организирана, системска и усогласена дејност на професорот и студентите т.е. наставникот и учениците, при која што студентите/учениците активно и според определен систем:

1) Се здобиваат со знаења, навики и вештини;
2) Ги развиваат своите физички и психички способности;
3) Изградуваат научен поглед кон светот;
4) Ја совладуваат вештината на учењето и културата на работата;
5) Се оспособуваат за самообразование и практична работа;
6) Се воспитуваат како сестрано развиени личности.

Од тука согледувајќи ја важноста на наставниот процес, можеме да кажеме дека начинот на неговото изведување и спроведување мора да биде најквалитетен и најприфатлив и за професорите и за студентите. Дигитализацијата која почна одамна секаде да се применува не го заобиколи ниту образованието. Појавата и брзиот развој на компјутерската техника овозможи примена на компјутерите и во образованието. Појавата и развојот на интернетот и неговата достапност овозможи примена на интернетот и во наставниот процес и тоа многу одамна.
Најголемата промена во наставниот процес се случи со појавата на Ковид 19 пандемијата во 2020 година секаде низ светот. Пандемијата наложи прекин на класичниот начин на одржување на наставта во образовните установи и потреба од воведување online настава т.е. настава која ќе се изведува од дома и ќе се следи од дома со примена на интернет, компјутер, паметен телефон, таблет и платформа за најава. Значи дури и појавата на светската пандемија не можеше да направи образовната надградба да застане пред се

заради тоа што наставата е важна и значајна, но секако и благодарение на развиената информатичка технологија во денешно време секаде во светот.
Преминот од класична во online настава за образовната заедница во која се и студентите и професорите беше проследен со двоумење, скептицизам, неверување и сл. Но за кратко време се покажа спротивното. Наставниците, професорите, учениците и студентите за кратко време се адаптираа на промените, обезбедија се што им е потребно за течење на наставниот процес и наставата продолжи да се одвива непрекинато и во време на пандемијата. Online наставата беше правото решение бидејќи не смееше да се дозволи пандемијата да му наштети на квалитетот на студирање и учење на оние во чии раце се наоѓа иднината на нашата земја, но и иднината на светот. Универзитетите ширум светот и училиштата почнаа да користат различни платформи за далечинско учење како што се Microsoft Teams, Zoom, Google Meet, Google Classroom и други. Целта на секоја од тие платформи беше следење на наставата од дома со примена на интернет и ресурс за инсталирање на однапред одредената платформа. И универзитетите и училиштата во нашата држава ги прифатија предизвиците и непречено спроведуваа online настава. Повеќе од две години се спроведуваше наставата на тој начин. Со средување на состојбата со пандемијата постепено образовните институции повторно се отворија.

Преглед на литература

Математиката е насекаде околу нас. Без математика не можеме да објасниме некои сложени физички и природни појави. Потребата од математичари е се поголема, а бројот на математичари се помал. Како резултат на тоа, а и поради други причини доста често се анализираат резултатите на студентите по математичките предмети на универзитетско ниво [13].

Сведоци сме на повеќе истражувања поврзани со наставата во услови на најновата пандемија со Ковид 19. Анкетирани се студентите со цел да се види нивното мислење за online наставата за сите предмети но посебно за математичките [8]. Потоа, анализирани се резултатите од постигнувањата на студентите на завршниот испит по предметот Оперативни системи на Факултет за информатика при Универзитет „Гоце Делчев“ Штип од различни учебни години. Едните од студиска 2018/2019 кога наставата се одвиваше на класичен начин со физичко присуство и другите од 2019/2020 кога наставата се одвиваше online преку платформа [3]. Целта на истражувањето била да се увиде кој начин на спроведување на настава допринесува за подобри резултати на завршниот испит. Цел на претходни истражувања биле и постигнувањата на студентите на колоквиумите (прв и втор) при различни начини на нивно спроведување [10]. Влијанието на online наставата врз постигнатите знаења на студентите е истражувано и преку набљудување на резултатите на студентите на прв и втор колоквиум по предметот Математика на Факултет за природни и технички науки, Универзитет „Гоце Делчев” Штип, така што студентите следеле настава и полагале прв колоквиум со физичко присуство, а материјалот за втор колоквиум го следеле online и колоквиумот го полагале online [9].

При организирањето на online настава по математичките предмети многу професори се трудеа да користат некој образовен софтвер во основното, средното и високото образование. Значењето на софтверот, важноста од неговото користење во образовниот процес и предностите што ги носи со себе во постигнувањата на учениците и студентите може да се види во [4], [5] и [7].

[6] Дава опис на функционирањето на образовниот процес за време на пандемијата со Ковид 19. Акцент е ставен на примената на ИТ технологиите за успешно спроведување на наставата. Истакната е важноста од примената на ИТ технологии во образованието, а со тоа и предностите што тие ги носат.

Online наставата беше предизвик како за учениците и студентите така и за наставниците и професорите. Наставниците и професорите уште пред појавата на пандемијата се подготвуваа за воведување на ИТ технологии во образовниот процес. Целта на [11] е прифаќање и користење на системот е-учење од наставниот кадар. [1] пак демонстрира успешна апликација за е-учење развиена со Adobe Captivate, која е моќна алатка за креирање интерактивни апликации. Апликацијата за е-учење е базирана на SCORM и ја оценувале учениците од VII одделение како и нивните наставници и родители. Евалуацијата покажала дека апликацијата за е-учење ја постигнала својата цел и може да биде основа за развој на слична апликација во сите училишта во Република Северна Македонија.

Електронското тестирање се спроведувало уште пред појавата на последната светска пандемија [2]. Online учењето пред појавата на последната пандемија не беше толку популано, но тоа не значи дека беше и непознато. Уште пред појавата на пандемијата се правеа напори и се вршеа истражувања да се увиде колку далечинското учење може да биде ефикасно и колку би имале полза од негово користење. Потврда за тоа се и проценките на потенцијалите на учењето на далечина преку видеоконференции направени во [14]. Исто така во [14], направена е споредба на мислењето на студентите за учењето на далечина преку видеоконференции и традиционалното учење во образовната институција. Во [12] авторите имаат за цел да ги споредат знаењата на студентите по предметот Калкулус 2, од два технички факултети во две различни академски години 2014/2015 кога наставата се реализирала со класична метода со табла и креда и 2015/2016 година кога наставата се спроведувала како комбинација на класичен метод и користење на математички софтвери како MatLab и Mathematica, во период кога немало некаква пандемија.

2. Што е online настава?

Спроведување на наставата преку вебинар платформа за учење и користење на дигитални алатки за нејзино реализирање како и интернет при што предавачите и слушателите не се во иста просторија т.е. секој си е на своја избрана локација можеме да кажеме дека претаствува online учење или online настава. Online наставата во целост почна да се применува со појавата на Ковид 19 вирусот и се применуваше се до стабилизација на состојбата со истиот. Речиси преку ноќ, образовните установи беа заменети со софтверски алатки кои требаше да овозможат реализација на наставата и ефективност во учењето во вонредни услови. Од наставниците, учениците, родителите, професорите и студентите се очекуваше лесно и брзо да се прилагодат на новонастанатите услови. Се разбира, предизвиците беа бројни и не се врзуваат единствено за подготвеноста да се користи технологијата. Имено, успешната online настава подразбира подготовка, осмислување и планирање на сите видови интеракција од традиционалната училница во online просторот. Претходно пред појавата на вирусот наставата беше дигитализаирана, се користеа компјутери во наставата, се користеше интернет, се користеше moodle, но наставата се изведуваше во образовните објекти и директните контакти беа присутни. Online начинот на спроведување на наставата наиде на различни коментари од луѓето инволвирани во него на било кој начин, но и од тие кои директно или индиректно не беа инволвирани. Коменатрите, размислувањата, ситуацијата во која сме денес, беа едни од причините да го креираме овој труд во кој ќе дадеме наше видување за online наставата.

3. Предности од спроведување на наставата online

Разликите помеѓу наставата во училница/предавална и online наставата постепено се намалуваа. За ова голема заслуга има технолошкиот напредок, ИКТ алатките и слично преку кои е овозможена интеракцијата во живо во процесот на online учење.

Мислењата за квалитетот на наставаниот процес во периодот кога наставата се одвиваше online се различни. Како и да е, мислењето на секој поединец треба да се почитува и согледувајќи го општото мислење да се прават промени со цел постигнување на квалитетно образование дури и подобро од претходното класичното. Во продолжение наведуваме листа на предности при изведување online настава по математичките предмети:

- Ако во класичната настава таблата е ресурс кој наставникот го користи за да го напише предвиденото за часот и после испишување на табалата напишаното треба да се избриши, во online наставата исто може да се користи табла како Microsoft Whiteboard така што при испишување на листот во кои работиме имаме опција истиот да го зачуваме и прикачиме на студентите или учениците на некои од ресурсите за споделување документи. Таблата е алатка што помага во обезбедувањето интеракција со учениците и поттикнува нивно учество. Како и таблата во традиционална училница, таблата на вебинар алатките има слични основни функции – да се забележат и илустрираат основни поенти од предавањето, да се запишат клучни зборови при нафрлање идеи од учениците/студентите, за решавање на некој проблем или пак постепено објаснување на одреден концепт или решавање на некој проблем. Во наставата по математичките предмети електронската табла имаше големо значење пред се поради потешкотиите што студентите и учениците ги имаат со наведените предмети. Електронската табла овозможува подобро разбирање на материјалот пред се поради тоа што решавањето на задачите е проследено со етапно објаснување чекор по чекор;

- Споделувањето екран е една од најчесто користените алатки на вебинар платформите. Како што наговестува и самиот назив, се работи за алатка што овозможува споделување на документи и апликации од компјутерот на наставникот/професорот со учениците/студентите. На овој начин, наставникот и учениците заедно може да разгледуваат слајд презентација од предавањето, да презентираат делови од учебниците во електронски формат, заеднички да пребаруваат на интернет, да гледаат/слушаат аудиовизуелни материјали и слично. Притоа за разлика од училница каде за да можат студентите или учениците да ја гледат презентацијата треба скапа опрема како плазма телевизори и тоа од новите модели или проектори, при online наставата не е потребна додатна опрема;

- За наставниците е олеснување што материјалите за учење (презентациите) можат брзо и лесно да бидат ажурирани, а учениците и студентите речиси истовремено да ги добијат промените. За математичките предмети ова е важно бидејќи презентациите лесно можат да се дополнат со задачи во зависност од нивото на знаење на учениците/студентите;

- Ресурсите за учење се флексибилни и многубројни. Фактот што online наставата се одвива со посредство на компјутер и интернет, ги прави многу подостапни различни бази на информации и податоци за учениците/студентите во процесот на учење. Покрај материјалот од вежби и предавања што го имаат студентите по математичките предмети, како и материјалот од часовите што го имаат учениците, за совладување на предвидените содржини и искоренување на потешкотиите при решавање задачи многу е важно да се користи дополнителен материјал кој може да се најде и симне од интернет.

4. Недостаоци од спроведување на наставата online

Дали сите ученици и студенти добиваат образование што му доликува на времето во кое живееме денес? Дали online образованието е она што ни е потребно? Прашања кои често се поставуваат. Одговорите на овие прашања се различни. Но, во глобала од сите нив, па и од нашето мислење за online наставата можеме да ги издвоиме следните причини поради кои би ја избрале класичната настава во училница по математичките предмети:

- Online наставата, каде вниманието на учениците/студентите е насочено кон информациите што се добиваат од компјутер, може побрзо да ги замори учениците и студентите и да го намали нивното вниманието и мотивацијата. При учење математика концентрацијата на учениците и студентите како и задржување на нивното внимание се особено важни;
- различни технички проблеми можат да го успорат текот на часот;
- Online часот значително се разликува од часот во традиционална училница по тоа што наставникот нема целосен увид во вербалните и невербалните реакции на целата група за време на часот. Успешноста на учењето во значаен дел зависи од можноста за интеракција меѓу наставникот и учениците или професорот и студентите, можноста за вклучување на ученикот/студентот во процесот на учење и добивање фидбек од учениците/студентите во процесот на наставата. Додека во традиционална училница наставникот може успешно да ја следи реакцијата на учениците/студентите и спонтано да комуницира со нив, оваа динамика е поинаква во online просторот. Многу потешко е да се следи реакцијата на учениците/студентите доколку се повеќе од 9 на една online сесија, особено додека наставникот е зафатен со споделување содржини, презентирање и отстранување на технички проблеми за време на часот. При учење математика, па и други предмети ова е особено важно бидејќи наставникот или професорот добива информација за знаењето на учениците/студентите, а тоа е особено важно бидејќи добива информација со кои ученици/студенти треба да поработи повеќе;
- Наставниците и професорите треба да направат генерална проба на часот со сите алатки што планираат да ги користат (тест на интернет конекција, тест на камера, слушалки и микрофон и тест на ИКТ алатки). На тој начин ќе ги превенираат техничките проблеми за време на часот. Наставниците и професорите треба претходно да го закажат часот и пред одржување да проверат дали информацијата за online часот (линкот) е споделен до сите ученици/студенти и дали сите се запознаени со техничките предуслови за учество на часот. Сето ова дополнително го зголемува времето кое наставникот или професорот треба да го потроши при спремање на наставниот час;
- Подготовката за online настава вообичаено бара поголем труд и време отколку традиционална настава, бидејќи бара детално планирање на формите на интеракција. Овој процес може да трае од една до неколку недели, во зависност од тоа колкаво претходно искуство имале наставницигте/професорите во користењето алатки за online настава. Исто така, овој начин на спроведување на настава за наставникот/професорот е нов и претходно не истражуван па сето тоа влева страв и скептицизам;
- Квалитетната настава е проследена со издвојување време за самостојна работа на некои содржини од страна на студентите и учениците. Притоа, самостојната работа на ученикот или студентот мора да биде под раковотство на наставникот или професорот што при online наставата е многу отежнато;
- не сите ученици или студенти имаат пристап до модерна технологија (некои семејства се сиромашни, а некои студенти живеат во рурални средини), тоа го отежнува следењето на online наставата;
- Директниот контакт (очи во очи) за време на час или консултации се незаменливи и при користење на било какви напредни технологии.

Заклучок

За реализација на наставата многу е важна подготовката на наставникот. Подготовката ќе биде добра, доколку наставникот претходно потроши доста време на нејзино планирање. Подготовка подразбира реализирање на систем постапки и активности кои ќе овозможат да се создадат услови за квалитетен и рационален воспитно-образовен процес во наставата. Но, покрај подготовката на наставникот за наставата важно е и тоа како истата се спроведува. Поради тоа што до 2020 година наставата беше со физичко присуство, а во 2020 се воведе online настава некаде до средина на 2022, потребно е да се изведе заклучок што понатаму. Некои теоретичари и истражувачи ја нагласуваат способноста на online заедниците да поддржуваат ефективно учење, додека пак други го свртуваат вниманието кон проблемите врзани за недостиг на внимание и учество, економски предизвици и претходен отпор меѓу наставниот кадар и образовните институции кон виртуелните образовни средини. Наше мислење е дека за математичките предмети најдобро е наставата да се одржува во образовните институции. Заклучокот произлегува врз основа на претходно наведените предности и недостатоци. Недостатоците доминираат и покрај големото значење на предностите.
Значи, и покрај обидите за спроведување на учење на далечина образовните институции сеуште се незаменливи во спроведувањето на образовниот процес, а особено за одржувањето на часовите по математичките предмети, независно од развојот на техниката и технологијата.

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ALGORITHMIC METHOD IN DYNAMIC DOSING SYSTEMS BASED ON WEIGHT MEASURING PRINCIPLES

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Abstract

Algorithmic method and a technical solution are suggested in order to increase performance of worm-and-wheel dosing systems (bagging machines) operating on weight measuring principles. The results from the weight measuring processed by using Fourier transformation and extrapolation of the weight transformation curve. The method applied in an algorithm for controlling weight in two situation of the working cycle of the flour-bagging machine: selective weight measurement of net and tare. The algorithm allows increasing the productivity without changing the mechanical design of the machine. This improvement helps make the machine competitive with the best Western packaging machine manufacturers.

Key words

Bulk dosing systems, dynamic weigh, extrapolation, algorithmic method

Introduction

Dosing of bulk materials for production purposes is a very common process. Most dosing appliances and machines based on indirect methods for mass measuring by accepting specific weight and bulk materials' flow as measured quantities. However, these parameters influence the weight precision rather somewhat negatively.

In order to improve enterprise' competitiveness in a market economy the quality of products should be constantly increasing, and by extension productivity. In accordance to ISO 9001 for products' quality certification, one of the requirements is that precision in packaging should be constantly improved and controlled. The paper aims to improve precision in dynamic dosing of packaged (in bags) flour as well as to increase productivity requirements.

Some basic factors, which influence batching, are "deposing on walls", "the sinusoidal features of bulk flow during worm-and-wheel dosing", unequal humidity and different aerated indices of bulk materials, etc. A controlling algorithm compensates factors that alter slowly in the course of time (humidity). Other factors lead to serious errors in weight measuring (deposits of measured quantities), thus they have to identify and made evident by alarm indicators [1].

Decisive factors, which increase precision of dynamic measuring, are "determined deviations", which result from the sinusoidal law in worm-and-wheel feeding. Another is random distribution of flour specific gravity during dosing. Both characteristics must taken into consideration.

Typical Requirements of Bulk Material Dosing Devices

The base for a classification of different dosing and proportioning devices for bulk materials is a prior definition of the associated requirements and the expected performance measures. For this, it is common sense to concentrate on the following four basic characteristics:

I. *Accuracy*. The accuracy of a dosing or weighing system is the degree of closeness of measurements of a quantity (e.g. massflow) to that quantity's true value).

II. *Stability*. The stability of a bulk material dosing unit typically defined as a time interval in which the accuracy definitions associated to the system can guaranteed without any manual intervention.

III. *Availability*. The availability of a dosing unit can defined as the typical ratio between the times where the system is operatable and the total working time in a defined period.

IV. *Productivity*. Productivity depends on the proper functioning of the above process characteristics and then on the requirements for high economic indicators of the process. Higher productivity means less energy costs, labor costs, and higher competitiveness in a dynamically changing market. This article proposes a general solution for increase productivity based on controlling algorithm.

1. General Classification of Bulk-Material Dosing Devices

The base for a classification of different dosing and proportioning devices for bulk materials is the former definition of the functional entities of those machines. For this, it is reasonable to distinguish three main functional elements of typical dosing devices:

(i). Measuring, (ii). Conveying and (iii). Controlling. The combination of either any two or all three of these basic elements defines the specific character of the equipment, as shown in Fig.1

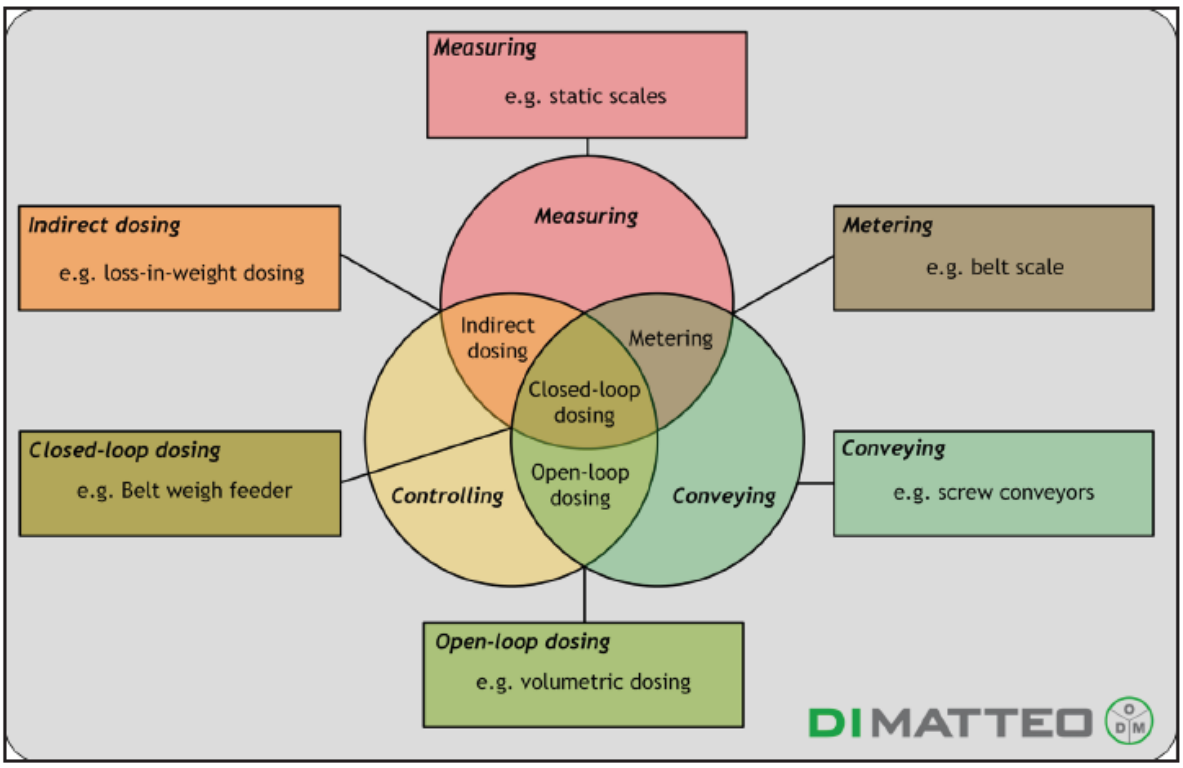

Fig. 4 Classification of different dosing/metering/weighing devices based on three basic functional elements

Here, it is possible to name six different classes of machines as a general taxonomy for the proportioning of bulk materials. The exact definition and corresponding aspects are summarised within Table 1.

Table 1 Overview of different dosing/metering/weighing devices

Class of Machine	Measuring	Metering	Indirect dosing	Open-loop dosing	Closed-loop dosing
Description	The actual volume V or weight m of the material is measured and used to define the actual amount at .a given time	The material is conveyed with a certain conveying speed **v** and at the same time the actual massflow is determined based on a measured weight **m**[kg]. **M**[kg/h] is define by v [m/s], l**m**[kg] and L[m] length of the scale.	The actual volume V or weight m of the material is measured and used to define the actual amount at a given time and at the same time a separate conveying system is controlled in order to achieve a certain volume flow **V** or mass flow **M** .	The actual conveying speed v is controlled based on a pre-defined calibrated relation in order achieve a certain volume flow . V or mass flow M	The actual weight **M** or volume **V** and the actual conveying speed v is measured to calculate the **M** actual mass flow or volume flow **V**. The actual conveying speed continuously controlled in order to achieve a desired mass or volume flow.
Measured values	**m** [kg], V [m³]	v [m/s], **m**[kg]	v [m/s], m[kg]	-	v [m/s], m[kg], **V** [[m³/h], **M** [kg/h
Control variables	-	v [m/s] **M** [kg/h]	**V** [m³/h], **M** [kg/h]	v [m/s]	v [m/s] -> **V** [m³/h], **M** [kg/h]
Type of operation	-	Continuous	Discontinuous	Continuous	
Type of dosing			Gravimetric	Gravimetric	
Example	Silo scale	Belt scale	Differential dosing setups (e.g. loss-in-(weight systems	Screw conveyor wit pre-defined calibrated relation between volume and screw speed	Weigh Scale

Source: author based on [5]

In this article we sugest new combination of dosing sytem based on combination between Open-loop dosing and Closed-loop dosing used in bag filling machine of the flour in mill factory. This is the first step to increase productivity of the bag-filling machine.

2. Discontinuous batching dosing system for bulk material

The chart for batching and dosing bulk materials as shown in Fig. 1 includes a worm-and-wheel mechanism driven by an electric motor, weigh-measuring transformer, and a regulating unit for feeding and dosing. The regulator is a position regulator. Theoretically, it is well known that best results for precision and quick action are achieved when a 5-sector speed diagram is used [2]. Conducted experiments show that different parts of the speed diagram can optimized in order to increase precision [3].

In Fig. 2, shown discontinuous batching dosing system completed with two-bag filing machine work in DEM Kulpin – Serbia. Two control system work synchronously with one belt for filled bags. These bag filling machine work semi-auto mode. The operator attaches an empty bag to the machine's outlet valve screw and then everything is automatic including dumping the finished bag onto the belt. In new systems bag filling machine assembled with bag placer and all the process is automatically. The two bag filling machines synchronized with each other through a connected algorithm.

The block diagram of the discontinuous batching dosing system shown in Fig3. This dosing principle chosen because it provides maximum accuracy with high productivity. This is necessary because of the market.

Fig. 5 Bag Filling machines in mil factory Kulpin, Serbia

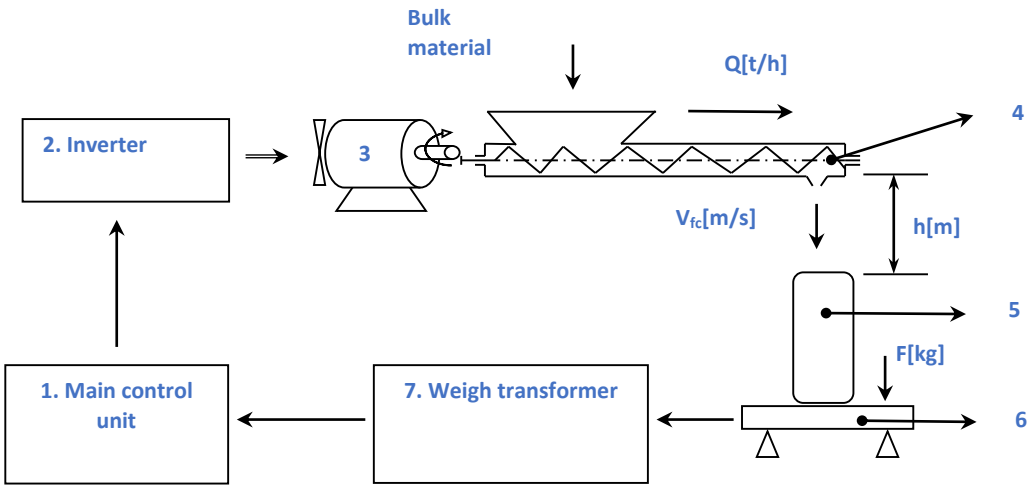

Fig. 6 Electronic system for dynamic dosing in worm-and-wheel mechanisms 1 - Main control unit; 2 - Frequency control of the asynchrony electro motor; 3 – 3-phase electro motor; 4 - dosing worm-and-wheel mechanism; 5 - Bag; 6 – Tens metric system; 7 - Weigh transformer;

Basic advantages of the system:

1. Main control unit is controller based on microprocessor MC9S12DG256 with 24 DI, 24 DO and ADC7730 with two analog input for tense system, one analog input for measure temperature with DS18B20 – one wire temperature sensor. The kernel of the software work in *real time* and Interrupt handling done through a priority matrix. In this way measuring and control system work properly. The author developed this controller and system software. The controller and system software used in many applications and systems more than 15 years.
2. Inverter selected *senseless technology*, which achieves better speed control both at a constant level and during braking, which, compared to ordinary inverters, is decisive for achieving higher weigh accuracy.
3. 3-phase asynchronously electro motor selected for *reliability* and price
4. Dosing worm-and-wheel mechanism made with additional *spreader wheel* and additional hopper for *pre-volume dosing.*
5. Tense system work with two cell connected to ADC7730 in continuous conversion mode. The 16-bit analog to digital conversion work continuously with time of conversion about 10 mSec. ADC7730 has key features Offset Drift: 5 nV/ºC, Gain Drift: 2 ppm/ºC, Line Frequency Rejection>150 dB, Buffered Differential Inputs, Programmable Filter Cutoffs Specified for Drift Over Time

3. Model of the technological cycle of the bag filling process

When dosing bulk materials the periodic constituent changes in accordance to the sinusoidal law [1]:

$$\overset{*}{m}(t) = m_{stat}(t) + \hat{m}_{din}\sin(\omega t + \varphi_0), \quad (1)$$

Where

- m*(t) - the mass of the total material for a certain time interval t
- $m_{stat}(t)$ - defines the linear mass gradient
- $m_{din}(t)$ - defines the periodic change of mass. This compound is a result of the spiral of the dosing auger.

We can determine the force exercised by the falling bulk flow onto the tens metric system:

$$F_{\Sigma}(t) = \overset{*}{F}(t) + \tilde{F}(t) = \underbrace{m_{stat}(t)g + \hat{m}_{din}\sin(\omega t + \varphi_0 + \tau)}_{product\_in\_bag} + \underbrace{\sqrt{2gh}\frac{dm_{stat}(t)}{dt} + \hat{m}_{din}\cos(\omega t + \varphi_0 + \tau)}_{falling\_column} \quad (2)$$

Where

- $\overset{*}{F}(t)$ - force of the weight of the flour in the sack
- $\tilde{F}(t)$ - force of the weight of the flour above the sack

The weight of the falling material is determined by

$$M_{\Sigma\, fc} = \overset{*}{M}(t) + \tilde{M}(t) = \sqrt{2gh}\frac{dm(t)}{dt} + \int_0^{\tau} \hat{m}_{din}\sin(\omega t + \varphi_0)dt \quad (3)$$

Where

- $\overset{*}{M}(t)$ - The mass of the flour, proportional to the *h* height from the bag to the dosing auger, as well as to the auger performance dm(t)/dt
- $\tilde{M}(t)$ - The mass of the flour defined from sinusoidal influence of the auger

From (2) and (3) the difference between the falling material and the dynamic constituent of the force on the tens metric system can estimated as:

$$\Delta\tilde{F}(t) = \tilde{F}(t) - \tilde{M}(t) = \hat{m}_{din}\cos(\omega t + \varphi_0 + \tau) + \hat{m}_{din}\frac{\cos(\omega\tau + \varphi_0) - \cos(\varphi_0)}{\omega}$$

$$\Delta\tilde{F}(t) = \hat{m}_{din}\left(\cos(\omega t + \varphi_0 + \tau) + \frac{\cos(\omega\tau + \varphi_0) - \cos(\varphi_0)}{\omega}\right) \quad (4)$$

4. Technological process controlled by Algorithm

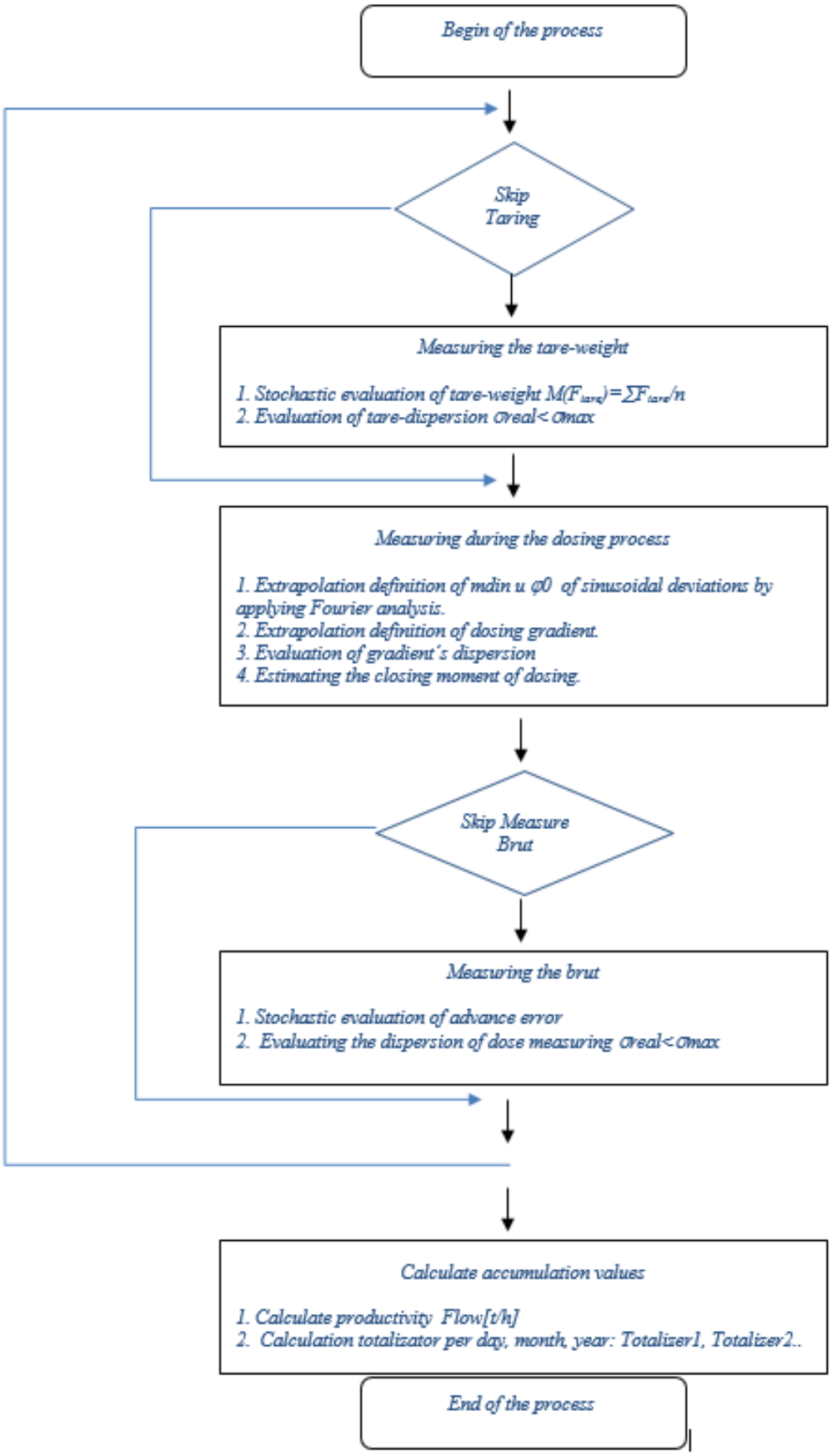

Fig. 3. Algorithm showing the discrimination of error in dynamic dosing by applying the extrapolation method

Results

Estimating the error from the tare measurement and the error from the measurement of the weight value - gross, allows the transition to an accelerated mode of operation. When these two values approach the minimum allowable, it goes into *turbo* operation mode.

For machines that use closed bags with valve filling of the packages, the performance limited by the speed of the valve, which is limited to 8 seconds + 2 seconds for releasing and filling the new bag. This limits the productivity to 9.0t/h.

Compared to western companies such as PAGLIERANI and FAVEMA on a similar technique, whose productivity is 7.5t/h, one can see the significant advantage obtained when using the algorithm in terms of the productivity indicator.The measurements and experiments were made on machines of the company Askon EOOD, which operate in Bulgaria, Serbia, BiH, Romania.

Table 2 Productivity of the bag-filling machine with different type cycles calculate in case of 25kg charge.

Type of machine	Measuring Tare [Sec]	Closing low clap	Dosing Fast and Fine	Closing high clap[Sec]	Measuring Tare [Sec]	Cycle Time [Sec]	Product. [t/h]
Common	4.0	1.0	5.0	1.0	4.0	15	6.0
With algorithm	0	1.0	5.0	1.0	0	7	12.9
Algorithm+ advanced fill	0	1.0	4.0	1.0	0	6	15.0

Conclusions

In today's conditions of strong competition and lack of workers, the productivity of machine equipment is of great importance. The competition in the market for technological equipment intended for flourmills in the European market, as well as in the world, imposes high criteria regarding the performance quality indicators of the machines and systems used in the production of flour and milled products. The price and reliability of the equipment are not sufficient criteria when choosing a certain type of equipment. The publication offers an algorithmic method that allows increasing the productivity of flour packaging machines by 25-30%. This method is applicable to all machines operating in the milling industry, regardless of supplier. The application of the algorithmic method allows to significantly increasing the performance without the need to change the mechanics or electronics. Only the pre-dosing module also implies mechanical changes to the packaging machines. A specialized software has developed which, through an online statistical analysis of the deviations of the measurement of the weight of the dose and the tare, provides an assessment of the possibility of applying the algorithm to a randomly selected machine.The algorithm works completely autonomously and does not require any settings or manipulations by the operator.

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IMPLICATIONS FOR THE ENVIRONMENTAL-ENGINEERING COMPROMISE AS A RESULT OF POWER AND ECONOMY TUNING A DIESEL ENGINE

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Abstract

As a result of the control era of automotive technology which began in the late 20th century, IC engines contain a large number of sub-systems that allow for better engine performance and vehicle maneuverability, while at the same time they satisfy increasingly strict environmental norms and standards when it comes to exhaust emissions in what is known as an environmental-engineering compromise. However, tuning today's high-performance engines in which the trade-offs between performance, economy and emissions take precedence is a challenge for even the most experienced automotive engineers as it includes major implications for the environmental-engineering compromise. The aim of this paper was to analyze these implications and determine if the changes in power and fuel consumption question the operation needs of the vehicle and the driver's requirements, as well as the amount of exhaust emissions that find their way in the ambient air. The POWER/PERFORMANCE optimization led to a 36% increase in engine power (78 to 106 kW), a 9 % decrease in fuel consumption (6.6 to 6.0 l/100 km) and consequently 30% reduction in CO_2 emissions (3.43 % to 2.38 % of the total volume of exhaust gasses). The ECONOMY optimization, which was primarily aimed at a decrease in fuel consumption and a climate-friendly improvement of the environmental map of the engine, led to a 42 % decrease in CO_2 emissions (3.43 % to 1.99 % of the total volume of exhaust gasses) and a 13.5 % decrease in fuel consumption (6.6 to 5.7 l/100 km), while maintaining an increase in engine power for 23 % (78 to 96 kW). Aside from these obviously positive implications, the results provided an insight in the negative trade-offs that these optimizations bring, such as an increase in local pollutants, including PM and NOx emissions.

Key words

Calibration, optimization, environmental-engineering compromise, performance, fuel consumption

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AUTONOMOUS ROBOTIC VACUUM CLEANER

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Abstract

In today's world, technology surrounds us, and its impact on our daily lives is undeniable. The use of advanced gadgets and software has made our lives easier, thanks to the automation happening around us. The vacuum cleaner has been the last to receive a significant upgrade among the many household appliances. However, the autonomous robotic vacuum cleaner market has seen great success in recent years. This paper aims to explore the complex algorithms powering autonomous robotic vacuum cleaners and make them more understandable. By doing so, this technology will help us to finish our daily tasks more efficiently and with minimal involvement.

Keywords

Robotic vacuum cleaner, Arduino, Printed circuit board, Algorithm.

1. Introduction

Today, we are surrounded by advanced technology from various aspects. From cutting-edge devices to sophisticated software, our lives are made easier thanks to the automation that surrounds us [1]. The use of autonomous devices, such as domestic robots, allows us to perform tasks without direct involvement or wasting time on things that can be easily and efficiently done by robots [2]. The need for automation, especially when we are overwhelmed with tasks and responsibilities, provides us with relief in our work and greater efficiency in accomplishing what we want to achieve [3]. Over the past decade, robot vacuum cleaners have become increasingly popular automated household appliances. They are designed to save time and effort while providing a thorough cleaning of floors. The rapid evolution of these vacuum cleaners means new features and technologies are added every year to better fulfill consumer needs [4]. The market for robotic vacuum cleaners was valued at $4 billion in 2022 and is expected to rise even more by the end of 2023. This tremendous market growth is attributed to the development of industrial robots, as well as the prevalence of smart homes and IoT technology [5]. The latest robotic vacuum cleaner developed by Samsung even features artificial intelligence software, sophisticated 3D sensors and cameras for spatial mapping [6].
We will try to develop a robotic autonomous vacuum cleaner that will help us in our everyday lives. Based on the Arduino microcontroller and some commonly sourced electronic components, we will design a model of a robotic vacuum cleaner. We will design an appropriate circuit, as well as a rudimentary algorithm that will power the robot. Finally, we will test the robot in the real world and study its behavior with obstacles. Previous work in this field will provide us with experience in the design process [7] – [9].

2. Design of the autonomous robotic vacuum cleaner

We will begin our research with the design of the autonomous robotic vacuum cleaner. Firstly, we will design the electronic circuit. Using the AutoCAD Eagle software and other CAD tools, we designed a rudimentary circuit. It consists of:

➢ Microcontroller – 1 x Arduino Uno – a microcontroller board based on the ATmega328P microprocessor chip [10]. It has 14 digital input/output pins (of which six can be used as PWM outputs), six analog inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection for programming and serial monitoring, a power jack, an ICSP header, and a reset button. The board contains everything needed to support the microcontroller, and there is an extensive library of functions and qualified support from the manufacturer, as well as the community of users around the world.

Features of the ATMega328P Processor [11]:

- Memory:
- AVR CPU at up to 16 MHz
- 32KB Flash
- 2KB SRAM
- 1KB EEPROM
- Security
- Power On Reset (POR)
- Brown Out Detection (BOD)
- Peripherals
- 2x 8-bit Timer/Counter with a dedicated period register and compare channels;
- 1x 16-bit Timer/Counter with a dedicated period register, input capture, and compare channels;
- 1x USART with fractional baud rate generator and start-of-frame detection;
- 1x controller/peripheral Serial Peripheral Interface (SPI);
- 1x Dual mode controller/peripheral I^2C;
- 1x Analog Comparator (AC) with a scalable reference input;
- Watchdog Timer with separate on-chip oscillator;
- Six PWM channels;
- Interrupt and wake-up on pin change.

➢ Drive train – 2 x 28BYJ-48 – unipolar stepper motor with incorporated gear reduction, internally converted to the bipolar stepper motor schematic.

Features of the 28BYJ-48 stepper motor [12]:

- Rated voltage: 5 V DC;
- Number of phases: 4;
- Speed reduction ratio: 1/64;
- Step angle: 5.625° /64;
- Frequency: 100 Hz;
- DC resistance: 50 Ω ± 7 % (25 ℃);
- Idle in-traction frequency: 600 Hz;
- Idle out-traction frequency: 1000 Hz;
- In-traction torque: 34.3 mNm(120 Hz);
- Self-positioning torque: 34.3 mNm;
- Friction torque: 600-1200 gf*cm;
- Pull-in torque: 300 gf*cm;
- Insulation resistance: > 10 MΩ (500 V);
- Insulation grade: A;
- Rise in temperature: < 40 K (120 Hz);
- Noise: < 35 dB (120 Hz, No load, 10 cm);

➢ Motor controller – 2 x HW-134 – bipolar stepper motor controller driven with the A4988 integrated motor driver circuit, included with DIR, STEP, and ENABLE inputs.

Features of the A4988 stepper driver module [13]:

- Max. operating voltage: 35 V;

- Min. operating voltage: 8 V;
- Max. current per phase: 2 A;
- Micro-step resolution: Full step, ½ step, ¼ step, 1/8 and 1/16 step;
- Reverse voltage protection: No;
- Dimensions: 15.5 × 20.5 mm (0.6″ × 0.8″);
- Short-to-ground and shorted-load protection;
- Low RDS (ON) outputs;
- Thermal shutdown circuitry;

➢ Sensors – 3 x HY-SRF05 – Ultrasonic distance sensor, provides 2 cm to 400 cm non-contact measurement function, with a ranging accuracy of 3 mm.

Features of the HY-SRF05 ultrasonic sensor [14]:

- Trigger pin format: 10 uS digital pulse;
- Sound frequency: 40 kHz;
- Echo pin output: 0 – Vcc;
- Echo pin format: output is DIGITAL and directly proportional with range;
- Measurement range: 2 cm to ~ 4.5 m;
- Measurement resolution: 0.3 cm;
- Measurement angle: up to 15 deg;
- Measurement rate: 40 Hz;
- Supply voltage: 4.5 V to 5.5 V;
- Supply current: 10 to 40 mA;
- Connector: standard 5-pin male connector which can plug directly into breadboards;
- Static current: less than 2 mA;
- Detection distance: 2 cm - 450 cm;

➢ Power supply – 1 x GOLF 10 Ah Li-Ion power bank.

Features of the GOLF 10 power bank [15]:

- Capacity: 10000 mAh;
- Input: DC 5.0 V - 2.0 A;
- Output: DC 5.0 V - 1.0 A / 5.0 V - 2.1 A;
- Size: 64.5 x 14.5 x 132.5 mm;

The circuit, given in Appendix 1, consists of the Arduino UNO microcontroller, which is supplied with 5 V DC voltage from the power bank. The motor controllers and ultrasonic sensors are connected to the digital IO pins of the microcontroller, as well as to the 5 V DC voltage supply from the power bank, and the stepper motors are connected to the motor controllers.

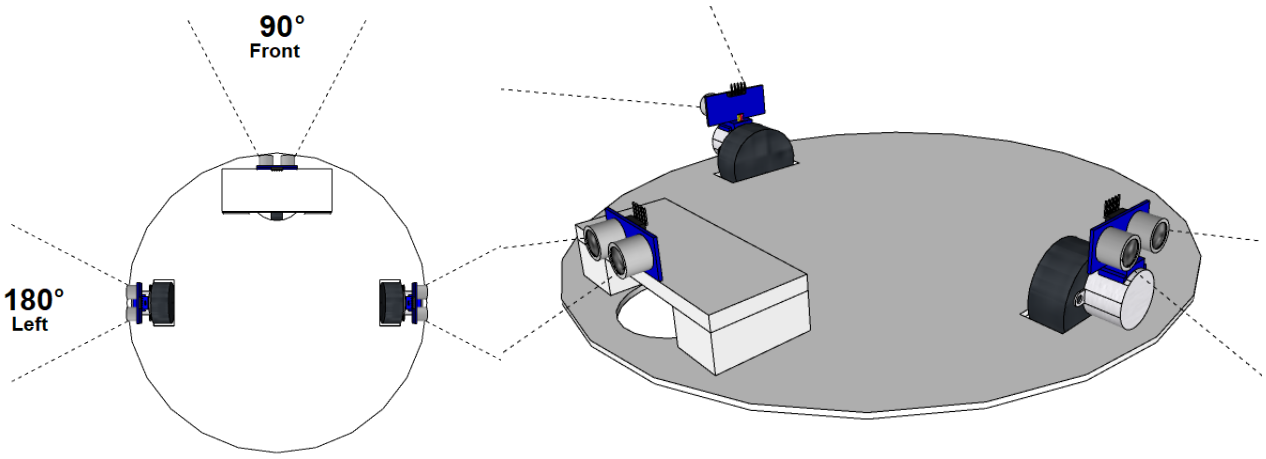

Fig. 1 (a) Top view of the robot model, (b) Side view of the robot model.

After the design of the circuit, we will design the body of the robot. Using the SketchUp 3D CAD software, we came up with the design of the robot (Fig. 1a and Fig. 1b) that consists of:

- Base – HDF (High-Density Fiberboard) with a diameter of 35 cm and 3 mm thickness. Appropriate holes are incorporated for the drive and support wheels.
- Drive wheels – two rubber model wheels with 48 mm diameter, mounted directly to the output shaft of the stepper motor. The wheels are mounted at 0° and 180° (left and right sides), which gives the robot the ability to rotate in place.
- Support wheel – one omnidirectional wheel with a diameter of 30 mm, and a turning diameter of 60 mm. This wheel is mounted at 90° (front side), thus giving the robot support from tipping over.
- Stepper motors – mounted to the drive wheels and to the base with appropriate aluminium brackets.
- Sensors – ultrasonic sensors, securely mounted above each wheel, giving the robot the ability to see in front, to the left, and to the right.

After the process of designing the robot, we can begin the programming of the robot. The Arduino Uno microcontroller is relatively simple to program with the help of online libraries and resources. The programming process will begin by creating a simple algorithm that will control the robot, which is given in Appendix 2.
The full code that controls the robot is given in Appendix 3, and snippets of the code are explained below:

```
#include "BasicStepperDriver.h"
#include "SyncDriver.h"
#include "NewPing.h"
```

With this segment of code, the appropriate libraries for using the motor controllers and ultrasonic sensors are included.

```
#define MOTOR_STEPS 4096
#define MOTOR_X_RPM 10
#define MOTOR_Y_RPM 10
#define DIR_X 8
#define STEP_X 9
#define DIR_Y 10
#define STEP_Y 11
#define MICROSTEPS 1
```

Here we are setting the parameters of the stepper motors. We are defining the steps per revolution, maximum speed, as well as the pins for controlling the stepper motors.

```
#define TRIGGER_PIN_FRONT 3
#define ECHO_PIN_FRONT 2
#define TRIGGER_PIN_LEFT 6
#define ECHO_PIN_LEFT 7
#define TRIGGER_PIN_RIGHT 5
#define ECHO_PIN_RIGHT 4
#define MAX_DISTANCE 200
```

Here we are setting the parameters of the ultrasonic sensors. We are defining the trigger and echo pins, as well as the maximum distance that can be measured by the sensors.

```
void setup() {
	stepperX.begin(MOTOR_X_RPM, MICROSTEPS); // Left motor
	stepperY.begin(MOTOR_Y_RPM, MICROSTEPS); // Right motor
}
```

In the setup function, we are defining the maximum speed and micro-stepping of the motors.

```
void loop()
{
	start:
	unsigned int distance_front = sonar_front.ping_cm();
	unsigned int distance_left = sonar_left.ping_cm();
	unsigned int distance_right = sonar_right.ping_cm();
```

In the loop function, we're defining the variables in which we are storing the distances from the appropriate sensors. The distances are measured with the function ping. The value given by this function is the distance to an obstacle that is in front of the sensor in cm. The following are the commands that are used for controlling the movement of the robot:

```
 if (distance_front >= 15)
 {
	controller.rotate(+118, +118);
	goto start;
 }
```

If the measured distance forward is more than 15 centimeters, then the motor controllers are given the command to turn 118°, which moves the robot 10 cm forwards.

```
	else if (distance_front <= 5 && distance_left >= 15 && distance_right >= 15)
	{
		controller.rotate(+241, -241);
		goto start;
	}
```

If the measured distance forward is less than 5 cm, and the measured distances left and right are more than 15 centimeters, then the robot turns right 90° by default.

```
	else if (distance_front <= 5 && distance_left <= 5 && distance_right >= 15)
	{
		controller.rotate(+241, -241);
		goto start;
	}
```

If the measured distances forward and left are less than 5 cm, and the measured distance to the right is more than 15 cm, then the robot turns right 90°.

```
	 else if (distance_front <= 5 && distance_left >= 15 && distance_right <= 5)
	{
		controller.rotate(-241, +241);
		goto start;
	}
```

If the measured distances forward and right are less than 5 cm, and the measured distance to the left is more than 15 cm, then the robot turns left 90°.

```
else if (distance_front <= 5 && distance_left <= 5 && distance_right <= 5)
{
        controller.rotate(+482, -482);
        goto start;
}
```

If the measured distances forward, right, and left are less than 5 cm, then the robot turns right 180°, i.e., the robot goes back in the direction that it came.

3. Assembly of the autonomous robotic vacuum cleaner

With a completed model and schematic for the robot, as well as the appropriate program, the assembly of the robot can begin. The stepper motors with the drive wheels are mounted to the base. The support wheel is mounted in the front, utilizing an appropriate bracket. For testing purposes, special BOBs (Break Out Boards) are designed and manufactured with the purpose of easing the design process. These special PCBs (Printed Circuit Board) allow quick and secure changes in the wiring of the components. All the components are connected according to the circuit diagram using appropriate wires and connectors. The power bank is mounted in the front, and by doing so, the center of mass is moved closer to the front of the robot. After the processes of mounting and connecting the components are finished, everything is checked to make sure that the design requirements are met.

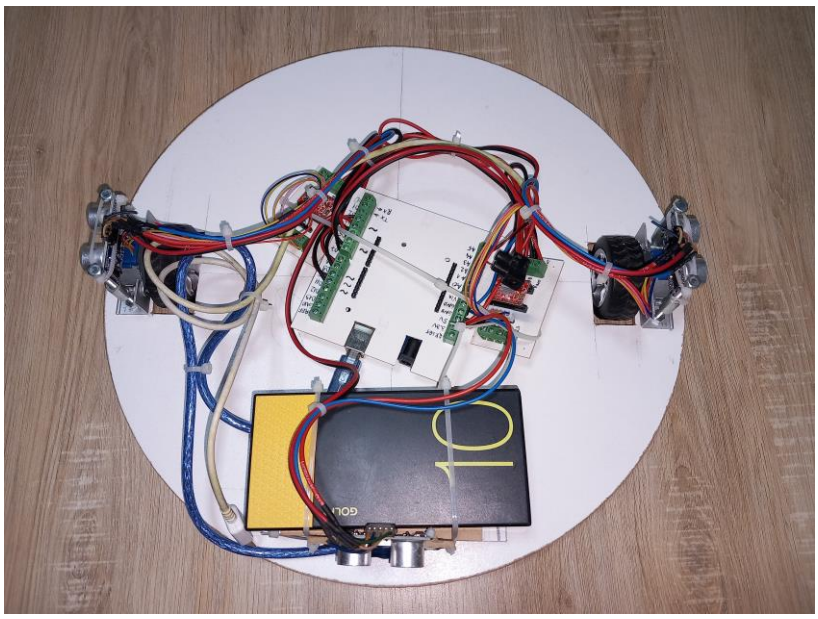

Fig. 2 Assembled and connected model of the autonomous robotic vacuum cleaner.

4. Results and Discussion

The robot is put into action. The power bank is connected to the microcontroller, and the program that drives the robot is executed. Subsequently, the robot starts to move according to the algorithm and the obstacles in the room that it is placed in. The algorithm provides the robot with the ability to avoid basic obstacles, such as walls, large furniture, and other medium to large sized objects. On the other hand, there are some drawbacks to this design of the robot and its algorithm. The robot can't go over obstacles that are more than 1 cm tall, such as carpets,

and the existence of blind spots in the front-right and front-left area limits the robot's ability to detect obstacles that are less than 10 to 15 cm wide.

5. Conclusion and Future Work

For more efficient work of the robot, we need to implement some changes. Firstly, the sensors should be positioned at better positions, therefore providing fewer blind spots. Furthermore, an infrared or ultrasonic distance sensor should be placed in the front of the robot, oriented downwards, thus providing the robot with the ability to detect obstacles that are taller than 1 cm and to avoid edges, such as stairs.
Moreover, the algorithm needs some changes. It should be able to avoid getting the robot stuck in a loop. In addition, the algorithm should be optimized to provide better coverage of the room that it operates in.
Finally, to have a completed autonomous robotic vacuum cleaner, we need the ability to collect dust. A vacuum system should be implemented, with appropriate suction motors and dust and particle filters, along with a dust reservoir that can be easily cleaned. Additionally, an upgrade is necessary to the power supply as well. Instead of a 5 V power bank, a 12 V Li-Ion battery should be installed, which will enable the robot to work for a longer time and to provide power to the vacuum system.

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Appendix 1

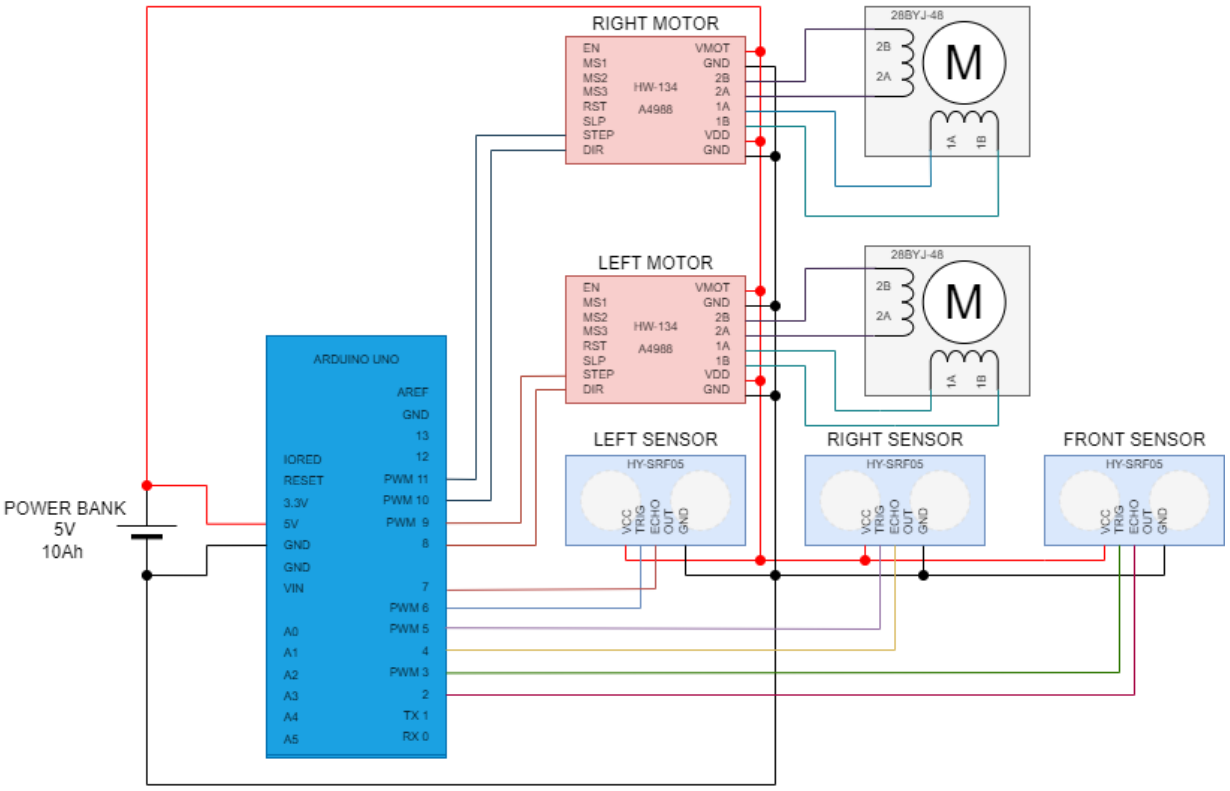

Fig. 3 Electronic circuit for the autonomous robotic vacuum cleaner

Appendix 2

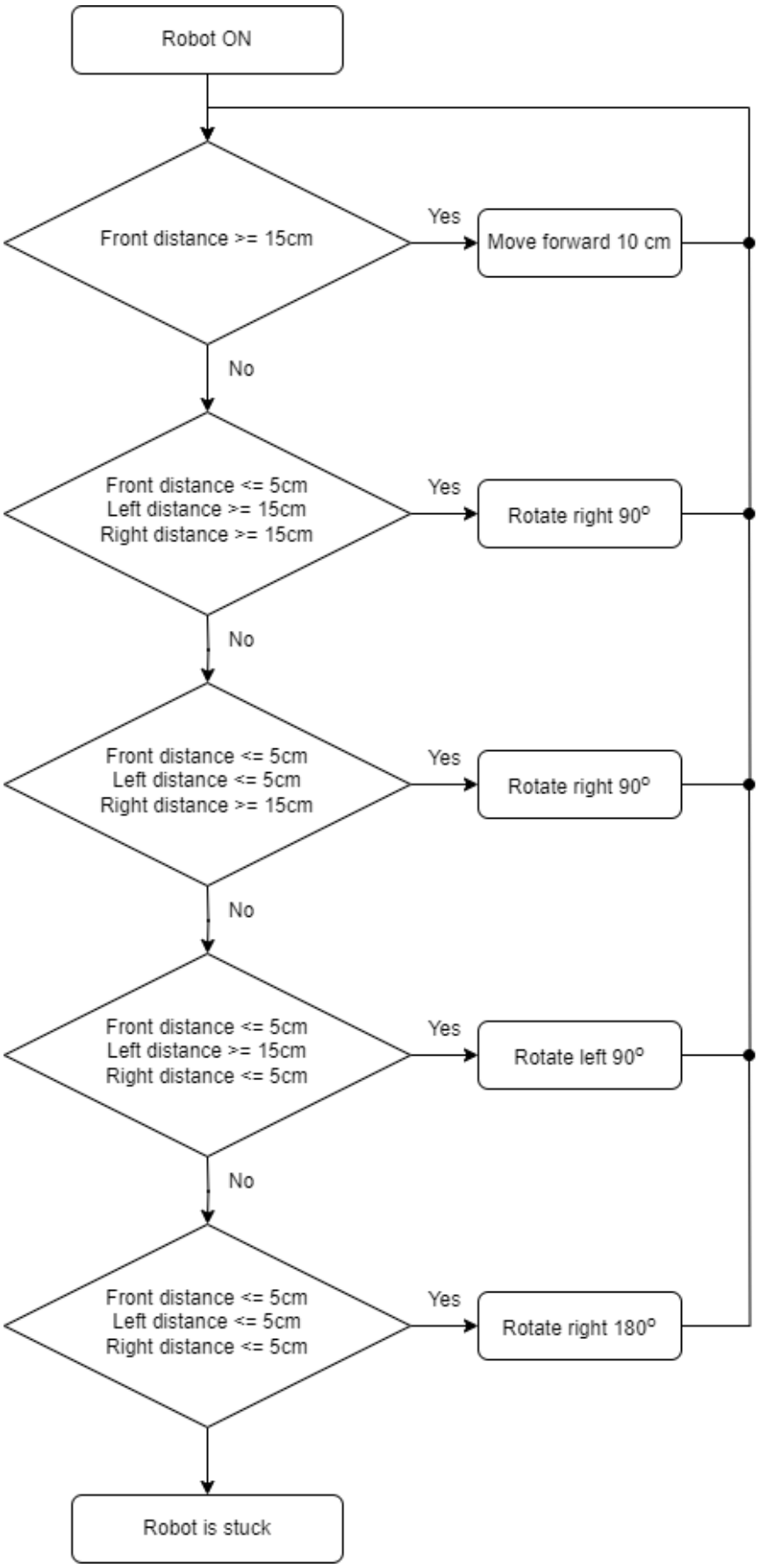

Fig. 4 Algorithm for the autonomous robotic vacuum cleaner

Appendix 3 – Full source code for the Arduino microcontroller

```
#include "BasicStepperDriver.h"
#include "SyncDriver.h"
#include "NewPing.h"
#define MOTOR_STEPS 4096 // (964,-964) - 180*; (241,-241) - 90*
#define MOTOR_X_RPM 10   // (+,+) - forward;       (-,-) - reverse
#define MOTOR_Y_RPM 10   // (+,-) - rotate right;  (-,+) - rotate left
#define DIR_X 8         // 1B - orange; 1A - pink
#define STEP_X 9        // 2A - yellow; 2B - blue
#define DIR_Y 10        // 1B - blue; 1A - yellow
#define STEP_Y 11       // 2A - pink; 2B - orange
#define MICROSTEPS 1    // 0.85mm/*; 1.176*/mm
#define TRIGGER_PIN_FRONT 3
#define ECHO_PIN_FRONT 2
#define TRIGGER_PIN_LEFT 6
#define ECHO_PIN_LEFT 7
#define TRIGGER_PIN_RIGHT 5
#define ECHO_PIN_RIGHT 4
#define MAX_DISTANCE 200
BasicStepperDriver stepperX(MOTOR_STEPS, DIR_X, STEP_X); // Left motor
BasicStepperDriver stepperY(MOTOR_STEPS, DIR_Y, STEP_Y); // Right motor
SyncDriver controller(stepperX, stepperY);
NewPing sonar_front(TRIGGER_PIN_FRONT, ECHO_PIN_FRONT, MAX_DISTANCE);
NewPing sonar_left(TRIGGER_PIN_LEFT, ECHO_PIN_LEFT, MAX_DISTANCE);
NewPing sonar_right(TRIGGER_PIN_RIGHT, ECHO_PIN_RIGHT, MAX_DISTANCE);
void setup() {
        stepperX.begin(MOTOR_X_RPM, MICROSTEPS); // Left motor
        stepperY.begin(MOTOR_Y_RPM, MICROSTEPS); // Right motor
}
void loop() {
        start:
        unsigned int distance_front = sonar_front.ping_cm();
        unsigned int distance_left = sonar_left.ping_cm();
        unsigned int distance_right = sonar_right.ping_cm();
        if (distance_front >= 15) {           // move forward
                controller.rotate(+118, +118);
                goto start;
        }
        else if (distance_front <= 5 && distance_left >= 15 && distance_right >= 15) {        // rotate right
by default
                controller.rotate(+241, -241);
                goto start;
        }
        else if (distance_front <= 15 && distance_left <= 5 && distance_right >= 15) {        // rotate right
                controller.rotate(+241, -241);
                goto start;
        }
        else if (distance_front <= 15 && distance_left >= 15 && distance_right <= 15) {        // rotate left
                controller.rotate(-241, +241);
                goto start;
        }
        else if (distance_front <= 5 && distance_left <= 5 && distance_right <= 5) {  // rotate right 180
                controller.rotate(+482, -482);
                goto start;
        }
}
```


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