Abstracts of the publications

of Assoc. Prof. Bohos Rupen Aprahamian, PhD,

submitted for participation in a competition for academic position "Professor",
professional area 5.2 “Electrical Engineering, Electronics and Automation”,
scientific specialty “Electrotechnology”,
published in the State Gazette No. 93 / 26.11.2019

Abstracts of group Г.7. publications - Scientific publications in issues that are referenced and indexed in world renowned scientific information databases

Г.7.1. Streblau M., Aprahamian B., Simov M., Dimova T., The influence of the electrolyte parameters on the efficiency of the oxyhydrogen (HHO) generator, Proceedings of 18-th International Symposium of Electrical Apparatus and Technologies SIELA, 2014, pp. 225 – 228

The electrolysis of water is an electrochemical process wherein hydrogen and oxygen are derived. The resulting mixture of oxygen and hydrogen is called oxyhydrogen or Brown's gas. This paper presents an experimental study of the regime of operation of an oxyhydrogen (HHO) generator depending on the parameters of the electrolyte - concentration and temperature by monitoring the amount of gas produced per unit time compared to the electricity input.

The operating regime of the oxyhydrogen (HHO) generator and the quantity of the produced gas are affected by a number of factors, such as electrolyte concentration, temperature, current density, frequency of the supplied voltage and some design parameters.

The purpose of this paper is to investigate the influence of the frequency of the supplied voltage on the efficiency of the HHO-generator for a specific configuration of the electrolysers.

The design and the wiring diagram of the HHO-generator prototype undergoing experimental study are presented in the paper.

The paper presents results regarding:

- time dependence of the generation of one liter of gas on the temperature and concentration of the electrolyte;
- MMW (Milliliters of HHO per Minute per Watt) of electrolyte temperature and concentration;
- flow rate of gas produced, depending on the concentration and temperature of the electrolyte.

The oxyhydrogen is widely used in various technological processes for different types of materials and in recent times is also used to increase the efficiency of internal combustion engines. For optimal efficiency of the oxyhydrogen generator is necessary adjustment of its operating parameters such as current, voltage and electrolyte concentration. For each construction embodiment, these parameters have specific values.

Based on the presented studies, conclusions were drawn regarding:

- the nature of changes in parameters such as efficiency, flow rate and time depending on the temperature and concentration of the electrolyte;
- opportunities to achieve maximum values of the studied parameters.

Г.7.2. Dimova T., Aprahamian B., Marinova M., Streblau M., Increasing the efficiency of permanent magnet separators by maintenance of certain functional state of the object of separation, Proceedings of 18-th International Symposium of Electrical Apparatus and Technologies SIELA, 2014, pp. 29 – 32

According to the specific features of the object of separation, the separating unit is selected to ensure maximum extraction of ferromagnetic impurities. For proper choice of construction, it is necessary the separation process to be examined in details. The paper examines the results of an experimental study of lattice type separator with labyrinth type placement of the permanent magnets. It is designed for separation of ferromagnetic inclusions in organic products (e.g. raw cocoa). The conducted experiment is planned and an approach to determine some parameters of the product is proposed, which significantly affect the process of separation. For this purpose, it is designed and implemented an algorithm for determining the functional state of the mixture. The distribution of the magnetic field in the working space of the separating unit is analyzed, as a 2D model is created.

The characteristics of the separation process with permanent magnets require attention and specific approach for its modeling and management. In the reference literature the magnetic force is considered as determining the effectiveness of the separation device, but no less important is also the functional status of the object of separation. The use of common models for the description of the significant functional factors can affect the characteristic changes in the separated mixture and hence the parameters of the separation process. It is therefore necessary to maintain the system of factors relating to the mixture in a certain functional condition to ensure optimal separation.

The objective is the development and application of an algorithm to determine the functional state of the mixture, which affects the efficiency of the separation process with permanent magnets. In determining the boundaries of the input factors is given special attention to the size of single particles in the product. In order to provide the desired particle size of the raw cocoa, after milling the product passes through a standard sieve to ensure both uniformity and homogeneity.

To set the magnetic filter of the separator unit a previously established 2D model had been used. The distribution of the magnetic field in the working space of the separator is analyzed. The results are checked for authenticity and qualify for adequacy.

Two-dimensional models have been created of the system of permanent magnets in a separator, showing the pattern of distribution of the magnetic field, whereby the effect of uniformity and concentration in the working air gap is sought. All results obtained can serve as a basis for more extensive studies of the process of separation with permanent magnets.

Г.7.3. Dimova T., Marinova M., Aprahamian B., Investigation of the magnetic field of a separator with specific configuration of the magnetic filter, Proceedings of 19-th International Symposium of Electrical Apparatus and Technologies SIELA, 2016, pp. 72 – 75

Depending on the specific features of the object of separation and the steps of the process separating apparatus are selected, to provide the maximum degree of extraction of ferromagnetic impurities. To select the correct and most suitable design of the separating apparatus is necessary pre-dimensioning of the magnetic system.

The article examines mathematical model based on the finite elements method of separator with permanent magnets with a specific structure, expressed in special tapered section presence and with permanent magnets of different shapes. The specifics of the processed product impose certain restrictions on the speed of the material, the operating temperature, the humidity, etc.

Using the FEMM 4.2 software are developed different versions of the configuration of the magnetic system in order to achieve a maximum degree of purification expressed in maximum extraction of ferromagnetic particles.

In the process of magnetic separation of the ferromagnetic ingredients from a given product under treatment, the action of magnetic forces is used. The effectiveness of the magnetic system for separation depends largely on the kind and form of the magnetic poles, which determines the type of the magnetic force lines. Since separators with permanent magnets are flexible systems that do not need power supply in order to function, a number of manufacturers benefit from their effectiveness, economy and mobility.

Setting the magnetic filter of the separating apparatus a specially created pre-set 2D model, which corresponds to the real separator, is used.

The distribution of the magnetic field in the working area of the separator is analyzed. The results are checked for authenticity and qualify for the adequacy of the model.

The aim of the article is to study the magnetic field of a separator with a specific configuration of the magnetic filter by compiling a mathematical model by which to achieve the maximum degree of purification of the processed organic product.

2D models have been created of a system of permanent magnets, showing the pattern of distribution of the magnetic field, whereby the effect of uniformity and concentration in the working air gap is sought. The obtained results can be used for further structural modifications of the separator.

The used approach can be applied to develop a generalized methodology for designing separators with permanent magnets and to choose the type of the magnetic filter according to the specifics of the separated material.

The obtained results, based on the chosen approach for analysis, can also be used for solving other problems with separating of materials by help of permanent magnet separators. The chosen mathematical approach can be used for practical realization with sufficient accuracy and reliability.

Г.7.4. Dimova T., Marinova M., Aprahamian B., Assessment of the influence of the magnetic filter type on the magnetic field of a separator type MCR-5, Proceedings of 19-th International Symposium of Electrical Apparatus and Technologies SIELA, 2016, pp. 76 – 79

The magnetic separation is a process of great practical relevance. The specifics of the separated material determine the type of the used separator. The aim is to achieve the maximum degree of purification of the processed product. The paper examines a construction of real magnetic separator type MCR 5 with a specific problem defined by the practice. The analysis was conducted using a specially developed mathematical models based on the finite elements method. Models of the separator's structure with ferrite material concentrators and gaps of non-magnetic material were examined as well as those with different orientation of the magnetic induction vector of the individual permanent magnets. The stationary magnetic field of the system is analyzed as a flat parallel system, taking into account the nonlinear properties of the materials, which are separated by the separating apparatus. Also are examined the influence of the thickness and the material of the outer body (housing) of the separator. The distribution of the field is modeled numerically using the finite elements method and the software package

FEMM 4.2. The results allow to optimize the structure of the magnetic separator and to achieve the highest level of purification.

The purpose of this work is to assess the impact of different types of magnetic filters relating to the arrangement of the permanent magnets and the portioning gaps to achieve maximum degree of purification at fixed design parameters of the separator. The portioning gaps are made of non-magnetic, paramagnetic or ferromagnetic material.

The initial design of the MCR-5 separator had 14 permanent magnets oriented in the same direction without gaps between them. In this way, the magnetic filter was in fact a monolithic body with high tension of the field on its surface, which was not effective for the purposes of the separating device. This was proven in the process of exploitation. Its ineffectiveness necessitated a different solution to its design. By help of computer modeling calculations were made of different versions of configuration. Thus, the number of permanent magnets was decreased and the magnetic force was increased.

The results from the computer modeling are presented in the paper. The models are created by help of the FEMM 4.2. software, based on the method of finite elements. The problem is magneto-static and axis-symmetrical, where zero and natural boundary conditions are presumed.

The created 2D models enable a preliminary evaluation of the magnetic field. With the introduction of gaps of magnetic and non-magnetic material between the magnets, a higher residual induction is achieved and better coercive force, which guarantees higher effectiveness of the separating device.

By providing gaps of non-magnetic and magnetic materials, the following results are achieved:

- Decreased number of permanent magnets, which will result in a decreased price of the device;
- Decreased weight of the separating device;
- Higher degree of purification.

The developed versions with ferromagnetic concentrators between each of the permanent magnets show that this is a good option for implementation of the magnetic filter, because the accumulated magnetic energy in the concentrators results in a greater force of attraction of the ferromagnetic particles in the product.

Г.7.5. Dimova T., Marinova M., Aprahamian B.,Marinov M., Investigation of the exploitation modes of a special type magnetic separator, Proceedings of 15-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2017, pp. 444-447

The paper is dedicated to the study of a separator with permanent magnets designed for processing of sunflower sprat before it enters a ball mill. The objective is to ascertain that the content of iron impurities in the material under treatment is close to zero so as to obtain pure product and to prevent damage to the mill. This is achieved through regular and timely cleaning of the separator, precise specification of the modes of its operation and of the reliability of its magnetic filter. The treated material is examined at the end of the technological cycle for the quantity of separated ferromagnetic impurities. Experiments have been conducted on the working order of the magnetic filter of the separator with permanent magnets. It has been proved possible to obtain such unevenness of the magnetic field, though which to obtain increased intensity of the field or, similarly, to do so by replacing permanent magnets with alternative ones. Recommendations have been given for proper reconstruction and repair.

In the process of operation, certain deviations have been detected from the nominal operating parameters of the separator. To find an optimal variant for reconstruction and repair of the magnetic filter, various computer configurations have been developed of the magnetic system of the separator. In all six of the proposed variants, the type of the permanent magnet is the same, the minimum magnetic induction in the operation area being stipulated at 0.1 T and the maximum magnetic induction on the filter surface between 0.33 T and 0.4 T. Variants of four and two Alnico permanent magnets have been realized which are magnetized in the same direction but generate an uneven magnetic field such as to provide values of the magnetic force of attraction and retention of ferromagnetic bodies within the range of 0.7 N to 5.5 N. The value of the two magnets does not exceed the value of one large magnet with the same technical parameters. Replacement does not require further changes in the design of the separator and ensures complete use of the operation area without any non-operating areas.

A planned experiment has been conducted to verify the degree of purification of the product under treatment after passing through the cycle conveyor - separator - mill. Samples have been taken from the segment before and after the ball mill. Regular cleaning of the magnetic filter shows a degree of extraction of ferromagnetic particles up to 60%.

The results obtained via mathematical calculation were analyzed, and the magnetic filter was fully replaced; instead of initial permanent magnets, prismatic permanent magnets were placed, which were magnetized along their transverse axis, whereby induction B_{max}=0.4 T was attained in the area between the magnetic poles. This change was achieved relatively easily, because permanent magnets were placed in a special movable module. Finally, an experiment was conducted and evaluation was made of the effectiveness of the separator. The experimental results showed a complete purification of the processed product from ferromagnetic inclusions.

Through mathematical modeling, the magnetic field of separator type E-15 has been analyzed. A suitable option for replacing a sector of its magnetic filter has been found, which increases the degree of purification and prevents damage to the transporter line.

Г.7.6. Dimova T., Streblau M., Aprahamian B., 3D Modeling of the Magnetostatic Field in Separation Apparatus, Proceedings of the First International Conference on High Technolody for Sustainable Development HiTech, 2018, pp. 215 – 217

This paper is devoted to three-dimensional mathematical modeling of the magnetostatic field in separation apparatus. The created models are based on a specific practical task, given by the manufacturer of the technological equipment. Conclusions are made about the used permanent magnets in the investigated magnetic separators. Using the Comsol Multiphysics software are developed different versions of the configuration of the magnetic system in order to achieve a maximum degree of purification expressed in maximum extraction of ferromagnetic particles.

The aim of the research is to solve a magnetostatic task in a three-dimensional field, which applies to determine the magnetic induction in the working space of a separation apparatus, and then to determine the magnetic force of attraction, acting on particles with different properties. Several 3D models have been developed to address this specific task, reflecting the change in construction and operating regime of the separation apparatus.

The conducted study allows making a number of conclusions about the used permanent magnets in the separating apparatus. The choice of the type of material for the permanent magnet is determined by the technical requirements, the operating conditions, the economic indicators and the technological restrictions of the particular separation apparatus. Materials which have

high field intensity are used for permanent magnets despite the fact that their magnetic energy is small. Nonetheless, the permanent magnet should be of minimal size and at minimal cost. These requirements are mutually contradictory, but in constructive designs a compromise solution is possible to be reached.

Г.7.7. Dimova T., Aprahamian B., Marinova M., Research of the Magnetic Field Inside a Drum Separator With Permanent Magnets, Proceedings of the 16-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2019, pp. 621-624

The paper presents a study of the pattern of the magnetic field inside a drum separator with permanent magnets. The construction of the separator and the position of the permanent magnets are described, and data are obtained experimentally along the longitudinal and cross axis of the drum separator. Attention is paid to the characteristics of the used magnetic material and its properties. By computer modelling, a pattern is obtained of the magnetic field of the separator. A comparison is made between the obtained results and the conducted experiment. Analysis is made of the possibilities to improve the operating regime of the separator by using novel magnetic materials for permanent magnets.

The separation construction under consideration consists of two drums, which are located in one plane, rotate in opposite directions, and a working zone is formed between them. Each drum is made up of three concentric cylinders - an external non-magnetic rotating cylinder, an internal stationary cylinder of paramagnetic material and a third, also stationary cylinder, on which the permanent magnets are located. The permanent magnets are arranged radially in a certain sequence and occupy one-third of the drums. The construction allows separation of the product being treated into two or three fractions, which eliminates the need for re-separation to the end of the production cycle.

Depending on the settings for the size of the working air gap, the separator has a flexible application and can be used for separating not only cereals and seeds, but also molding mixtures or building materials, which are subject to recycling. The main advantages of the separation system are - it shortens the technological cycle, reduces the production costs and does not generate dispersed magnetic fields that would affect the rest of the equipment.

The theoretical investigation of the drum separator has been done by FEMM 4.0 software, by help of which a two-dimensional modeling has been made of the magnetic field by the method of the finite elements. Source of the field is the system of permanent magnets described above. The problem is of magneto-static type, flat-parallel and non-linear because the characteristics of the ferromagnetic materials are assigned with their non-linear B-H curves.

From the realized experimental research, the following conclusions have been made:

- The theoretical approach presented here allows a visual, fast and easy definition of the distribution of the magnetic field in the operating zone of the separator with a variable configuration with set characteristics of the permanent magnets.

- A comparison of the theoretical and experimentally registered data shows a deviation of about 10 %. This permits to use the developed program model for future partial optimization of the constructive solutions for achieving a qualitative and efficient separation.

- The appropriate choice of the material for the magnets is of considerable significance for the improvement of the characteristics of the separator with permanent magnets. This would allow the separation both of ferromagnetic and paramagnetic materials.

Г.7.8. Todorov V., Aprahamian B., Tahrilov Hr., Applicability of peristaltic pumps in installations for vegetable oils processing, Proceedings of 19-th International Symposium of Electrical Apparatus and Technologies SIELA, 2016, pp. 331 – 334

The paper presents an overview of the operating principle of the peristaltic pumps and lists their advantages and disadvantages, which can be observed in technological installations designed to transport chemicals for processing viscous products and vegetable oils. Summarized data for selection of peristaltic elements according to a specific application is presented as well. The constructed laboratory installation with peristaltic pumps for hydration of crude vegetable oils provides an opportunity for applying different methods for calibration and control of the dosing of the two-component mixture. An idea is proposed for minimizing the total number of the pumps in the installation through re-directing the component flows, with an option for organizing circles for additional influence.

The technical solution of the proposed installation for hydration of vegetable oils is constructed using modular multi-store principle in order to achieve perspicuity and opportunities for introducing changes in the method of controlling the technological process.

Using a programmable logic controller (PLC) it is possible to control:

- Temperature regime, capable of adjusting the temperature parameter and controlling the heating interval for each of the containers.
- The ratio of the components of the mixture, as well as the logic of mixing, by controlling the peristaltic pumps.
- The moment of activation and the intervals of electric current impact on the targeted mixture.

The peristaltic pumps are applicable in processes related to the transportation of liquid and semi-liquid substances. Various methods for overcoming the observed drawbacks are also applicable. Data specifying the particular configuration suitable for the type of the working fluid and the requirements of the dosing process is presented. In addition to the familiar working principle a solution for simulating the stage of the hydration of the vegetable oils is offered, together with the opportunity for introducing corrections and selecting parameters, which are specific for the process.

Г.7.9. Andreev P., Aprahamian B., Safety system for handling medium and high voltage apparatus, Proceedings of 19-th International Symposium of Electrical Apparatus and Technologies SIELA, 2016, pp. 9 – 11

Present paper discuss an idea for developing a safety message delivery system. Messages are displayed depending of which apparatus is near the user and they consist of hints for correct operation with the equipment, safety instructions and control panels. The idea is based on Bluetooth Low Energy and Android smart devices.

Safety messages can be displayed on the screen of Android based device equipped with Bluetooth 4. On the device must be installed application, which monitors the beacon devices. The app brings messages or method of operation depending on which electrical apparatus is near the user. Messages can be pre-stored in the phone’s memory or Internet database can be used. Another option is various webpages to be displayed depending on user’s location. Under this option, editing messages process is greatly facilitated. The user may be directed to control panels or panels for data review.

When the smart phone received the radio signals from the beacon, it measures RSSI (Received Signal Strength Indicator). The RSSI is measured in dBm (decibel-milliwatt).

When user approaches to the beacon, this value increases. It can be calculated approximately by measure of how much the radio signal has decreased in power between the antennas. The path loss is related to the distance between beacon and smartphone and the signal wavelength.

Using beacons it is possible to build proximity based message delivery system. Beacons are perfect for indoor location system because they are cheap, small and use less energy than other methods. In addition, they require Bluetooth 4 for communication and proximity detection. These means, that they can be used with smart phones and tablets without using other hardware.

Using this new technology, a new way for communication between electrical apparatus and humans can be developed.

Abstracts of group Г.8. publications - Scientific publications in non-refereed scientific peer-reviewed journals or in peer-reviewed volumes

Г.8.1. Aprahamian B., Raev Hr., An experimental method of investigation of an asynchronous induction motor's magnetic fields, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 2, 2009, pp. 27 –30

The asynchronous induction motors are the most commonly used motors in ship electric drives. The investigation of their magnetic fields is an essential part of their working regimes exploring.

The magnetic fields of an asynchronous induction motor was studied using an experimental method that enables the screening of the magnitude and the shape of the magnetic fields in the stator and in the rotor, separately and in joint action in different working regimes of the motor. Applying an appropriate method of investigation the real pattern of the magnetic fields of the stator and the rotor can be drawn reading the motor's load, the influence of the kind of supply (single-phase or poly-phase) and the influence of the dephasing element (such as capacitor). These fields are taken in a real functioning asynchronous induction motor, which is very important advantage over the method of process modeling.

A special experimental model is built by separating the stator and the rotor of a real functioning motor in two equal parts. The first part is active on behalf of transformation of the electric power into mechanical power. The second part is passive, made with the same laminated, cylindrical iron cores as the active stator and rotor, but without windings.

When the active stator of the model is supplied with alternating voltage a rotating magnetic field with circular or elliptic shape is created. Some part of this field, called active part, crosses the winding of the active rotor and induces internal generated voltage in the rotor winding. The shaft of the induction motor starts rotating. The current in the active rotor creates magnetic field, rotating with synchronous speed toward the stator. Some part of this field, called active part, crosses the active stator and in interaction with the active part of the stator field forms the effective outcome field.

The remaining part of the field of the stator, called passive part, crosses the passive rotor and its magnitude and shape are independent from the field of the rotor. By parity of reasoning, the remaining part of the field of the rotor, called passive part, crosses the passive stator and its magnitude and shape are independent from the field of the stator. As result three fields exist in the model: rotor field, stator field and effective outcome field. The three fields are rotating with the same speed and there is no technical problem for their accurate measuring.

The measuring is completed with special probe coils, covering the route of the relevant magnetic field. The field of the rotor is registered by a probe coil installed in the passive stator. The effective outcome field is registered by a probe coil installed in the part of the stator facing the active rotor. Another probe coil installed in the stator and facing the passive rotor registers the field of the stator. The elliptic shape of the field is proved by switching signals from the running and the starting windings of the motor to the „x" and „y" channels of an oscilloscope.

Г.8.2. Aprahamian B., Raev Hr., A method of improving the commutation of a single-phase universal motor, Constanta Maritime University Annals, Romania, year X, vol.12, 2009, pp. 169 –172

The main purpose of this paper is to analyze a method of commutation of a single-phase universal motor and to improve the commutation using partly shielded supplementary poles. Considerable improving of the commutation is experimentally registered which is confirmation of the theoretical treatment of this problem.

The program of the experimental examination includes:

- Examination of the commutation of the windings sections with different initial values of the current intersection. Thus, we define the moment with relatively most unfavorable moment of commutation.
- Examination of the influence of the supplementary poles in this most unfavorable moment.
- Examination of the influence of the copper shield on the curve of the current in the commutating section.

Diminution of the picks of the commutation current due of the application of supplementary poles is experimentally registered.

In the same time, some worsening of the commutation in other parts of the current's sinusoid is registered. This is due to the fact, that the half of the supplementary pole has magnetic flux with phase angle shifting from the main magnetic flux and without any influence on the reactive generated voltage.

This research proves that it is possible to improve the commutation of single-phase universal motor by shielding some part of the supplementary poles of the motor. Considerable improving of the commutation is experimentally registered which is confirmation of the theoretical treatment of this problem.

Г.8.3. Aprahamian B., Dimitrov B., An experimental method of control of the process of drying of ship high-voltage induction motors by programmable logic controller, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 2, 2010, pp. 37 – 44

The high-voltage induction motors are widely used in ship electric propulsion drives, like AZIPOD and in ship bow thrusters. The stability of insulation resistance of the electrical machines is closely connected to the methods of control of the process of drying during the periods of operation and repair.

We propose an experimental method that enables to control the process of drying of ship high-voltage electrical machines by programmable logic controller.

The article proposes a drying system, allowing control by programmable logic controller (PLC).

Following functions are provided:

- Automatic control of the drying process carried out through the implementation of the PLC software. This lapses the need of human involvement. Practically, the control of insulation in the drying process is carried out in the recommended interval of 1-2 hours, which in standard conditions is imposed by the measurement operator.
- Suspension of the drying process after reaching the nominal parameters of insulation. In terms of energy efficiency, this system reduces the possibility of excess consumption of electricity.
- Option to record measured values and determining the absorption coefficient used for analysis of the drying process, respectively assess the state of the motor.

The main conclusions of our work are:

- The PLC system allows automatic control of drying and according to timer settings provide cyclical measure of insulation. This frees up staff from routine monitoring of the process.
- The system provides timely suspension of drying, after reaching the introduced in the program limits. Thus, in terms of energy efficiency, the system is ensuring lower cost of electricity for drying, i.e. the process does not continue unnecessarily long.
- Advanced programmable devices allow routine recording of values, connection to a computer, etc. The data obtained is suitable for analyzing the overall condition of the motor.
- Although the proposed model is used to Moeller Easy PLC family, the proposed system can be built with any programmable apparatus having the necessary functions. Thus, the proposed hardware allow the construction of relatively inexpensive and reliable system.

Г.8.4. Aprahamian B., Streblau M., Marinova M., Influence of power source parameters in induction heating of bearing bushings of ship propeller shafts, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2011, pp. 9 – 16

Alongside the existing classical methods of volume heating of the bearing bushings for installation on propeller shafts the possibility of heat treatment using low-frequency induction heating is very newsy and hopeful.

A major disadvantage of most methods of heating is the large energy consumption and the emergence of unacceptable temperature differences in the detail, leading to the appearance of various defects in its structure. This requires a detailed examination of the processes using the method of induction heating.

The purpose of this paper is to give a recommended range for the frequency of the power source and the power output in the detail by examining their influence on the distribution of the

temperature field in the volume of the heated bushing and consideration of the process efficiency.

Two-dimensional model is used, which considers both the electromagnetic and thermal problem. The simulation of the electromagnetic processes is accomplished using harmonic electromagnetic analysis. In order to assess the adequacy of the build model many experiments are conducted on non-ferrous brass bushings.

From the obtained results is found that the increase of the electrical efficiency should pursue the increase of the frequency.

Interesting are considered the frequencies in the range between 50 and 100 Hz, since the temperature differences along the axis of the workpiece do not exceed 3 ^{o}C, while at frequencies above 100 Hz, the difference is over 3 and up to 5 ^{o}C.

The following recommendations, based on the conducted investigations can be given - to achieve a homogeneous temperature field in the detail with only 5 oC temperature difference is necessary to use sources with frequencies up to 250 Hz. The same requirement is likely to be achieved at frequencies 440 Hz, but with lower power emitted into the detail - under 1 kW. At this frequency, there is an opportunity for even heating with capacities above 1 kW, but the detail must be preheated in advance.

The used approach makes possible to develop adequate theoretical models for studying the process of induction heating for different configurations of the details and the inductors.

Г.8.5. Aprahamian B., Streblau M., Modeling of Electromagnetic and Thermal Processes of High-Frequency Induction Heating of Internal Cylindrical Surfaces of Ferromagnetic Details, Proceedings of XLVI-th International Scientific Conference on Information, Communication and Energy Systems and Technologies - ICEST 2011, Niš, Serbia, vol. 3, pp. 981 – 984

Currently increasingly widespread the application of the induction hardening of ferromagnetic details, due to the high efficiency and universality of this kind of heat treatment.

For the most part, the companies, which realize this method, have limited power capacities and limitations in the frequency range. For these reasons, certain difficulties arise in the induction hardening of cylindrical internal surfaces and achievement of even hardened layer along the detail providing specific depth. Optimization of the technological regimes can be effectively done using computer models.

For this purpose, two-dimensional model was developed, simultaneously analyzing the electromagnetic and thermal processes, having taken into account their influence on the properties of the detail and with his help we have optimized the parameters of the inducers.

To carry out the theoretical investigation two-dimensional axial symmetric model is used, analyzing both the electromagnetic and thermal problem. The simulation of the electromagnetic processes is done by harmonic electromagnetic analysis.

With the above model, theoretical investigations were conducted at constant voltage and frequency.

The distribution of the vector magnetic potential and magnetic induction demonstrate the existence of double layer (with two highly different permeability zones) heat penetration medium under section of the workpiece until in the end of the process the temperature of the workpiece has passed the Curie point and the distribution of the electromagnetic field cover greater layer then the layer of the heat penetration.

Another important point is the achievement of uniform heating of the workpiece at a depth of the set hardening layer. The temperature difference is less than 50°C throughout the volume of the heated layer.

To ensure high efficiency it is necessary to use ferromagnetic cores in the system inducer - detail.

The ferromagnetic core shape must follow the configuration of the inducer. For this purpose, a better option is the preparation of magnetic core by molding rather than applying standard core configurations.

The used approach makes possible to develop adequate theoretical models for studying the process of induction heating for different configurations of the details and the inductors.

The investigated technological process has been applied in the production of steel sleeves of train carriage braking systems. In Bulgaria, the main manufacturer of such sleeves is Pomorie PLC, furnishing with annealed steel sleeves the railway companies of Germany, Bulgaria and other countries of the European Union.

Г.8.6. Aprahamian B., Dimitrov B., Dankov L., Application of PowerInt IP Expert software in ship LED lighting systems design, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 2, 2011, pp. 9 – 16

The LED technology is applicable for the ships' navigation and signaling lights, including sidelights, stern light, anchor light, maneuvering lights and warning signals, ensuring high-reliability, low-maintenance and reduced electrical-load-power requirements, resulting in low through-life costs. The lights meet the Colregs (International Regulations for Preventing Collisions at Sea), which means they are suitable for night operations.

The paper analyzes the application of software IP Expert in the design of marine lighting systems with LEDs. The products of the same manufacturer (PowerInt) are oriented to power sources and our aim was to examine their application on the ships.

The experimental studies were carried out by the reconstruction of the lighting system of the ship, consisting in replacing incandescent lamps with LED matrix.

Several circuit solutions have been implemented through each of the technologies offered by PowerInt - DPA, LinkSwitch, PeakSwitch, TinySwitch and TOPSwitch, using the generated by IP Expert topography of the scheme.

From the research can be deduced the following important conclusions:

- PowerInt surveyed controllers are applicable to developing circuit solutions for ship lighting.
- The schemes provide an opportunity to supply a wide range of input voltages and stability of baseline characteristics. This is achieved by the introduced optical feedback.
- IP Expert software provides topography of the scheme directly applicable to the research problems and does not require any modification.

Г.8.7. Aprahamian B., Streblau M., Starbakov Vl., Stavrev D., Technological aspects of the induction hardening of internal rotary surfaces of ship joints, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2012, pp. 15 – 24

The surface hardening by induction heating has many advantages over other methods of conventional thermal processing. It is known that this method is applied to achieve high hardness in the surface layer maintaining a resilient core. The implementation of the required thermal cycle depends both on the characteristics of the material undergoing processing and of the parameters of the system of induction impact. Some difficulties arise in high-frequency hardening of internal cylindrical surfaces of ferromagnetic joints with relatively small diameters, as there is a pronounced the Ring effect, leading to displacement of the eddy currents in the detail and to reduce the efficiency, and hence the quality of the products. The purpose of this work is to study the technological aspects of the induction hardening of internal rotary surfaces.
For achieving the objective of hardening with induction heating are used sample joints, made of steel type C50 EN 10083-2. To further study of the realized regimes of induction impact multiphysics simulation experiments were made using the Heat Transfer Module of the Comsol Multiphysics software. To assess the degree of impact and its applicability for hardening of the details a metallographic analysis was performed. Polished cuts are used, parallel to the axis of the details, hence their length.
On the presented preliminary simulation analysis of the proposed experiment is observed inequality in the distribution of the magnetic potential with application of the presented in the methodological part of this paper methodological parameters of impact and duration of 2.5 seconds, although the presented inductor is fully geometrically consistent of the processed details. This determines a shortage of power leading to insufficient for phase changes of the material temperature of heating, both in depth and the surface, where the magnetic field lines are concentrated.
The results of the preliminary numerical simulation analysis using the finite elements method is fully confirmed by a metallographic analysis carried out on details subjected to induction impact with the presented operating parameters.
The most - favorable impact, providing the technical requirements to the joint is obtained by heating at 3.5 sec.
The maximum surface hardness is 680 $HV_{0.1}$, reaching 400-450 $HV_{0.1}$ in a depth of 1,5 mm.
The layer is with suitable microstructure and geometry.
From the available results the following conclusions can be wrought:
- To achieve uniform distribution of the temperature field along the axis of the joint and reduce overheating in his ends is necessary to use a shorter inductor to compensate the Boundary effects and to reduce the full impendence of the system achieving higher values of the power in the circuit.
- The methodology used for the simulation provides sufficient accuracy and applicability of the software Comsol Multiphysics use in the design of inductors for high frequencies.

Г.8.8. Streblau M., Aprahamian B., Multiphysics model of inductor-detail system for volume heating in frequency midrange, Proceedings of 17-th International Symposium of Electrical Apparatus and Technologies SIELA, 2012, vol. 1, pp. 308 – 314

A number of advantages over other conventional methods characterizes the volume induction heating of non-ferromagnetic steel details. Especially for this type of heat treatment is the ability for precise monitoring and control of the technological parameters in order to achieve the necessary requirements according to the technical documentation.

To determine the specific parameters of the system inductor-detail it is particularly appropriate the implementation of computer models describing the electromagnetic and thermal processes in the detail and in particular in the inductor.

The purpose of this paper is the realization of a model of the system inductordetail that is neglecting the heat transfer to the environment and from the inductor by radiation and convection, and the power source is loaded as a source of voltage. The properties of the steel are set as a function of the temperature.

The results of an experiment with an induction system, powered by a machine generator with a rated power of 125 kW and a frequency of 10 kHz, are presented. To monitor the heating process, two thermocouples were installed to read the temperature at the base of the neck and along the conical surface of the shaft.

The following main conclusions can be made from the obtained results:

- The presented model describes with reasonable accuracy the electromagnetic and thermal processes in the system regardless of the adopted assumptions.
- Some part of the value of the error is due to the analytical approximation of the physical properties of the material.

Г.8.9. Dimova T., Aprahamian B., Determining the impact of some technological parameters of the process of separation of ferromagnetic particles trough a separator with permanent magnets, Proceedings of 17-th International Symposium of Electrical Apparatus and Technologies SIELA, 2012, vol. 2, pp. 34 – 41

This paper presents the results from the experimental study of a separator with permanent magnets designed for separation of ferromagnetic inclusions of loose granular product. A planned experiment was conducted and approach is suggested for determining the impact of some technological parameters on the process of separation. The obtained results are analyzed. A 2D model was developed of the separation device magnetic system to illustrate the distribution of the magnetic field by use of FEMM software product.

The devices for separation differ in design depending on the specific purpose, type and quantity of the material for separation, as well as on a number of other parameters.

For the experiments, a separator of WM-50C type with permanent magnets was used. This type of separator with permanent magnets is used successfully for separation of foundry sand and porcelain mixtures ($CaCO_3$, $MgCO_3$, etc.). It has small dimensions and achieves high degree of purification compared to other separators of the same class. The separator successfully separates ferromagnetic particles of greatly varying weight: $(10 \div 500 \times 10^7)$ μg.

We studied two materials commonly used in the production of tubular heaters: magnesium oxide and foundry sand. The experiments proved that the results from the study of both products coincide quantitatively.

The conducted analysis shows that the position of the permanent magnets ensures a simple design and high safety of operation. A non-magnetic film is placed over the magnetic system. The film facilitates the subsequent removal of the ferromagnetic particles derived from the processed product.

Using statistical modeling, the impact of the assigned factors and the combinations between them has been determined in percentage. Analyzed is the impact of the set factors and the possible combinations one by one for a specific case of separation with permanent magnets.

The resulting linear regression equation has a relative error below 10 %, which allows us to conclude that the model is reliable. Using this model, is possible to calculate optimal values of the factors for setting up the separator. 2D models have been created of a system of permanent magnets, showing the pattern of distribution of the magnetic field.

Г.8.10. Streblau M., Aprahamian B., Shtarbakov V., Tahrilov H., The Influence of the Geometry of the Inductor on the Depth and Distribution of the Inductively Hardened Layer, Proceedings of XLVII-th International Scientific Conference on Information, Communication and Energy Systems and Technologies - ICEST 2012, V.Tarnovo, Bulgaria, vol. 2, pp. 564 – 566

The hardening of internal cylindrical surfaces of ferromagnetic details require to achieve a rate of heating ensuring uniform hardened layer in depth of the detail. To meet these requirements is necessary to create an appropriate distribution of the temperature field in the volume of the detail.

The purpose of this paper, based on a proposed theoretical model, is to present a specific solution to design the shape of the inductor used to heat the inner surface of the cylindrical sleeve type detail.

The heating and hardening of the detail is carried through an inductor with ferromagnetic core, powered by a tube generator, with duration of the process 10 s. The quality of hardening is determined by metallographic analysis.

A theoretical study using axial symmetric model is performed. The results for the distribution of the electromagnetic and thermal fields are presented in the paper.

The following conclusions based on the presented results are found:

- The system inductor-detail with specially shaped inductor, corresponding to the hardened surface provides the necessary distribution of the electromagnetic field in the depth of the detail that determines the appropriate temperature distribution along his longitudinal surface;
- The results show that relatively small sizes and distance between the inductor and the detail require the use of profiled wire for making the inductor. This determines the relatively better electromagnetic connection and a more even distribution of the electromagnetic field opposite the wires;
- The lack of internal core of the inductor set loss reduction, respectively redistribution of the active power and increases the ability to reduce the number of turns of the inductor. Accordingly, this leads the increasing of the magnetic flux and power emitted in the detail that provides high-speed heating.

Г.8.11. Димова Т., Апрахамян Б., Щреблау М., Едно изследване върху технологичните параметри при сепарация с постоянни магнити, Трети международен научен конгрес „50 години ТУ-Варна”, том III, с. 214 – 218
(Dimova T., Aprahamian B., Streblau M., Investigation on the Technological Parameters for Separation with Permanent Magnets, Proceedings of the Third International Scientific Congress “50-th Anniversary of Technical University of Varna”, vol. III, pp. 214 – 218 – in Bulgarian)

Due to a number of advantages, there is an increasing use of magnetic separation. This also raises some questions related to the theoretical and practical application of these separation

methods. Improving the quality and effectiveness of its implementation requires refinement of existing methods of research and improvement of design and technological solutions. The solution to the above questions is related to the application of new mathematical models and computer-aided research methods.

The purpose of the study is to build, based on the experiments carried out with an active permanent magnet separator, a regression model corresponding to the real magnetic separation process that allows optimization of the process.

The studies were performed with a permanent magnet separator type WM-50C, examining the influence of various factors on the degree of purification. The factors studied were - concentration of ferromagnetic particles, thickness of the layer of the processed product, number of separations, relative humidity and temperature.

The factors affecting the efficiency of the separation have been identified and their significance has been assessed under the specific conditions, which determines the increase in the possibilities for more accurate prediction of the application limits of the permanent magnet separators.

A mathematical model has been developed to study the technological parameters of a permanent magnet separator. The adequacy of the model was evaluated through real experimentation. The mathematical model can be used to study larger electromagnetic systems for the preliminary evaluation of technological possibilities for separation of bulk materials.

The results can be used to estimate and optimize the separation process of ferromagnetic materials with different magnetic permeability.

The implemented model can be used as a basis for creating a semi-industrial variant for separating ferromagnetic impurities from non-ferromagnetic mixtures.

Г.8.12. Щреблау М., Апрахамян Б., Щърбаков Вл., Тахрилов Хр., Ставрев Д., Изследване влиянието на скоростта на относително преместване на детайл при индукционно нагряване на външни цилиндрични повърхнини чрез компютърно моделиране на процеса, Трети международен научен конгрес „50 години ТУ-Варна", том III, с. 237 – 242

(Streblau M., Aprahamian B., Shtarbakov V., Tahrilov H., Stavrev D., Investigation of the Influence of the Speed of Relative Movement of the Workpiece in Induction Heating of Outer Cylindrical Surfaces through Computer Modeling, Proceedings of the Third International Scientific Congress "50-th Anniversary of Technical University of Varna", vol. III, pp. 237 – 242 – in Bulgarian)

The prevalence of the method of induction heating for hardening of steel details and increasing demands to improve efficiency and quality of heat treatment require proper determination of the technological process parameters. In continuous regime the speed of travel of the workpiece relative to the inductor defines the temperature to which the product is heated and the time and speed of operation of the process. To take into account its impact on technological parameters of the process of induction hardening, it is necessary to conduct a comprehensive analysis of the system inductor-workpiece. For the purpose a dynamic model is developed, that takes into account the peculiarities of the regime of continuous heating.

The mathematical model is implemented for the two-dimensional domain in a cylindrical coordinate system. The following assumptions were adopted when implementing the model:

- the model is two-dimensional and axisymmetric;

- the heat treatment process is continuous and, during heating and cooling, the inductor position receives discrete values along the z axis;

- the inductor is water-cooled and it is assumed that it does not change its physical characteristics during the heating process;

- cooling in water is modeled by convective heat transfer along the part of the workpiece;

- the radiation to the environment is neglected due to the small relative time for heating of the respective areas of the workpiece surface and due to the shielding action of the inductor against the non-heated area of the workpiece surface.

An experiment was carried out on an inductor-detail system powered by a 66 kHz high frequency generator. The heating process is continuous and the detail is cooled by a water shower. The material of the workpiece is ferromagnetic steel 40X.

The pre-hardened specimens have been prepared with grinders to determine the hardness values per section of the workpiece.

The maximum relative error between the two studies is no more than 10 %, which proves the adequacy of the model applied. The proposed computer model for the analysis of heating processes for tempering and cooling modes after verification by indirect methods - metallographic analysis of the metal structure - has been proven to be adequate. The temperature distribution is consistent with previous studies, which shows that the model can be used for analysis when solving a multifaceted problem.

Г.8.13. Dimitrov B., Aprahamian B., Andreev P., Experimental investigation and modeling of thermal processes of LED matrix cooling system, Трети международен научен конгрес „50 години ТУ-Варна", том III, с. 223 – 227

Under review are transient and stationary temperature processes in the work of the LED arrays.

Studies have been conducted based on measuring the distribution of temperature field with IR thermography camera and numerically carried out by mathematical models.

The latter are formed by the finite element method and computational procedure implemented in specialized software

The aim is to explore approaches for modeling of thermal processes in the system LED matrix radiator-cooling-fan-environment.

In this study, measurements are made using IR thermocamera that is set according to the coefficient of blackness of the aluminum radiators.

The results of the proposed experimental studies can be obtained by numerical modeling conducting computational procedure.

The model was built by using the mathematical apparatus developed for transient heating investigation.

FEM modeling can determine the characteristics of the system LED array-cooling radiator, confined to the geometric dimensions of the radiator and need convection.

It also allows the analysis of thermal regimes in different mounting positions of the radiator in a particular equipment, the presence of external heat sources, etc.

The used mathematical apparatus and software provide results with sufficient precision.

The precision increases taking into account the characteristics of the contact layer between the LED array and radiator surface.

Boundary layer is set by using the option highly conductive layer, through which can be avoided the geometric modeling.

Г.8.14. Aprahamian B., Dimitrov B., Dankov L., Modeling and analysis of a reconstruction of ship searchlight using LED matrix, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 2, 2012, pp. 17 – 26

The searchlights of the ships and the lifeboats are designed to help in the rapid identification of people fallen overboard and to communicate with other ships and shore. To safely perform these functions, they need to be powered from independent sources, and their capacity is determined by SOLAS (International Convention for the Safety of Life at Sea), according to the required duration of illumination. Although light communication is shifting from various forms of radio communication, it is still indispensable element of navigation equipment of each vessel. New LED light sources provide high brightness, high efficiency (the ratio of light to electricity usage) and responsiveness (the transition from off in a state of maximum brightness). This allows for the construction of relatively small-sized searchlights with multiple parameters exceeding the requirements of SOLAS.

In this paper, an available reconstruction of the ship searchlight with replacement of the used incandescent lamp with LED matrix is proposed and analyzed. By achieving such modernization reduced power consumption, high reliability and extended life cycle of the facility is meant. For this purpose, we performed a comprehensive analysis of the searchlight to the standard form and then reconstructing it.

An appropriate installation mode of the LED matrix providing the required optical characteristics of the searchlight is proposed and comparative analysis of the results is done, arguing the relevance of the reconstruction.

The LED matrix of the developed model of searchlight has electric power of 90 W and is composed of nine LEDs, 10 W each. The geometry of the searchlight is not significantly different from the original design. The necessary installed power and the number and location of the LED matrices are determined experimentally. The lighting capacity of the searchlight is studied through the model. The results show that the reconstructed device can fully replace the original searchlight. The model is made using specialized software that allows conducting simulation procedure and determination of the optical and thermal parameters of the modelled object.

The proposed lighting is designed as a model representing a conceptual option for modernizing widely used ship searchlight. A prototype of the searchlight can be fabricated and experimentally studied. At this stage of the conducted experimental and numerical procedures can be drawn:

- The created models and the results of the thermographic investigation of the original searchlight, lead to the conclusion that the LED matrices can be used for modernization of the device, providing the increase of the light output, despite the reduced consumption of 300 W to 90 W.
- The experimentally studied power system works with high efficiency. The conducted tests show that is suitable for powering LED matrices and in practice the system can operate continuously throughout all the night.
- The power to the searchlight can be supplied from a battery, using the proposed scheme in the paper.

- The expectations are that the reconstruction will increase the reliability of the device, and will get a much better spot illumination, facilitating the search and rescue at sea and increase the distance of the light communication.

Г.8.15. Aprahamian B., Streblau M., Stavrev D., Shtarbakov Vl., Influence of the technological parameters on the distribution of the temperature field and the depth of the hardened layer during the induction heating of the internal cylindrical surface of ship steel bushings, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2013, pp. 9 – 14

The surface hardening by induction heating has many advantages over other methods of conventional thermal processing. It is known that this method is applied to achieve high hardness in the surface layer maintaining a resilient core. The implementation of the required thermal cycle depends both on the characteristics of the material undergoing processing and of the parameters of the system of induction impact. Some difficulties arise in high-frequency hardening of internal cylindrical surfaces of ferromagnetic joints with relatively small diameters, as there is a pronounced the Ring effect, leading to displacement of the eddy currents in the detail and to reduce the efficiency, and hence the quality of the products. The purpose of this work is to study the technological aspects of the induction hardening of internal rotary surfaces.

For achieving the objective of hardening with induction heating are used sample joints, made of steel type C50 EN 10083-2. To further study of the realized regimes of induction impact, multiphysics simulation experiments were made using the Heat Transfer Module of the Comsol Multiphysics software. To assess the degree of impact and its applicability for hardening of the details a metallographic analysis was performed. The microstructure was investigated using a light microscope Neophot 32. The results of the preliminary numerical simulation analysis using the finite elements method is fully confirmed by the metallographic analysis carried out on details subjected to induction impact with the presented in the methodological part of this paper operating parameters.

From the available results the following conclusions can be wrought:

- To achieve uniform distribution of the temperature field along the axis of the joint and reduce overheating in his ends is necessary to use a shorter inductor to compensate the Boundary effects and to reduce the full impendence of the system achieving higher values of the power in the circuit.
- The methodology used for the simulation provides sufficient accuracy and applicability of the software Comsol Multiphysics use in the design of inductors for high frequencies.

Г.8.16. Streblau M., Stavrev D., Aprahamian B., Shtarbakov Vl., Investigation of the process of hardening by induction heating of steel grade 40x(DIN 41Cr4): numerical modeling, experimental verification, structural changes, International virtual journal "Machines, Technologies, Materials", year VII, issue 11, 2013, p. 29 – 32 (http://mech-ing.com/journal/11-2013.html) and Proceedings of the 10-th International Congress "Machines, Technologies, Materials", vol. 1, 2013, pp. 60 – 63

Hardening of iron-carbon alloys by means of induction heating is a widespread technology for the thermal treatment of machine elements. The combination of many factors such as temperature, time and rate of heating (austenization), respectively cooling; depth of penetration;

specific surface power; the initial and extremely macro and microstructural states of the material, as well as its thermal and physical characteristics, are of complex importance for its proper implementation in view of the technological requirements in the particular case.

Thus, of great practical importance is the ability to predict the final macro and microstructural state when applying specific parameters of inductive impact.

The purpose of the present work is to analyze and adjust the thermal cycle by the resulting temperature distribution in the workpiece and time-temperature diagrams for layers of workpiece at a certain depth.

A multifaceted analysis of the electromagnetic and thermal problem resulted in a numerical layer analysis of the temperature distribution in depth of the tested 40x steel samples (DIN 41Cr4) and the corresponding phase-structural changes.

The results of the metallographic analysis show agreement with those of numerical modeling. This makes it possible, by numerical modeling, to determine the input parameters of the inductor-detail system in order to fulfill specific technological requirements for the thermal processing of parts.

Based on the presented model, results were obtained regarding the variation of the surface temperature of the workpiece and the depth of the hardened layer depending on the value of the specific surface power and the time of the process. The data presented can be used to adjust the electromagnetic and thermal process in the inductor-detail system.

Г.8.17. Aprahamian B., Goranova M., Model-experiment comparative analysis of roof type photovoltaic generator, Proceedings of XLVIII-th International Scientific Conference on Information, Communication and Energy Systems and Technologies - ICEST 2013, Ohrid, Macedonia, vol. 2, pp. 735 – 738

The object of the presented study is a roof type photovoltaic generator delivering energy to the electricity grid through an inverter. A model-experiment comparative analysis of the roof type photovoltaic generator is proposed. The model is made during the design of the generator using the PVSyst software, and the experimental data are recorded by the system for one year.

The purpose of the comparison is to examine the factors influencing the accuracy of the model and specifying measures for its improvement.

A comparative analysis of the data obtained both from the model and the experiment conducted on photovoltaic generators is proposed. These are of roof type, built with modules from two different technologies.

The data from the model are obtained using the PVSyst software in designing the generators. The experimental data are year-round operation of the system PV-generator - converter.

The aim of the study was to identify the factors influencing the errors in the models and approaches to correct the design of the system.

The obtained results show that the error in the initial model is significantly higher in the winter.

To obtain the most accurate results from the PVSyst model it is necessary to make corrections to the discussed factors in the following way:

- The correction of the Ohmic losses (losses due to resistance) requires to point that due to the low transmission power the losses in the cables in the winter are smaller. The correction of this factor in the model should define losses less than 2 %.

- The correction of the Albedo factor should comply with the recommended values for the season.
- Because the PV generators are for relatively low power, the mismatch losses are minimized by selecting the modules according to their characteristics. This is reflected in the corrected model, where they are reduced to 1 %.
- The Nominal Operating Cell Temperature (NOCT) correction factor is corrected by reporting his value every month according to the average ambient temperature.

The PVSyst model should be calculated separately for each month, which increases the accuracy of the obtained results.

Г.8.18. Goranova M., Aprahamian B., Heat-accumulation system powered by photovoltaic modules, Proceedings of XLVIII-th International Scientific Conference on Information, Communication and Energy Systems and Technologies - ICEST 2013, Ohrid, Macedonia, vol. 2, pp. 759 – 762

In this study a heating system working with Glauber's salt as heat-accumulation material is proposed.

That is powered by renewable source - roof type photovoltaic (PV) generator.

A design methodology for the system: PV generator - low temperature printed circuit board (PCB) heater - container with heat-accumulation material is proposed.

A direct link between the generator and the heaters is used, since the characteristics of the system allow maximum use of the source.

A complete laboratory experimental model, used for space heating, is presented.

The studied heating system should reach full melting of the salt in which the energy is accumulated.

As a result of the phase transition is obtained a cooling curve, wherein the heating process is more efficient compared to the materials without a phase transition.

The system PCB heater - PV generator is designed to provide the desired temperature control of the heating. The direct connection of the heaters and the generator without using converter reduces the investment cost and is shortening the repayment of the system.

On the other hand a converter would be useful as a voltage-adding power system through which shortages of power of the PV generator can be compensated.

The system operates in a stable condition, as it is less dependent on the shading, contamination of the modules, changing the resistance of the heating element during the operation, etc.

The proposed design ensures uniform heating of salt by uniform field across the PCB heater. Furthermore, the containers of parallelepiped shape can be mounted on the walls of the room without the loss of the space therein.

Г.8.19. Streblau M., Aprahamian B., Dechev At., Dimov D., Investigation of the influence of the electric current’s magnitude on the operating regime of an oxyhydrogen generator, Proceedings of the Symposium "Practical energy problems and trends in efficient technologies" PEPTET’2013, Sofia, Elektrotechnika + Electronika Journal, vol. 5-6, 2013, pp. 86 – 90

The electrolysis of water is an electrochemical process in which hydrogen and oxygen are obtained. This is done under the influence of an electric current flowing through the electrolyte. The resulting mixture of oxygen and hydrogen is called oxyhydrogen or Brown's gas. In this paper is presented an experimental investigation of the behavior of an oxyhydrogen generator utilizing electrolyzers with cylindrical and disc shape electrodes. The input electrical parameters of the electrolyzers are observed, and the amount and flow of the gas on the output of the generator.

The aim of the paper is to investigate the impact of the magnitude of the electric current flowing through the electrolyte on the behavior of the oxyhydrogen generator. Therefore the input and output parameters of the Brown's gas system are monitored.

The investigation was conducted using an oxyhydrogen generator with two different electrolyzers – with cylindrical and disk shape electrodes. The used electrolyte is 5 % and 20 % solution of NaOH (sodium hydroxide). Both electrolyzers are supplied with a source of DC voltage. The determination of the amount of the produced gas is implemented by a special flowmeter. The time to obtain one liter of oxyhydrogen is also measured.

The relations of the voltage, the gas flow rate, the time, the electric power, the energy and the MMW (Milliliters of HHO per Minute per Watt) as a function of the magnitude of of the flowing electric current, respectively, at the indicated values of the concentration of the electrolyte and with different form of the electrodes in the electrolyzers are experimentally investigated.

The energy required to produce one liter oxyhydrogen in electrolyzers with cylindrical electrodes increases along with the increase in magnitude of the flowing current, while in the case of disc shape electrodes relatively uniform values are achieved in the investigated range of the current levels. The latter is due to the relatively low applied voltage and the low resistance due to the small distance between the electrodes.

The effectiveness of the electrolyzer with cylindrical electrodes decreases with the increase of the flowing current, while in the case of disk shape electrodes its value remains relatively constant.

When changing the concentration of the electrolyte no relatively high changes in the parameters of the system are observed. Of course, with application of higher percentages of the electrolyte solution concentration, some increase of the effectiveness of the electrolyzers has been registered.

Г.8.20. Димова Т., Апрахамян Б., Щреблау М., Изследване конфигурацията на магнитното поле в сепаратори с постоянни магнити за очистване на слънчогледови семена, Доклади на Юбилейната научна конференция „50 години катедра ЕТЕТ", Годишник на ТУ-Варна, том 1, 2013, с. 54 – 58
(Dimova T., Aprahamian B., Streblau M., Exploration of the Magnetic Field Configuration in Permanent Magnet Separators for Purification of Sunflower Seeds, Proceedings of the Scientific Conference "50-th Anniversary of the Department of Electrical Engineering and Electrotechnology", Annual Journal of Technical University of Varna, vol. 1, 2013, pp. 54 – 58 – in Bulgarian)

According to EU Regulation 742/2010 in the processing of cereals, solid inclusions should not exceed 1.5 % of the total volume of the crop and ferromagnetic inclusions should be absent in the final product. For the separation of ferromagnetic impurities from the feedstock, a magnetic field separation method is applicable, characterized by the following features:

advantages - reliability, economy, efficiency, mobility and disadvantages - relative weakening of the field over time and its optimal distribution.

The efficiency of the separation devices is determined by the following factors - the magnitude and uniformity of the distribution of the magnetic force in the working gap and the degree of purification (extraction) of the ferromagnetic particles. The first factor is determined by the type and configuration of the magnetic system. There is a problem in determining the second factor - the degree of purification, because it depends directly on the concentration of the ferromagnetic particles in the product being separated.

The concentration of ferromagnetic particles in laboratory tests is fixed and predetermined, but in real conditions, it is always a random variable. This condition requires that the evaluation be carried out experimentally.

In this regard, the purpose of the present development is to trace the influence of the location of the permanent magnets that make up the magnetic filter of the separating device and the distribution of the field generated by them.

To accomplish this goal, three main tasks have been accomplished, which are to plan an experiment, implement an experiment, and build a model of the separating device.

The study was conducted in the following order:

- Preliminary assessment of the separated mixture and determination of the basic design parameters of the separation device;
- Experimental determination of the magnetic induction in the working space of the separator;
- Theoretical modeling of magnetic field distribution using a finite element based software.

The following conclusions were drawn from the conducted studies:

- The uniform distribution of the magnetic induction can be achieved by increasing the air gap between the individual magnets;
- It is found that part of the magnetic flux is scattered outside the separator. This can be avoided if the housing of the device is made of paramagnetic material;
- It is advisable to carry out further studies based on a theoretical model developed using the finite element method in order to reach an optimal decision on the field distribution.

Г.8.21. Aprahamian B., Goranova M., Specific properties of HIT-type photovoltaics containing nanodimensional layers and their application in autonomous photovoltaic systems, Nanoscience and Nanotechnology – Nanostructured Materials, Application and Innovation Transfer, issue 14, 2014, pp. 176 – 179

The paper presents an experimental investigation made for comparative evaluation of the performance of the HIT (Heterojunction with Intrinsic Thin layer) type photovoltaic modules containing nanodimensional layers compared to silicon mono-crystalline modules. Experiments were conducted under real operating conditions by monitoring an autonomous photovoltaic system. The data is summarized, allowing for comparison between technologies in the following basic regimes: direct irradiation of varying intensity, equal and different orientation of the modules, fully and partially shading. The results show improved performance of the HIT type modules containing nanodimensional layers within 7-10 %. The experimental results were confirmed by comparison with mathematical model of the photovoltaic modules, built in MatLab.

The comparison between the HIT type of modules containing nanodimensional layers and the silicon mono crystalline modules is conducted by measuring the electrical characteristics under

real operation conditions of the PV modules.That supplements the provided by the manufacturers data, obtained predominantly in the laboratory. The results show up to 10 % more output of the HIT type of photovoltaic generator.

The following conclusions can be drawn from the present study: In the same power range the HIT-type of photovoltaic modules are of higher efficiency, respectively, with higher output than equivalent mono-crystalline modules. The losses from partial shading of the HIT-type of photovoltaic generator are smaller.

A methodology for joint use of both technologies is developed. It is used for reconstruction of old generators and replacement of modules with new ones, produced using the HIT technology. Analytical modeling is applicable to the HIT technology and the results of the implemented in MatLab model are with sufficient precision.

Г.8.22. Aprahamian B., Printed thick film heating elements for use in ships, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2014, pp. 17 – 24

The paper presents our work in developing printed thick film heater elements on ceramic substrates for heating in the range of 300 – 400 ^{o}C. Two types of samples are realized and experimentally investigated. Their leakage currents are measured and their resistance to the sea mist impact is checked. The heater elements on ceramic substrates are considered promising for application in ships.

Having analyzed many dielectrics available, we found Al_2O_3 ceramics to be the most suitable one for use as substrate of the heating elements. All samples were prepared on square 96% Al_2O_3 ceramic substrates with a side of 2 inch (50.8 mm) and 0.9 mm thick. Thick film inks are deposited on substrates by a screen printing process. The samples are produced using a technology similar to that for the production of Printed Circuit Boards with a number of special technological features.

The experimental production was realized in the Laboratory of CONIS ELCO Ltd. (former Capacitor plant, Kyustendil, Bulgaria). Two types of samples were produced, using Al_2O_3 ceramic substrates and screen printing technology of formation of the resistive and protective layers and of the contact terminals sites.

In experimenting the procedures mentioned parameters were changed many times and their effects upon the quality of the layer were studied by statistical analysis.

An entire protective layer covering entire plane of the element on the side of the resistive layer was applied on samples of heater elements by screen-printing, this layer enabling operation of the heater in direct contact with conducting objects without using additional insulation.

Prototypes (samples) are developed with the following parameters: area of the heater – 2,58. 10^{-3} sq.m., maximal power for this area – 60 W, maximal operating temperature – 380 ^{o}C, dielectric strength - 1500 VAC. Power supply may be of direct or alternating current of up to 250 V.

Standard tests for resistance to the impact of sea mist of the samples of heating elements were performed.

The tests were conducted in the Laboratory for material analysis and testing and calibration of measuring facilities of the “Acad. A. Balevski” Institute of Metal Science of the Bulgarian Academy of Sciences. Ten samples of heating elements were tested and before and after the

experiment the active resistance of their resistive layer was measured. The maximum change recorded from the initial resistance is 1.23 %, which is considered acceptable.

The proposed process for obtaining protected printed thick film heating elements is considerably simpler than the classical technology applied for the production of tubular heaters for ships.

The proposed heating elements are suitable for use in direct contact with conductive objects without the use of additional insulation details due to the low values of leakage current through the ceramic substrate and the protective layer.

The proposed heating elements are made by additive technology by eliminating the mechanical contact of two or more bodies forming the heater which may lead worsening the thermal contact and decreasing the reliability of the heaters.

There is no technological barrier to applying the protective layer after attaching the contact terminals, which strengthens mechanically the terminals and seal them.

The proposed heating elements have a very good resistance to high humidity environments and environments containing salts (sea mist). Therefore, they can find application in navigating heating appliances working in indoor ship areas.

Г.8.23. Streblau M., Aprahamian B., Modeling of the process of volume induction heating in continuous regime, Proceedings of the International Scientific Symposium Electrical Power Engineering, Varna, 2014, pp. 96 – 98

A number of advantages over the conventional methods characterizes the volume induction heating of details of structural steel, namely: maintaining the desired temperature distribution in the workpiece; relatively high efficiency; quality of machined details; possibility to control the process parameters, and possibility to automate the technological process.

In the paper is proposed and examined a model of inductor-detail system for volumetric heating of ferromagnetic steel in a continuous operation performed by relatively moving of the workpiece toward the inductor.

Typical representatives of the systems for volume induction heating in continuous operation are the Russian devices of the series KIN. These are a type of orifice induction furnaces, used for volumetric heating of structural steels. The inductor for these types of systems is made in a cylindrical, oval or rectangular shape. The inductor is isolated with glass tape and pour with refractory concrete. Inside the inductor are provided two water-cooled casing pipes from non-magnetic steel, on which are moving the details. This type of induction systems operate at a relatively low frequency in the range from 2.4 to 8 kHz.

The main disadvantage of the induction heating is the receiving of some typical for the electromagnetic and temperature fields parameters defining the quality of the heating process and respectively the tuning of the system inductor-detail. Even more striking is the problem in processes related to the relative movement of the workpiece toward the inductor.

For this purpose, it is appropriate the use of models, which can realize a sufficient number of theoretical studies. In the paper is presented an approach to the modeling of the system inductor-detail providing a continuous heating process by moving the workpiece toward the inductor.

The purpose of this paper is to present a model of the inductor-detail system for volumetric heating in continuous operation regime. The properties of the materials involved in the pattern of the model are set according to the current value of the temperature. The model is implemented in

an environment of Comsol Multiphysics 4.4 software. The relative movement of the workpiece toward the inductor is performed using the "Moving mesh" tool.

The setup of the model is realized using an experiment held in "Terem - Han Krum" Ltd. in city of Targovishte. The supplied power to the inductor is provided by electrical generator with a rated voltage 600 V and frequency 2.4 kHz maintaining forced power factor $\cos\varphi = 0.95$. The inductor is made by copper wire and poured with fireproof concrete. Cylindrical details with dimensions - d = 50 mm and l = 200 mm undergo volumetric heating. The material is steel grade C45 (EN 1.1191). A regime of a continuous heating process is realized with duration of 30 s and final temperature on the surface of the workpiece - 1100 ° C.

From the results obtained through a theoretical study and the realized experiment is found a relative error below 10%, which determines the adequacy of the model.

With the applied approach can be precisely determined and optimized the process parameters of volumetric thermal induction treatment at continuous regime of heating, such as:

- Value of the supplied voltage to the generator;
- Frequency of the supplied voltage;
- Speed of movement of the workpiece.

Г.8.24. Todorov Vl., Aprahamian B., Tahrilov Hr., Opportunities for application of electrotechnological methods when processing vegetable oils, Proceedings of 14-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2015, pp. 231 – 238

The intensifying of the precipitation process as a result of the application of electric field and electric current provides opportunities for modernization of the technological processes and combination with working technological schemes for vegetable oil processing. The purpose is to achieve coagulation and separation of the received fractions without the use of the currently applied technology for salting of the aqueous solution. The application of permanent magnetic field shows stable tendency for acidity decrease, acceleration of the precipitation process and improvement in the limpidity of the received oils. The simultaneous influencing with devices for magnetic processing of the water and electric coagulation of the mixture requires significant changes in the existing chemical processes with non-reagent ecological electrotechnology. The proposed design of devices for field processing of vegetable oils suggest that the magnetic influencing should be carried out on stages, separately - for processing of the incoming water flow - and/or in combination – together with electric field via an electrode system on the mixture of vegetable oil and water.

The process of hydration can be intensified by exposure to electric field and electric current. A higher level of coagulation can be achieved by applying alternating voltage through an electrode system in the raw oil-water emulsion. This aims at achieving larger formations of coagulated substances, as well as enhancing the precipitation process (hydration and separation of the precipitates).

At the same time, the application of permanent magnetic field on the suspension tends to reduce acidity, speed up the process of precipitation and increase the limpidity of the processed oils. The results prove the applicability of the magnetic field in the process of oil hydration when improvement of its parameters is sought.

The purposes of this research are:

- testing the opportunities for introducing electrotechnological methods for processing vegetable oils which aims at eliminating their treatment with chemicals; analysis of the technological process and determining the points where electromagnetic field can be applied.

- analysis of the characteristics of the received products (oils) and distinguishing the ones which are results from the applied electrotechnological methods;

- designing the prototype of a device which will improve the vegetable oil quality by introducing electromagnetic field in its processing in laboratory conditions. The device will be used for experimental studies with subsequent laboratory analysis of the processed oil characteristics.

The sample device for processing with electromagnetic field is electrotechnologically designed on modules so further options can be added.

The method presented in the current study aims at improving the quality of the product.

The process of hydration can be divided into few stages:

- Preparatory stages – influencing with magnetic field (before the electrode system of the incoming water flow).
- Secondary stages - the target mixture goes through magnetic field, which can be combined with electric field.

The proposed construction of cylindrical magnets of steel spacers enhances the performance and the technical maintenance of the device for magnetic influence.

The organization into cycles, including feedback, is a rational decision for achieving the desired values of the target parameters.

The module principle of the device construction ensures options for achieving flexibility of the chosen variants and allows subsequent additions.

The coagulation process of the disperse system intensifies as the field strength near the electrodes increases. It leads to increased polarization and deformation of the double electric layer of the particles, this way increasing their speed and their concentration around the electrodes.

The type of the current and the topology of the electric field influence the process of electrocoagulation.

In comparison with the application of direct current, when alternating current is used polarization coagulation and partial dissolution of the electrodes are observed.

The technical implementation of the device should be suitable for chemically active environments due to the requirement of non-presence of electrode ions in the processed emulsion.

The kind of the electrodes appears to be an important factor due to the intensity of the electric field, which they generate.

The application of alternating current with adjustable frequency allows further refinement of the technological parameters of the process.

Uneven field with high intensity allows industrial or semi-industrial application.

Г.8.25. Marinov M., Streblau M., Penev T., Aprahamian B., Study of the electromagnetic characteristics of synchronous generator by replacement of the excitation winding with permanent magnets, Proceedings of 14-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2015, pp. 14 – 17

The aim of the paper is to investigate the characteristics of alternator which rotor's winding is replaced with permanent magnets while the expense for the construction of the new magnet is kept at minimum.

For realizing the rotor with permanent excitation, were used neodymium magnets type NFB38 with cylindrical shape and the following dimensions: D = 10 mm; H = 20 mm.

If the magnets are not arranged in the right way, the resultant magnetic field will be extremely weak because the magnets will be short connected.

During the selection of the magnets was investigated the magnetic field distribution over the nail-like poles. The comparison is made between three different rotor excitation types – with electromagnetic, with neodymium and ferrite permanent magnets.

From the concluded experiments, it can clearly be seen that the suggested low-expense model is highly inefficient. The reason is that the inability to regulate the magnetic field density and the construction of the rotor poles.

Г.8.26. Atanasov S., Aprahamian B., Penev T., Design of cylindrical inductors for surface hardening of steel details through the use of high frequency induction system, Proceedings of 14-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2015, pp. 261 – 264

The main task of the paper is presentation of the calculation and production of cylindrical inductors for surface hardening. Many experimental studies were made using special manufactured inductors, which may be used in various applications of the induction hardening, i.e. for surface hardening of shafts, hubs, bushings. The high-frequency induction heating is a technology providing high effectiveness in heat treatment of steel parts. Instead of other methods of heating, here only the surface is heated, thereby increasing the hardness and the wear resistance maintaining the ductility of the medium. This saves a lot of energy, increases processing speed and productivity.

To calculate the parameters of a cylindrical inductor the following input data is necessary: frequency of the operating current, workpiece dimensions, depth of the hardened layer, the material from which the workpiece is made.

The electrical calculations of the inductors are preceded by thermal calculation. By the thermal calculation are determined the heating time and the necessary power density, in which the temperature and the required her distribution across the section of the detail are reached.

Based on these conditions are made electrical calculations of inductor with nominal power of 100 kW and air gap h = 0,3 cm. As a result of these calculations are set the values of the current in the inductor and the voltage on its terminals depending on the diameter and width of the inductor. First is determined the width of the inducing conductor and the gap between his work surface and the surface of the heated detail. The size of the gap inductor - detail is adopted at the minimum in terms of efficiency of the inductor - from 1.5 to 3 mm. for details with diameters up to 50 mm. Only a section of the detail or the whole detail can be tempered.

For the production of a sample inductor are used an average of 1 m copper pipe, 2 nozzles for water compound, about 330 mm copper strip and a plastic for making the pattern, onto which the inductor is wounded.

The main results of the study are related to the calculation and construction of cylindrical surface hardening inductors, suitable for work with high-frequency system. Relevant calculations necessary for the design of each inductor, suitable for the high-frequency system are applied.

Results of an experimental research of the inductors prove that they operate properly and can be used in various applications of induction hardening, for example surface tempering of shafts, hubs, bushings, etc.

Г.8.27. Dimova T., Marinova M., Aprahamian B., Streblau M., Application of the magnetic field in separation of biological products, Proceedings of 14-th International Conference on Electrical Machines, Drives and Power Systems ELMA, 2015, pp. 265 – 269

Essential for optimum use of the magnetic separator apparatus is proper calculation and design of the magnetic system, determining the magnetic forces in the work area and the parameters that have a significant impact on the process of separation. The article described a comparison of theoretical models of separators with permanent magnets intended for processing biological products. The created models are tested for adequacy by experiment.

The object of study in the present work is a permanent magnet separator designed for separation of ferromagnetic particles from sunflower seeds at the stage of pre-packaging. The purpose is to develop a specific design of a separator, where the size and the configuration of the permanent magnets is such that it could make it possible to increase the magnetic force acting on the ferromagnetic particles and in this way to achieve a more effective separation. The idea is to solve a problem of a private company for processing seeds and industrial crops.

A separator of the MCR-5 type produced by the company Elica Elavator EAD, Silistra, is investigated. The initial design of the MCR-5 separator had 14 permanent magnets oriented in the same direction without gaps between them. In this way, the magnetic filter was in fact a monolithic body with high tension of the field on its surface, which was not effective for the purposes of the separating device. This was proven in the process of exploitation. Its ineffectiveness necessitated a different solution to its design. By the help of computer modelling calculations were made different versions of the design configuration. Thus the number of permanent magnets was decreased and the magnetic force was increased.

The models are created by help of the FEMM 4.2. software, based on the finite elements method. The problem is magneto-static and axis-symmetrical, where zero and natural boundary conditions are presumed. Based on the obtained results, the force was determined, which acts on a ferromagnetic particle moving vertically within the volume of the processed biological mass. The created models were verified experimentally, and the relative error between the model and the experiment was up to 5 %.

In order to prove the increased effectiveness of the separating device, an experiment was planned to demonstrate the higher degree of purification when using the changed magnetic filter of the separator of MCR-5 type.

The created 2D models enable a preliminary evaluation of the magnetic field. With the introduction of gaps of magnetic and non-magnetic material between the magnets, a higher residual induction is achieved and better coercive force, which guarantees higher effectiveness of the separating device.

By providing gaps of non-magnetic and magnetic material, the following results are obtained:

- Decreased number of permanent magnets, which will result in a decreased price of the device;
- Decreased weight of the separating device;
- Higher degree of purification.

The developed versions with ferromagnetic concentrators between each of the permanent magnets show that this is a good option for implementation of the magnetic filter, because the accumulated magnetic energy in the concentrators results in a greater force of attraction of the ferromagnetic particles in the product.

Г.8.28. Aprahamian B., Adopting of sensors with amorphous resistive layers in electrical measuring of speed of fluids in ships, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2016, pp. 17 – 20

New resistive elements, formed upon electro-insulated plate of vacuum thick ceramics by magnetron sputtering or screen-printing of amorphous resistive layers are studied. The elements possess a relay-type strong negative temperature dependence of resistivity. The new elements are adopted as sensors in standard bridge circuits for measuring of speed of fluids. Prototypes of sensors with various compositions of amorphous metal layers are analyzed and compared. The new elements show better sensitivity compared to a standard sensors.

Having analyzed the existing types of hot-wire anemometers, we came to a conclusion that it is possible to improve their sensitivity by replacing the silver wire sensor with a flat sensor consisting of a ceramic plate with an amorphous metal layer, reminiscent of a printed circuit board.

In the process of developing of the sensor prototypes aluminum oxide ceramics produced by Rosenthal and Rubalit (Germany) were used.

All specimens were prepared on square ceramic substrates with a side of 2 inches (50,8 mm) and 0,9 mm thick. Having analyzed more than 10 possible procedures for forming a conducting layer upon a ceramic substrate, we preferred the following two of them: magnetron sputtering and screen-printing of the resistive layer, both procedures being applied in integrated circuits production.

In forming the sensor prototypes by magnetron sputtering Russian stainless steel of 12X18H9T grade (German grade X10CrNiTi18-9), containing C – 0,12 %, Cr – 18 % and Ni – 9 % is used as well as amorphous alloys of the same steel. Two compositions of the amorphous alloy with mass content of Titanium of 13,9 % and 15,5 % respectively were tested. Coating was performed in a vacuum-pumping plant of B-90 type of Hochvakuum – Germany.

In forming the sensor prototypes by screen-printing, special amorphous pastes were used for resistive layer material, including pastes produced by Heraeus – Germany and DuPont – USA. Commercial DuPont Model 8010 printer was used, the main parameters of the technological process being as follows: speed of the printing panel – 35 mm/sec, thickness of the emulsion layer of the screen – 11 μm, average baking temperature – 850 °C, time of maintaining of the baking temperature – 10 min, paste viscosity – 105 Pa.sec.

Changes in resistivity of the sensor placed vertically in an airflow caused by the flow velocity were analyzed. Two types of sensors were tested:

- A silver wire (90 % Ag) with a diameter of 0,1 mm and a length of 60 mm;
- A sensor on ceramic plate with magnetron sputtered amorphous layer of 12X18H9T grade steel with 13,9 % Titanium and a thickness of 6 μm.

The new sensors are adopted as sensors in standard bridge circuits for measuring of speed of fluids. The new sensors are multi-purpose devices and are suitable for use in ships.

Г.8.29. Aprahamian B., Elaboration and testing of laboratory stand for investigation of an arc fault detection device, Journal of Marine Technology and Environment, Constanta Maritime University, Romania, vol. 1, 2016, pp. 11 – 16

The arcing faults may have a severe impact on the ship or on the crew. The paper presents the elaboration and testing of a laboratory stand for investigation of an arc fault detection device in the Technical University of Varna. The presented laboratory stand will train future electrical engineers to work with this new protection device.

Our laboratory stand contains the Siemens 5SM6 AFD (Arc-Fault Detection) unit with mounted 5SU1 RCBO with rated current 16 A and rated voltage 230 V, 50 Hz.

The laboratory study aims to be recreated arcing through regulation (increase) in current shunt Rsh, connected to the phase conductor at the entry of the protection device and the other end is connected to the output neutral conductor.

An experiments were conducted with the participation of the Siemens 5SM6 AFD unit with mounted 5SU1 RCBO (Residual Current Circuit Breaker with Over Current Protection) in a circuit with R, R-L and R-C character of the load.

The objective is to determine the efficiency of the protective apparatus and to characterize the specific features of the developing process. With oscilloscope are recorded the timing diagrams of the supply voltage at R, R-L and R-C character of the load and voltage 25 V. Similar to the previous charts are recorded, but at a voltage 35 V. Also are recorded cases of formation of impulse current during the extinguishing process of the electric arc in different character of the load.

Three types of experiments were performed with the laboratory stand.

- Experiment with active load R, with increasing the input voltage.
- Experiment with active-capacitive load R-C with increasing the input voltage wherein the capacitance $C = 10\ \mu F$.
- Experiment with active-inductive load R-L, with increasing the input voltage, wherein the inductance $L \approx 10$ mH.

The arc fault detection device serves a dual purpose – not only will it shut off electricity in the event of an arc fault, but it will also trip when a short circuit or an overload occurs. The AFD unit provides protection for the branch circuit wiring and limited protection for power cords. With its fast response and the manner of recognizing of emerging arcs, this protection is becoming a necessity for ships. In addition, it is proven its effectiveness in preventing fires in ships, caused by occurred short circuit connections.

The realized experiments demonstrate the operability of the protective apparatus. The extinguishing of the arc is in interval of time much smaller than the half-cycle of the supply voltage, which achieves limiting of the arc current. The rapid current breaking rise characteristic pulses occurring as an overvoltage surge.