ABSTRACTS OF SCIENTIFIC PAPERS

submitted for participation in the competition for holding the academic position ,,Associate Professor" in the professional field 5.13 ,,General Engineering", in the academic discipline ,, Engineering methods for modeling and analysis", announced ДВ № 53/20.06.2023.

of

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HABILITATION THESIS (MONOGRAPH)

[B3] Konsulova-Bakalova, Maria Ivanova, Automation of engineering work. Automated Design and Analysis, Gea Print - Varna, 2021, Bulgarian language, first edition, ISBN 978-619-184-047-2

Reference in the original language: Консулова-Бакалова, Мария Иванова, Автоматизация на инженерния труд. Автоматизирано проектиране и анализ, Геа принт – Варна, 2021, Българско първо издание, ISBN 978-619-184-047-2

The object of the present study is modern technologies in the field of automated design and their application in engineering practice. Despite the variety of software systems for automated design, there is a common approach to working with them which is presented in this paper.

The subject of this monograph is to explain the methods of automation of engineering design and analysis. The examples presented involve relatively simple geometric objects but the explained principles can also be used on considerably more complex shapes. Products such as Dassault Systèmes, SolidWorks, AutoDesk's AutoCAD, and CoreTech System's Moldex3D were used to implement illustrative examples.

The purpose of this paper is to assist designers in understanding the principles of operation and use of automated design systems and to provide some guidelines for solving practical problems. The focus here is on the first stages of design related to two and three-dimensional object modeling and performing some engineering calculations based on the created geometric models. The remaining design stages, associated mathematical methods and software products are complex and sophisticated enough to be the subject of independent development by the relevant specialists.

The first chapter introduces the basic concepts used in geometric modeling. After a brief historical overview, the types of automated design systems are identified and some of their features are listed.

The applied method has been identified as the primary approach to creating graphical images. Although it does not require the study of the mathematical description of geometric objects, knowledge of the basic mathematical descriptions underlying the creation of geometric objects would be useful to anyone involved in automated design. Automated design, in terms of designing and analyzing geometric models, is an iterative process requiring a criterion for evaluating the generated geometric models - whether they could perform the functions for which they are designed under actual working conditions. To this end, the monograph devotes special attention to computational and simulation methods. In engineering practice, the structure and form of designed objects are of fundamental importance. It depends on the accuracy of their description whether the geometric model will be able to perform its functions once it is reproduced as a real object. Geometric modeling is a generalized method which incorporates various model-building methods that complement each other to form a common description that can be used in all human automation processes.

Chapter 2 is devoted to two-dimensional geometric modeling. It is characterized by multivariate - providing different methods to create the same bivariate model. The choice of method is based on the knowledge and experience of the user. The main method for creating two-dimensional graphical objects can be taken as the method of construction geometry. It creates a link between traditional, manual drafting and the use of CAD systems to create drawing documentation. The method of construction geometry applied to the automated design of two-dimensional graphical objects produces a uniquely defined partially smooth curve. The method is very convenient because it does

not require entering the exact coordinates of the points on the contour boundary. On the other hand, the two-dimensional modeling process is characterized by active user participation and is made possible by the interactivity of graphical modeling application programs. Modeling is a creative process and very little of it is formalised. Traditionally used two-dimensional graphical primitives are a sufficient basis for creating planar models. Due to the emerging trend to create technical documentation that is increasingly complex in terms of images and level of detail, it is advisable to use block definitions for common objects in drawings. Dynamic blocks are particularly useful with the ability to input non-geometric information into two-dimensional models. For some of the standardized elements in the drawings, the degree of automation can be increased by using a sequence of actions written with programming code (macros or scripts).

The subject of chapter three is three-dimensional modelling. To work effectively with CAD systems for volumetric modelling, it is necessary to know the geometric modelling schemes. Their features are clarified and special attention is paid to surface modelling. Modern CAD systems include a variety of three-dimensional modelling methods. A combination of known volumetric geometric and surface representation schemes are used to create the models. There are multiple paths (combinations of functions used and representation schemes) that can be used to create 3D CAD models. No single method can be specified that is uniform and involves a unique sequence of commands. The process of dimensional modelling is a creative activity and cannot be formalized. Typified options for creating three-dimensional models can be specified to help designers who are entering the field of automated design. Such variants are presented in the examples section of this chapter.

Some formalization of the process of creating three-dimensional models can be made in terms of standardized parts, such as gears, bearings, bolts, nuts, etc. whose dimensions and shapes are prescribed by standards. Thanks to the method of extracting copies of primitives, libraries of standard elements are created in CAD systems. They can be incorporated into the database when building more complex composite geometric models.

The author recommends that designers should make more active use of the possibilities for adding non-geometric information to the CAD models created by them. Thus, the designed 3D models become not only a separate part but also a unit of the design process. A link is created between design, process prescription and control programs which is the goal of anyone involved in engineering automation - automating as much of the activity as possible.

Chapter Four contains a description of the methodology for performing engineering analyses. The finite element method (FEM) is presented as the basis of the computational procedures in automated design. Most CAE systems include analysis modules using FEM, the specifics of which are explained in this chapter. The features of optimization methods and injection molding simulation are outlined in separate sections.

Good judgment is required in the selection of geometric information to be used in computer simulation analyses. The monograph proposes methods for preparing and simplifying the geometric models for which the analyses are carried out. The discretization of the model is an important part. This paper presents practical advice for designing a finite element network supported by concrete examples. It is critical to ensure its accuracy for the resulting solution to have value when performing a computer simulation analysis. A good indicator of this is the convergence of the solution. Here, an example using a simplified geometric model is used to show how the way the model is discretized strongly affects the results obtained in a static linear analysis.

Without studying and knowing the fundamental theoretical features of the methods of computer simulations, one cannot talk about building adequate simulation models and the accuracy of solving problems using computer simulations. For this reason, the monograph offers the basic knowledge that is needed to perform simulation analyses of various types.

For a more complete and extensive study of process objects, higher-end automated design systems provide better capabilities and overall higher accuracy of calculations. However, it is shown through examples here that with appropriate geometric models and simulation analysis settings, high accuracy of simulation models can be achieved by lower-end automated systems. This requires a precise description of the geometric models, boundary conditions and discretization settings of the models.

While the process of creating geometric models is subject to some formalization, albeit not incomplete, especially concerning standardized details, in computer analyses the process can hardly be described as a well-defined sequence of actions. This is due to the variety of objects that can be investigated on the one hand and on the other the different types of analyses that are available when creating simulation models. The creation of a fully automated design process involving engineering calculations and analysis can perhaps be talked about in light of the recent Industry 4. 0 and Industry 5. 0 revolutions. With the advent of artificial intelligence and the ability to store and process an ever-increasing amount of information in parallel, engineering computation could be incorporated into a general scheme of full automation.

For complex objects, due to the variety of factors influencing the quality of manufactured products and requiring investigation in the design process, it is not sufficient to use computer simulations alone. They provide only one part of the information needed to evaluate the performance of the designed models.

Chapter five explains some statistical methods for data processing. Proprietary software products have been applied for one-dimensional and multidimensional clustering (state estimation) of complex objects, minimization of feature spaces by singular decomposition and orthogonal transformations and data preparation for solving the problem of diagnosis and optimization in the design of technological objects and other physical systems. An example application of the methods in a developed automated workplace is also provided.

Based on the concrete examples and the conclusions drawn in the individual chapters, it can be concluded that a high degree of automation has been achieved in the field of automated design and analysis as part of the overall product design process. On the other hand, the continuous development of new technologies implies even more serious automation of engineering activities. The use of artificial intelligence, which is already a fact in many fields, could be even more involved in geometric modeling and analysis. Of course, the creative element here is still a barrier to the implementation of these relatively new technologies. The beginning of more complete automation is the use of libraries with ready-made objects (databases). The practice so far and the increasing complexity of the designed products require more and more methods and tools to be included in an automation system, covering an increasing part of the design process. Combining known decision-making methods with computer-aided design and analysis capabilities can be seen as another step in this direction.

The theoretical and methodological basis of the research in the monograph is the result of scientific and applied developments of several authors in the field of modern technologies for automated design. They are based on rules that are synthesized in the design and analysis of a number of objects. The attached examples can be used by specialists working in various fields, as well as in the development of future scientific works.

SUMMARIES OF PUBLICATIONS
under indicators Г. 7 and Г. 8 of the reference on the fulfilment of the minimum national requirements for the academic position of „Associate Professor “

Summary of report [Г7.1] from the list of publications

*Stoyan Slavov, **Mariya Konsulova-Bakalova**, Optimizing weight of housing elements of two-stage reducer by using the topology management optimization capabilities integrated in SOLIDWORKS: A Case Study, Machines 2019, 7(1), 9; doi:10.3390/machines7010009*

This paper focuses on the results of a topological optimization based on finite element analysis on the housing and cover of a two-stage gearbox with helical gears using the SOLIDWORKS Simulation module. The goal of this study is to optimize the total weight of the gearbox by thinning specific areas of the cast gearbox housing elements according to the calculated minimum strain energy. The topology optimization algorithm used in this research yields an optimal structural shape of the gearbox hull elements with the highest stiffness, given a given amount of mass to be removed from the initial design space. The complete sequence of steps for carrying out the topology management optimization study is shown, taking into account the limitations arising from the design characteristics and the manufacturing method of the gear housing elements.

Since the SOLIDWORKS topological optimization module does not allow assemblies to be subjected to optimization, but only the individual part (the single 3D body), the 3D models of the body and hood parts are combined into a single 3D body and the result is saved as a part file. Thus, the limitations of the simulation module are overcome and a possible solution for other similar case studies is shown. Furthermore, as demonstrated by the example gear housing optimization, the built-in algorithm in SOLIDWORKS Simulation can be successfully applied even to relatively complex 3D models of device and machine housings.

Another point to consider is the results obtained from the analysis of the static stress and nodal displacements of the optimized and smoothed 3D model. In the example, when reviewing the SOLIDWORKS simulation results, there is a notice that warns that the values obtained are based on the entire optimized model, which may contain porous elements that are less rigid than fully dense elements. For this reason, these values should be viewed as a rough estimate of how the topologically optimized model might behave. For example, in the present topology optimization study, the obtained values for the static stress reach 4943. 94 (MPa), and the obtained maximum nodal displacement is 15.45 (mm), which cannot be achieved by physical design. Therefore, it is not advisable to accept these results as valid and a static analysis of the final closed 3D design should be performed as described in Section 5 of the publication. In order to avoid obtaining a resonance, the natural frequencies must be determined before and after the topologically based model optimization and they should be compared with the frequency of the forced oscillations resulting from the gearbox drive. For stable and reliable usage of the device, there should be no convergence between them.

By applying the finite element method to analyze the gearbox housing and by optimizing the topology, a reduction in the total weight of these parts within about 7.33% was achieved. At first glance, this may not sound like a very large reduction in the weight of the reducer compared to an individual piece of product, but in a larger production run, the effect of material savings will be felt. The proposed approach can also be applied to optimize the housing elements of heavy gearboxes and

gearboxes, which are typically designed with increased safety factors; e.g. for use in large ships and marine equipment, as well as in lifting, construction and/or machine tools.

By applying the finite element method to analyze the gearbox housing and by optimizing the topology, a reduction in the total weight of these parts by about 7.33% was achieved. At first glance, this may not sound like a noticeable reduction in the mass of the reducer compared to an individual piece of product, but in the long run, the effect of material savings will be felt. The proposed approach can also be applied to optimize the housing elements of heavy gearboxes and gearboxes, which are typically designed with increased safety factors; e.g. for use in large ships and marine equipment, as well as in lifting, construction and machine tools.

In conclusion, it should be noted that the results obtained in the present work are closely related to the model and design of the gearbox used and its input parameters. In other variations of gears and operating parameters, the optimization results may differ substantially from those shown in this work. Therefore, each construction must be considered individually, according to the design features and requirements of the final product.

It should also be noted that the topological optimization presented is based only on the load on the gear housing elements. It does not include additional factors, such as gearbox heating, noise emissions, etc., which may also affect the design parameters. Opportunities for further development of the present work may be the creation of approaches and algorithms for applying the topological optimization approach to similar three-dimensional housing bodies of other types of devices and machines, taking into account the influence of additional factors in their operation besides the workload from the transmitted forces, torques and reactions in the bearings.

Summary of report [Г7.2] from the list of publications

Y B Argirov, T M Mechkarova, A M Stoyanova, N M Atanasov and ***M I Konsulova-Bakalova****, Study on structure and mechanical properties of 20X13 steel welding joints, IOP Conference Series: Materials Science and Engineering, Volume 843, 7th International Conference on Actual Problems in Machine Building 25 March 2020, Novosibirsk, Russia Federation, doi:10.1088/1757-899X/843/1/012012*

The article examines a problem related to methods of controlling the structure and mechanical properties of weld joints formed during the restoration of riveted joints of turbine blades made of steel 20X13 (AISI, 420J2). For the study, methods were used for microstructural analysis, micro- and macro-hardness of two types of samples: one without additional heat treatment and the other with heat treatment after the welding process.

From the conducted structural tests, data were collected on the following zones and structures after welding: alloying zone (zone of partial melting of the base metal), recrystallization zone (Ac1, 820oC-Ac3, 950oC), the heat-affected zone, including the two zones and the base metal zone in the tested samples.

From the macrostructural tests, the individual zones characteristic of the weld joints were observed, which are shown in Figures 4 and 5. The figures give information about the purity of the weld joint, the absence of defects and non-metallic inclusions. The weld metal zone that is welded with the selected electrode has a homogeneous austenitic structure due to the high nickel content of the electrode.

It can be noted that there is roughening of the grains in a very thin segment of about 20 μm in the alloying zone. This roughening is only in the projecting parts of the joint, the root of the weld.

The structure in the recrystallization zone in the superheated zone is fine-grained, which is an indication of good mechanical properties, Figure 3b; Figure 4b. Carbides of the M23C6 type are observed at the grain boundaries.

A sorbate-troostite structure is observed in the base metal zone.

From the mechanical tests of micro- and macro-hardness, changes in the hardness in the individual zone of the weld were observed in both samples. It can be noted that in the heat-affected zone, there is no sudden increase in hardness, but a gradual increase towards the basic material.

Summary of report [Г7.3] from the list of publications

*A M Stoyanova, T M Mechkarova, Y B Argirov, **M I Konsulova-Bakalova** and N M Atanasov, Study of structure and physico-mechanical properties of welding joints on vessel tank of austenite steel SS316, IOP Conference Series: Materials Science and Engineering, Volume 843, 7th International Conference on Actual Problems in Machine Building 25 March 2020, Novosibirsk, Russia Federation, doi:10.1088/1757-899X/843/1/012013*

The article examines some problems related to the appearance of cracks and defects in the weld joints of a horizontal steel vessel tank after gas-machined electric arc welding (GMAW). Tests of the structure and mechanical properties of the welded joints between the cylinder and elliptical bottoms of austenitic steel SS316 conforming with AISI (X5CrNiMo17-12-2 according to BSS EN 10088-2) were performed. Proven microstructural and X-ray analysis methodologies are used to investigate changes in structure (weld, heat-affected zone and base metal). Mechanical properties are determined by measuring Vickers macro- and micro-hardness and static strain.

Summary of report [Г7.4] from the list of publications

*Stoyanova, A., Mechkarova, T., **Konsulova-Bakalova, M**., Yordanov, K. & Argirov, Y. 2020, "Computer simulation thermal analysis of low carbon plates welded with electrode abradur64", UPB Scientific Bulletin, Series D: Mechanical Engineering, vol. 82, no. 4, pp. 179-190.*

A computer simulation model was used to make a study of the process of heat transfer in steel plates that were welded by manual electric arc welding. Heat transfer during the welding process is simulated using SolidWorks Thermal Analysis. The main material used for the research was DD11 steel, and welding was performed with ABRADUR 64 welding electrodes. The temperature distribution in the different zones of the heat-affected zone was determined, according to the parameters of the welding mode. The simulation model of heat transfer during welding demonstrates that at the surface level, the steel plates do not reach high-temperature values that can cause some microstructural changes in the heat-affected zone.

It is evident from the metallographic analysis that pores of a random nature exist in the sample. There are no defects of any other kind. There are no cracks, non-metallic inclusions, or others at the alloy boundary, in the heat-affected zone or the weld metal. There is a strong dendritic structure in the weld metal zone. The alloyed electrode metal strengthens the welded surface. Summarizing the results of the set parameters with the help of the developed computer simulation model of heat exchange processes in planar welded samples, the temperature distribution in the objects can be obtained with sufficient accuracy. Based on the created computer model, it is established that the heat-affected zone does not reach the critical temperature, which is a prerequisite for believing that structural changes leading to destruction will not occur in it. This is proven by metallographic analysis. The experimental results confirm the results obtained with the computer model. The

examination of the temperature field allows the prediction of defects in the welding zone and the heat-affected zone, as well as the appearance of residual strains.

The proposed computer model can be used in further experiments. A possible change in the structure of the processed samples can be predicted.

Summary of report [Г7.5] from the list of publications

*Stoyanova, A., Mechkarova, T., **Konsulovabakalova, M.**, Yordanov, K. & Argirov, Y. 2020, "Investigation of strained and deformed state of low carbon plates after welding", UPB Scientific Bulletin, Series D: Mechanical Engineering, vol. 82, no. 3, pp. 263-274.*

The article examines the process of heat exchange during manual arc welding. Of interest are the deformations and strains that occur during the welding of steel sheets. For this purpose, a simulation analysis of the object was developed. Through thermal and static analysis, results were obtained for the distribution of strains and deformations at each point of the studied model volume.

It is evident from the metallographic analysis that no macro defects (cracks) are present both in the metal that was welded with ABRADUR54 and in the various weld zones. In only a few cases, occasional macropores can be observed, but they are sporadic. The microstructural analysis shows that dendrites oriented toward the alloy boundary are observed in the welded zones. The results of the simulation analysis are in complete agreement with the theoretical statements regarding the occurrence and distribution of thermal strains during welding. The obtained graphical results clearly show the difference in the displacements registered by the sensors when simulating the heating and cooling processes. Determining the maximum total deformations in welded structures is essential to solving the accuracy problems in their assembly. The maximum values of strains, deformations and displacements in the depth of the samples were obtained. The results of all sensors placed on the sample during heating and cooling are summarized in tables. The maximum values are obtained from the 1st sensor located in the welding zone and do not exceed the maximum possible for the material. In the cooling process, the greatest strains are grouped in the welding zone, which is explained by the different coefficients of thermal expansion of the materials and the differences in their mechanical properties. Determining the maximum stains makes it possible to predict the risk of cracking or failure of the layers during welding.

After complete cooling of the object, the residual strains can be evaluated according to their direction and magnitude and their effect on the working strains of the structure can be predicted. The demonstrated method for 3D modeling of heat exchange processes and assessment of the strain state in MMA welding has a universal character. Using a product like SolidWorks allows testing different welding technologies, by changing the initial parameters of the modes or by using different materials.

Summary of report [Г7.6] from the list of publications

*M. Stoyanova, **M. Iv. Konsulova-Bakalova**, Determination of abrasion resistance of welded layers, Conference: 18th International Congress of the International Maritime Association of the Mediterranean, IMAM 2019 at: Varna, Bulgaria, Sustainable Development and Innovations in Marine Technologies: Proceedings, - Gerogiev & Soares (eds) 2020 Taylor & Francis Geoup, London , ISBN 978-0-367-40951-7, p. 410-414*

Abrasive wear is a gradual change in the dimensions of a body during friction, manifested by the detachment of material from the surface and/or the appearance of residual deformation. Abrasive surface wear often results from cutting or scratching by hard bodies or particles. The mechanism of

this process involves the gradual separation of material from the surface in the form of fine chips or whole fragments, which were in a state of decay before being released as wear products.

Numerous methods have been developed for testing and simulating wear mechanisms, but there is no universal method for determining wear parameters. Measurements typically include weight, width or depth of the imprint and indirect measurements such as time required for coating wear or the load needed to change the reflective ability. Weight loss is direct but may not account for material displacement and shouldn't be used when comparing materials with different densities. Volume loss can be calculated through weight loss or determined based on wear geometry. Imprint width and depth due to displacement are related to volume and can be easily measured, but results from different test types aren't comparable. Indirect measurements are often limited in scope and application, making it challenging to provide crucial wear parameters. In theory, a wear measurement method should reflect the actual system performance, characterized by repeatability and objectivity.

The article's goal is to determine the abrasion resistance of low-carbon samples welded with three types of ABRADUR electrodes of different chemical compositions. The study used samples of DD11 low-carbon steel with a thickness of 10 mm. The article outlines the selected electrodes and their chemical compositions. The experiment was conducted under laboratory conditions, utilizing a methodology that measures the diagonal of the imprint obtained from the Vickers pyramid.

Based on these tests, some conclusions can be drawn. Comparative research on different electrodes for restoring details through welding allows validation of new material and/or construction choices for parts of engineering equipment subject to abrasive wear conditions. Modeling abrasive wear processes in lab settings facilitates the proper selection of suitable surface treatments for the contact zone and/or application of appropriate coatings. Analyzing results from abrasive wear on specific elements operating under high loads provides opportunities to enhance their durability.

Summary of report [Г7.7] from the list of publications

Slavov, S., Dimitrov, D., ***Konsulova-Bakalova, M****. & Vasileva, D. 2021, "Impact of ball burnished regular reliefs on fatigue life of AISI 304 and 316L austenitic stainless steels", Materials, vol. 14, no. 10.*

This paper describes an experimental study of the fatigue life of AISI 304 and AISI 316L austenitic stainless steels having type IV regular reliefs (PP) formed by surface plastic deformation (SDP) on flat surfaces using a CNC milling center. The methodology and equipment used to obtain regular reliefs are presented and described, along with a vibration-induced fatigue test setup. The results of the PPD process and the fatigue endurance experiments of the tested austenitic stainless steels were collected using one of the experimental planning methods. It was found that the presence of type IV PP does not deteriorate the fatigue strength of the studied steels. Pareto, t-test, and Bayes' rule techniques are used to determine main effects and interactions of significance between ball polishing mode parameters. The stochastic model is obtained, which is used to find the probability of obtaining the maximum fatigue life of parts made of AISI 304 or 316L. It was found that when the deforming force, the amplitude of the sine waves and their wavenumber take their maximum values and the feed rate is set at its lowest value, the probability of reaching the maximum fatigue life for the parts made of AISI 304 or 316L is equal to 97%.

In the present paper, simulation modeling and the finite element method are used as an aid before conducting the actual experiments. The purpose of the finite element analysis performed is to determine the parameters for setting up the fatigue test. A linear dynamic analysis was performed.

SolidWorks 2020-21 was used for its implementation. Inputs to the analysis include material properties of the specimens and applied uniform excitation (acceleration). The 3D models used are a simple geometric shape, which allows the application of model discretization with a small finite element size (2 mm and 0.1 mm tolerance). The maximum values of the equivalent stress in the model, the acceleration of the free end of the sample were obtained and the frequency curve was constructed. After conducting the real experiment, the two frequency curves - real and obtained with simulation modeling - were compared. The comparison between them shows that the finite element model gives results close to those obtained with the physical test. The resonant frequencies of the two tests differ by only 0.5%. The difference in terms of the maximum acceleration values at resonance between the measured and calculated values does not exceed 5%. Therefore, the results obtained from the model can be considered adequate and can be applied in other similar experiments.

The presented approach of using the factorial experiments and the Bayesian rule for data analysis reveals some trends regarding the influence of the main mode parameters of the PPD process and their iterations on the fatigue life of the studied steels. It provides good enough results in the case of experimental studies where it is not appropriate to perform a large number of trials and the obtained results for the studied parameter (i.e. fatigue failure cycles in our case) may have a relatively high variance.

This can significantly shorten the time and facilitate the efforts to obtain the necessary results to determine the optimal combination of values of the PPD mode parameters in production conditions. The methodological sequence for fatigue failure testing presented in the present work can be applied to other materials, processing methods and experimental designs involving a different number of influencing factors. In addition, the simulation model and the example of combining different computational and experimental methods can be useful in solving other similar problems.

Summary of report [Г7.8] from the list of publications

Vachinska-Aleksandrova, S., ***Konsulova-Bakalova, M****. & Markov, M. 2021, "An assessment of posture related MSDs risk in university employees using REBA method", Proceedings of the International Conference on Biomedical Innovations and Applications, BIA 2021, pp. 99.*

The work activities concerning a vast number of today's professions are generally static and after long period lead to fatigue and musculoskeletal disorders (MSDs). The university employees - both scientific staff and administration undoubtedly pertain to this category. A web-based survey related to ergonomic working posture and work discomfort was completed by 20 volunteers – 10 men and 10 women. Profile pictures of their postures while using computer were taken and analysed using the REBA method. Statistical processing of the results allows to make the following generalizations. Over 70% of the participants reported discomfort in the neck and around 60% - pain in their upper back. Further, 25% from all defined the pain as moderate. According to the REBA method the MSDs risk level of the sample could be classified as moderate.

The main purpose of the study was to investigate the prevalence of MSDs symptoms among university employees with high workload. The high education level of all voluntaries and their self-awareness regarding the knowledge about neutral posture did not guarantee a safety working position.

In general, REBA score detects respectively low risk (2-3 score) for the majority (60%) and moderate risk (4-5 score) for the rest 40%. However, these results contradict to the reported from employees' pain and discomfort. Unsatisfactory level of sport activity (at least 2 times a week) is the secondary reason for musculoskeletal symptoms. Prolonged sedentary work 7±2.3 hour/day and long

times immobilization without break 2.8±1.7 hours were the general reasons for the reported discomfort.

This research emphasizes the need of investment and efforts supporting the improvement of the ergonomic knowledge throughout the university employees for reduction of the time spent in awkward body postures, and avoiding the MSDs. In this line of thinking it should be mentioned that none of the participants changed the settings of the workstation according to her/his personal body anthropometry, including the monitor level to prevent torso flexion or keyboard/mouse position to balance the extension of limbs' muscles. Sometimes small changes of working habits or workstation settings decrease the risks related to occupational health and safety.

In addition, some authors suggest the usage of a posture correction device to support adoption of neutral trunk posture or for children education establishing healthy habits in that number through improvement of the design of the work-stations and thereby reduce the occurrence of MSDs.

From a safety point of view, it is particularly important to be noted that pain or fatigue can negatively influence the human's state and performance as well as to affect people's mental health and stress. Decreasing the prevalence of MSDs also reduces the physical and mental aspects of fatigue, which are very important for both employees and organisations.

Based on the highlighted above the following conclusions can be drawn:

- Need for ergonomic training and workstation adjustments to reduce the occurrence of MSDs among university workers are necessary;
- Adjustable furniture is associated with behavioral changes and raised awareness of the employees to use it;
- Good muscle tone from regular physical activities prevents back pain and injury, reduces the stress at work which may be engendered by musculoskeletal disorders;
- The number of participants was not big enough for deep analyzes but satisfactory to underline differences between males and female musculoskeletal systems and to confirm that women are more susceptible to muscle diseases;
- Employers must motivate employees to increase their personal health culture and encourage them to participate in courses related to ergonomics and effective organization of the workstation to avoid the appearance of MSDs;
- Additional studies should be conducted for reliable identification and control of the underlying ergonomic factors associated with the occurrence of MSDs and fatigue in each working environment.
- Investment in education and occupational safety knowledge will not only return a positive economical effect on the state health system, but also will lead to prolonged productivity of the employees and well-being in the years after retirement.

Summary of report [Г7.9] from the list of publications

***Konsulova-Bakalova, M**., Naskova, P., Malcheva, B., & Plamenov, D. Modelling a System for „Disinfection-Utilization" of Sludges from a Purification Plant for Waste Waters. Journal of Microbiology, Biotechnology and Food Sciences, 2023, 12(6) doi:10.55251/jmbfs.9583*

Sludge from a purification plant for waste waters are studied for presence of pathogenic and non-pathogenic microflora. Their disinfection is carried out by applying lime treatment (10%, 20%, 30% lime) with two species vegetation –lavender (Lavandula) and basil (Ocimum). The data from

the experiments are processed via statistic methods. Firstly,is carried out a correlation analysis for finding out dependencies between the concentration of the lime solution and the quantity of microorganisms. High coefficients of correlation are established. Then a regression analysis for creation of a mathematical model for the quantity of microflora in sludge treated in a different way is carried out –only with lime solution, with lime solution and planting of lavender or basil.

The obtained results show a strong correlation connection among the studied quantities. This gives grounds to be looked for a mathematical model on description of the microflora quantity in the sludge. More factors are added for the purpose –temperature, humidity and pH. In the article are presented the regression equations for the different methods of disinfection. The results give grounds to be affirmed that most of them canbe used successfully for finding the quantity microflora in studied sludge with known data for concentration of the solution, temperature, humidity and pH.

The following conclusions may be drawn on the grounds of the obtained results:•The different methods for treatment render greater impact on the presence of non-pathogenic microflora. This is proven by the obtained bigger coefficients of correlation at carrying out a correlation analysis. The planting of sludge with lavender or basil does not change significantly the statistical coefficients and dependencies. Both plants can be used equivalently independently or in combination with disinfection and deodorizing of sludge. Additional experiments are necessar for creation of an appropriate mathematical model of the quantity pathogenic microflora in sludge. The usage of other statistical procedures also would give better results. The search for a better mathematical description of this type of microflora is a task for subsequent developments of the team. The obtained regression equations for the non-pathogenic microflora would be used for description and quantitative determination of the studied types of microorganisms in the sludge. Taking into account the high and divergent sensitivity of the microorganisms in an extreme medium, as the sludge from a purification plant is, is necessary the analyzing in dynamics of pathogenic and non-pathogenic microflora interrelatedly with disinfection of the sludge with purpose safe and effective usage as fertilizer in agriculture.

Summary of report [Г7.10] from the list of publications

Slavov, S., Dimitrov, D., ***Konsulova-Bakalova, M.****, & Van, L. S. B. Research of the ball burnishing impact over cold-rolled sheets of AISI 304 steel fatigue life considering their anisotropy. Materials, 2023, 16(10) doi:10.3390/ma16103684*

The present work focusses on the research of the plastic deformation accumulated effect obtained after two different plastic deformation treatments, over the fatigue life of AISI 304 austenitic stainless steel. The research is focused on ball burnishing as a finishing process to form specific, so-called “regular micro-reliefs” (RMRs) on a pre-rolled stainless-steel sheet.

It is known that the toolpaths of the ball tool in vibratory BB must have a near-sinusoidal shape, in order for RMRs to be formed on the processed surfaces. This leads to an increase in the unfolded length of the toolpath in comparison with conventional BB operations. The task to optimize the BB process carried out using CNC equipment to minimize the unfolded toolpath length is relevant in the context of the contemporary requirements of production processes. In this regard, in the current work is an improved approach for connecting the calculated points from the BB toolpath that is proposed, as an attempt to optimize its unfolded length.

RMRs are formed using a CNC (Computerized Numerically Controlled) milling machine and toolpaths with the shortest unfolded length, generated by an improved algorithm, based on the

Euclidean Distance calculation. The effect of the predominant tool trajectory direction during the ball burnishing process (which can be coinciding or transverse with the rolling direction), the magnitude of applied deforming force, and feed-rate is subjected to evaluation using Bayesian rule analyses of experimentally obtained results for the fatigue life of AISI 304 steel. The obtained results give us reason to conclude that the fatigue life of researched steel is increased when directions of pre-rolled plastic deformation and the tool movement during ball burnishing are coincident. It also been found that the magnitude of deforming force has a stronger impact over the fatigue life, than the feed-rate of the ball tool.

Summary of report [Г8.1] from the list of publications

Konsulova-Bakalova, M., Nedev, A., "Parametric and non-parametric methods for data recognition from electronic nose type devices" - published in the journal "Mechanics of Machines" issue 77/2008, 41÷44 pp. ISSN 0861-9727

*Reference in the original language**: М. Консулова-Бакалова**, А. Недев, "Параметрични и непараметрични методи за разпознаване на данни от устройства тип "електронен нос" " – публикувана в сп. "Механика на Машините", брой 77/2008, 41÷44 стр. ISSN 0861-9727*

This paper is devoted to the choosing of a method for gas analysis data recognition. Recognition results with one parametric method - discriminant analysis and non-parametric methods - neural network and genetic algorithm are compared. For this purpose, results from an "electronic nose" type device are used, which are classified by the methods indicated. The training and testing samples are the same across cases. In this case, it is shown that discriminant analysis gives the best results.

The artificial nose is a device that determines the specific components of the gas environment and analyzes its chemical composition. In the present study, the electronic nose consists of four identical gas sensors incorporated in a suitable measurement system. The object of work is the process of recognizing odors and assigning them to some of the predefined classes. The recognition process is reduced to determining in the feature space the point corresponding to the current state of the object and its membership in the closest state class in the accepted sense. The choice of a recognition method can be made in a purely theoretical way or with practical experiments. The paper proposes the results of such studies.

In the methodological part, parametric and non-parametric recognition methods are discussed. As a representative of the parametric methods, discriminant analysis, a procedure based on a probabilistic model, is mentioned. The specifics of the training procedure as well as the recognition process are described. Non-parametric recognition methods are also considered for comparison. The best known of these is the neural network. There are different types of neural networks. In this paper, a method is chosen in which the neural network starts to form by finding the linear dependencies between the inputs and the outputs. A hidden layer is then added so that nonlinear dependencies can be detected. The input values from the first layer are multiplied by the weights and fed to the second layer, and so on. The process continues until a preset maximum number of neurons is reached.

Another non-parametric method is the genetic algorithm. The article describes the steps to go through it.

To compare between the types of recognition procedures, data from an electronic nose-type device with multiple (nineteen) classes of condition were used - several different concentrations for two gases (ethanol and methanol) and several classes of conditions for clean air with varying

humidity. Training and recognition were conducted with the same samples under different methods. The discriminant analysis is performed using Matlab calculations and a ready-made software product is used for the neural network.

The results show that, in this particular case, discriminant procedures yield better success rates. From the closeness of the results obtained with the three methods, one can infer the similarity between them.

Summary of report [Г8.2] from the list of publications

Konsulova-Bakalova, M., Popov, Z., "On the selection of training samples for automatic gas analysis and gas recognition algorithm" - published in J. "Mechanics of Machines" issue 77/2008, 45÷48 pp. ISSN 0861-9727

*Reference in the original language: **М. Консулова-Бакалова**, З. Попов, "Относно избора на обучаващите извадки за автоматичен газов анализ и алгоритъм за разпознаване на газове" – публикувана в сп. "Механика на Машините", брой 77/2008, 45÷48 стр. ISSN 0861-9727*

The paper discusses methods for measuring non-electric quantities such as concentration and pressure. It is theoretically justified and then it is proved with examples that for this purpose as primary transducers, it is possible to use respectively a microelectromechanical sensor - cantilever, for measuring gas concentration and a silicon membrane for measuring pressure. Suitable measurement circuits are also selected in which to incorporate the sensors.

A relatively detailed explanation of the design and operation of micromechanical sensing devices used in static and dynamic modes is given. In dynamic mode, the console is shaken until it falls into resonance. Changing its mass is known to change its resonant frequency. This registers in the appropriate electronics. When a biochemical layer is deposited on the surface of the cantilever, its sensitivity to certain substances increases.

The paper explains the methodology of recognizing three or more state classes in discriminant analysis and the presence of different covariance matrices. For better visualization, the state classes are represented in the area of the main directions. Training and recognition were conducted in several variants. A one-step process in which the system is trained on all classes of conditions - different concentrations of two gases and different concentrations of the same gases at different humidities. Multi-stage recognition is conducted at several levels. First assignment to one of the three major classes - alcohol, alcohol at high humidity and fresh air (no alcohol). At the second level, the type of alcohol - ethanol or methanol - is recognized, and at the last level, its concentration. The system is trained to recognize four types of concentrations.

Multi-stage recognition significantly complicates the programming algorithm. At the same time, experiments show that it does not seriously improve classification. However, both methods are sufficiently uniform and give a good level of correct classification. They can therefore be used for practical purposes. The main advantage of the proposed algorithms is that they ensure the independence of the detection process from the measurement process, i.e., they can be applied with different numbers and types of gas sensors included in a corresponding measurement scheme.

It has been shown that as the sample size increases, the recognition accuracy of specific classes increases. It was found that in the considered example, the minimum training sample size should be around eleven observations to achieve good recognition quality.

Summary of report [Г8.3] from the list of publications

Nedev, A., Konsulova-Bakalova, M., "Future fields for the development of engineering education" - Journal of Engineering Education. "Mechanical Engineering and Mechanical Science, Issue 5, Year IV, Book 1, 2009, ISBN 1312-8612, 9÷11 pp.

*Reference in the original language: А. Недев, **М. Консулова-Бакалова**, "Бъдещи полета за развитие на инженерното образование" - сп. "Машиностроене и Машинознание", брой 5, година IV, книга 1, 2009 г., ISBN 1312-8612, 9÷11 стр.*

The paper aims to determine and predict the general characteristics and unique skills of future engineers in Bulgaria. The current state of engineering in Bulgaria is examined as the coin of publication. The general trend in the state and development of the engineering, chemical, medical, agricultural, transport and energy fields worldwide is reported. Namely, the emergence of flexible automated industries, whose control is based on intelligent sensors (sensors) and actuators (actuators) according to algorithms and programs based on new control methods.

The general requirements for the future engineers who will operate this equipment are indicated (transition from design and construction to management and maintenance) and the main directions in the development of engineering are formulated. These are identified as: development of management theory (in the broadest sense); discovering and validating new areas of application of control technology; development of training in management methods and tools; methods and importance of control methods and techniques in the future development of the industry.

The need to produce new systems and products, introduce new hardware units, develop new theoretical methods and solve new types of problems are outlined as future challenges for control theory. Some of them are simulation modeling of real objects, developing new system concepts built on biological principles, adaptive methods for optimal stochastic control and synthesis of large systems with given properties.

The article attempts to answer the question: Why the interest of scientists in theoretical research lags, especially young ones? Another significant problem for the development of the engineering entity in Bulgaria has been pointed out the currently insignificant presence of Bulgarian publications in reputable theoretical publications.

It concludes by outlining the main challenges of the future and forecasting future developments. It is formulated through the three axes engineering - control - mechatronics. The main industries to be developed in connection with this are Automotive, Food Processing, Chemical and Pharmaceutical, Water Supply and Waste Sorting, Transport Infrastructure and Power Generation.

The paper concludes with the expected applications of control in non-conventional technical and non-technical fields and the development of control methods and techniques in line with the general development of the industry.

Summary of report [Г8.4] from the list of publications

Nedev, A., Konsulova-Bakalova, M., "A new approach to the construction of curricula in engineering disciplines" - Journal of Engineering, Vol. "Mechanical Engineering and Mechanical Science, Issue 5, Year IV, Book 1, 2009, ISBN 1312-8612, 3÷8 pp.

*Reference in the original language: А. Недев, **М. Консулова-Бакалова**, "Нов подход за изграждане на учебните планове по инженерни дисциплини" - сп. "Машиностроене и Машинознание", брой 5, година IV, книга 1, 2009 г., ISBN 1312-8612, 3÷8 стр.*

In general, the subject of the paper is the development of such methods, strategies, experiments, directions (hardware and software) and aids, with the help of which the objectives of management are best achieved. This applies to management with the same force as to those natural sciences which have their theoretical basis. This foundation should include the fundamentals of engineering and computer science as well as essential parts of mathematics, physics, chemistry and biology.

Starting from the fact that education is a conservative system and does not tolerate sudden revolutionary leaps, it is proposed that the introduction of training in technological processes and their control, which will be generally called mechatronic systems, be introduced initially in the Master's training in mechatronics for Bachelors in mechanical and electrical engineering. Then to open a Bachelor's degree in Mechatronics. The final stage is undergraduate and graduate training in "engineering" with the introduction of control technologies and systems in a common foundation.

The article identifies the main requirements of personnel users for electrical and mechanical engineers based on the experience of European universities. They are reduced to two groups of knowledge and skills - theoretical foundations of regulation and control methods and their software and hardware implementation and physical foundations of methods for identifying and compiling process models. In light of this knowledge and skills, courses and modules are presented that should be studied in both undergraduate mechatronics training for engineers in the core technology disciplines with a BSc and BSc mechatronics training. A sample structure of the material is given.

A substantial part of the knowledge of the so-called engineering field "mechatronics" is contained in the spectrum of methods an engineer must be trained on. They are grouped in the article as natural sciences - physics, biology, chemistry, mathematics, informatics, communications and management tools. It describes in detail how each of the knowledge fields is involved. Furthermore, it is recommended that they should be taught fundamentals so that engineers can be involved in various interdisciplinary teams during their active professional lives. Excessive detail in the Bachelor's degree should be avoided. In contrast, at the master's level, in-depth and specialized knowledge of specific technologies and their management systems must be included in the learning process.

It is believed that the future development of an engineer who finds himself in a new, more complex situation than his current knowledge and skills should be supported in two directions. On the one hand, expanding knowledge in emerging fields through participation in intensive educational and postgraduate courses. The other strand is the acquisition of new skills in developing or emerging narrow specialties.

The article concludes by answering the questions of whether such developments make sense and how reliable the presented forecast is for the future development of engineering education in the country.

Summary of report [Г8.5] from the list of publications

Konsulova-Bakalova, M., Nedev, A., "Example of measurement of non-electrical quantities using micromechanical sensors" - Journal of Electrical Engineering, Vol. "Mechanical Engineering and Machine Science" issue 5, year IV, book 1, 2009, ISBN 1312-8612, 12÷15 pp..

*Reference in the original language: **М. Консулова-Бакалова**, А. Недев, "Пример за измерване на неелектрически величини с помощта на микромеханични сензори" - сп. "Машиностроене и Машинознание", брой 5, година IV, книга 1, 2009 г., ISBN 1312-8612, 12÷15 стр.*

The dynamic mode of operation was chosen to perform the gas analysis because of its greater noise immunity and fast sensor performance. The resulting micromechanical system is relatively small in size and weight, and only the adhesion of a few molecules can change the resonant frequency.

A laboratory setup has been developed in collaboration between a Bulgarian scientific team and the team of prof. Kassing from the Institute of Nanotechnology at the University of Kassel, Germany. Bakalova Ph.D., then still eng. Bakalova developed the measurement electronics module and, at a later stage, the analysis of the data obtained from the sensor and the gas recognition by statistical methods.

Experiments prove that micromechanical sensors that have already proven their applicability, i.g. in cantilevers used in AFM (Atomic Force Microscopy) can also be successfully applied in gas analysis and pressure measurement after incorporation into a suitable measurement circuit. The sensors are built using micro- and nanotechnology, so they fit the requirements of modern miniaturization technologies. They are also suitable for multi-channel, multi-function systems.

Summary of report [Г8.6] from the list of publications

A. Nedev, M. Konsulova-Bakalova, H. Nenov, "A New Approach for Visualization, Estimation and Forecasting of the Status of Complex Objects (with Application on Energetics and Environmental Protection)", Energy Forum 17-20 June 2009, Proceedings, 455÷461pp.

*Reference in the original language: А. Недев, **М. Консулова-Бакалова**, Хр. Ненов, "Нов подход за визуализация, оценка и прогнозиране на състоянието на сложни обекти (с приложение в енергетиката и опазване на околната среда)", Енергиен форум 17-20 юни 2009, сборник доклади, 455÷461стр.*

In this paper, a "complex object" refers to a technical, production or societal system with a large number of state classes, described by multidimensional observation vectors. Tasks of the type formulated in the title arise in the assessment of the technical condition (diagnostics) of the energy, environmental or economic efficiency of facilities for their management. The complexity of this type of problem with a fixed dimensionality of the state vector is that specific classification decisions need to be made on the measurement results of the available observation vectors, which intersect substantially.

Initially, some specific tasks where the method can be applied are considered. These are technical diagnostics of stationary or transport power systems driven by powerful internal combustion engines, assessment and prognosis of the condition of power or production systems with steam turbine drive, evaluation and management of the efficient use of available energy resources in an industrial site and, last but not least, environmental assessment.

The last application area includes three types of tasks:

- Overcoming metrological issues to improve measurement accuracy and visual presentation of results in case of fuzziness. Specifically, it is the determination of the content of gases and gas mixtures in different ratios using multi-channel gas analyzers;

- Support decision-making processes on the extent of air pollution in the vicinity of landfills, industrial or agricultural sites, sources of hazardous or nuisance impacts on people;

- Recognition of organic and inorganic pollutants in spills in seaports and offshore areas.

The following problems are characterized by many state classes, multidimensional feature vectors which implicitly describe the states and fuzziness, and the intersection of feature spaces for the different state classes.

Based on the general characteristics of the problems, the tasks of the development are formulated:

- Search for recognition procedures after appropriate transformations of the physical feature space into new coordinate systems;

- Learning recognition algorithms;

- Representation of data in coordinate systems allowing the best distinguishability of condition classes.

In the methodological part, the dividing rule is presented, on the basis of which the data is divided into state classes and special attention is paid to the way the classes are taught. The main idea of the visualization stems from the possibility of representing the data in a new coordinate system after performing orthogonal transformations. The proposed method (principal component analysis) involves mathematical procedures transforming a certain number of (possibly) correlated variables into a smaller number of uncorrelated ones, called principal directions. Each axis is qualitatively independent and the first is chosen to represent the direction with the most variance, the second largest variance and so on. Thus, it is ensured the easy separability of the state classes in the new orthogonal space. Mathematically, the procedure is based on singular decomposition.

There are several examples of visualization of data that are difficult to distinguish in the source spaces but presented in the coordinate systems of their first principal directions already clearly form the individual state classes.

The paper demonstrates the broad applicability of the visualization method to a wide range of tasks.

Summary of report [Г8.7] from the list of publications

***Konsulova-Bakalova, M. Iv**. , Modern methods for design, calculation and analysis of machine structures, Mechanical Engineering and Technology, 2'2009, ISBN 1312-0859, 78÷81 pp..*

*Reference in the original language: **Консулова-Бакалова**, М. Ив., Съвременни методи за проектиране, пресмятане и анализ на машиностроителни конструкции, Машиностроителна техника и технологии, 2'2009, ISBN 1312-0859, 78÷81 стр.*

The paper presents modern methods for calculating and designing mechanical engineering structures. Several software products were used for this purpose - MITCalc, Microsoft Excel and Solid Works. Attached is an example of calculating of a master translation of a universal turning machine C11MB. Methods for analysis of the designed structures are proposed. A complete methodology for the design of mechanical engineering structures is presented.

However, in most cases, this is accompanied to one degree or another by software complexity and requirements for higher qualifications of the users working with it. This is exactly how the

question stands provided that the users are students. If the product they are offered seems too complex to grasp and requires long prior training to work with, they will reject it in advance as an option to support their independent work - such as coursework and theses. This has focused the attention of software developers and educators, on easier-to-understand products that conform to the design methodologies embedded in the learning process. From this point of view, a methodology for the calculation of mechanical engineering structures is proposed, based on a relatively new, at the time of publication, product MITCalc, which, however, is fully compatible with the CAD systems used by students of mechanical engineering - AutoCAD and SolidWorks.

To illustrate the capabilities of the software product, an example is applied in the paper - a calculation of a master translation on a machine tool. This task is the basis of a developed and defended diploma thesis in the Department of TMMM, at TU-Varna. The sequence of calculations is according to the accepted methodologies. Calculations of the belt and toothed gears were made, the modules were strength-calculated and the appropriate bearings were selected.

After calculating the gears and generating their spatial patterns, they are assembled into a complete joint. This is done in the SolidWorks environment. The product enables a complete simulation study of the designed compound. This is done through the Simulation module.

The attached example gives reasons to propose a general methodology following the methods set out in the curricula of students of mechanical engineering, by which to solve similar problems using software products. The individual stages are included in one algorithm. Entry of the task, calculation of the design and generation of the drawing documents is done in MITCalc. The ability to optimize the computed objects is a great advantage because it allows users (in this case, the students) to show more knowledge and select the most appropriate solution. Generally speaking, it can provide a solution faster (automatic design), but this is appropriate for approximate problem solving where minimal input information and only one optimization parameter are used.

The article is an example of a successful application in the practical training of students of a software product that has the most simplified appearance, affordable price and is also consistent with the theoretical methodologies studied during the learning process. Another contribution of the study is the demonstration of the joint use of several software products, which can be very useful in solving several practical problems.

Summary of report [Г8.8] from the list of publications

Konsulova-Bakalova, Maria Iv. *, Vassilev, Grisha V. , Opportunities for distance learning in CAD systems, Proceedings of the Union of Scientists - Sliven, Fifth National Conference with International Participation "Educational Technologies 2009", Sliven, Vol. 15, 2009 ISSN 1311 2864*

Reference in the original language: ***Мария Ив. Консулова-Бакалова****, Гриша В. Василев, Възможности за дистанционно обучение по CAD системи, Известия на съюза на учените – Сливен, Пета национална конференция с международно участие "Образователни технологии 2009", Сливен, Том 15, 2009 г. ISSN 1311 2864*

The article was published in 2009 when e-learning and distance learning started to be applied in university education. Even then, the publication rated this form of training as a very effective way of presenting the required knowledge. E-learning is a mandatory element of distance learning. The paper aims to show how distance learning can be organized for the specialties related to the study of

computer technologies through the possibilities of organizing and presenting information in an electronic environment.

Information environments for presenting learning materials are discussed. Attention is drawn to the fact that it is essential to follow the methodology of "learning by doing", whereby practical tasks and exercises are offered that allow a better way of learning the material.

The focus of the paper is CAD training. They represent a fast-growing software where you must constantly monitor new product developments to meet the demands of the job market. Modern design systems require substantial resources on the hardware side. On the other hand, the training is accompanied by numerous tasks for independent work, which achieves a high degree of training and good absorption of new knowledge and skills.

Based on the analysis of CAD training, it is concluded that the implementation of distance learning in computer-aided engineering design systems is feasible. To support this conclusion, an example of the presentation of the lecture material is presented in the paper. It is proposed to record lessons in the form of a video and then the resulting file is provided to the learners. The object on which this is applied is the automated design of the process of creating and assembling two gears. The stages of the designing are described, as well as the possibility of using this example in other disciplines, not only those related to computer-aided design.

The presented examples prove the feasibility of e-learning and distance learning of CAD systems. This, of course, requires some effort to be made by the teaching staff.

Summary of report [Г8.9] from the list of publications

Nedev, A., Bakalova, M., Hr. Nenov, Vl. Dimov, D. Kamberov, S. Sezgin, and G. Antonov, "Influence of the training sample size and the observation vector length on a diagnostic task," Jour. "Mechanical Engineering and Machine Science" issue 10, year V, book 1, 2010, ISBN 1312-8612, 49÷53 pp

*Reference in the original language: А. Недев, **М. Бакалова**, Хр. Ненов, Вл. Димов, Д. Камберов, С. Сезгин, Г. Антонов, "Влияние на обема на обучаващата извадка и дължината на вектора на наблюдение при на една диагностична задача", сп. "Машиностроене и Машинознание", брой 10, година V, книга 1, 2010 г., ISBN 1312-8612, 49÷53 стр.*

In this work, the focus is to synthesize diagnostic algorithms that provide sufficiently high efficiency with the most economical structure and easily implementable computational procedures. The complexity of an algorithm with an already chosen mathematical structure is determined by the number of state classes, the length of the observation vector and the amount of data used for training. The influence of the observation vector length, the training data volume and correlations on the performance of a nonlinear recognition algorithm solving a specific diagnostic task is investigated.

A total of 1300 observation vectors (100 for each state class) are included in the working observation sets. Preliminary analysis is done, which shows that changing states affect the observation vector, but due to the presence of many confounding factors, deterministic relationships are hard to establish. Therefore, in this case, minimum risk recognition is chosen. The methodology is explained in the paper.

The computational experiment consists of selecting a collection of diagnostic features, computing the mathematical expectation vectors and covariance matrix elements for the selected set

of features, recognizing and evaluating its performance, setting a new observation vector, and continuing the procedure.

For each set of experiments, the mean values of the partition functions by state class are presented. Presented in tabular form, they give the correspondence between the actual states and the recognized states. In addition, diagnostic tables showing the percentages of correct or incorrect classification are presented. Based on these results, the dependencies of the number of correctly recognized control recognition situations on the number of training data and the length of the observation vector are plotted graphically.

From the tabulated results and their graphical illustration, it can be seen that the particular problem at hand provides good recognition performance for 10-dimensional observation vectors trained with five observations per class. Further increasing the sample does not lead to improved results due to the high fuzziness of the data. Here the diagnostics are performed on a ship's main diesel engine, but the method is unified and can be used on different types of objects.

Summary of report [Г8.10] from the list of publications

Stoyanova A., Bakalova M., Mechkarova T., A Simulation Thermal Study of the Effect for Determing of the Temperature on the Surface Layer after Air-Plasma Gouging Cutting, Machine tehcnics and Technologies, TU-Varna, Issue 2, 2010, 77 pp, ISSN 1312-0859.

*Reference in the original language: Стоянова А., **Бакалова М.**, Мечкарова Т., Симулационен термичен анализ за определяне на влиянието на температурата върху повърхностния слой след въздушно-плазмено повърхностно рязане., "Машиностроителна техника и технологии", НТС, ТУ-Варна, Брой 2, 2010г.,77стр., ISSN 1312-0859.*

In this paper, the influence of temperature, thermal cycle and cooling rate in plasma machining of a 45 steel specimen is examined. The temperature distribution and heat fluxes in the zone of thermal influence after the air-plasma surface-cutting process is determined by computer simulation using the finite element method.

The chemical composition and physical properties of the material used are presented in the paper. Through a physical experiment, the specimen was processed by air-plasma surface cutting, after which the hardness of the surface layer was measured. The hardness data before and after the plasma treatment are placed. A computer simulation is performed based on data from the instrumentation used, such as mode parameters, ambient temperature, source power, etc., all described in the publication. Non-stationary thermal analysis was used. The results of the temperature variation were obtained for the whole period of analysis. The time-temperature curves at selected points are also plotted, matching the location of the thermocouples from the phhisical experiment.

A comparison of the experimental and simulation calculated results shows that the huge discrepancy (10-11%) between the two plots is in the region of high values above 850OC. In the 850-500 OS range, the discrepancy is 1-3%. In this case, it can be assumed that the accuracy of the calculation is good enough.

Summary of report [Г8.11] from the list of publications

Bakalova M., *Stoyanova A., Mechkarova T., A Simulation Study Surface Roughness after Air-Plasma Gouging Cutting, VII INTERNATIONAL CONGRESS MACHINES, TECHNOLOGIES, MATERIALS, Varna, Issue 1, 19-21.09.2011, ISSN 1310-3946, 175÷177 pp.*

Reference in the original language: ***Бакалова М.,*** *Стоянова А., Мечкарова Т., Симулационно изследване на грапавостта след въздушно-плазмено повърхностно рязане., "VII Международен конгрес МТМ", Варна, Брой 1, 19-21 септември 2011г., ISSN 1310-3946, 175÷177 стр.*

In this work, the capabilities of a new simulation model for the formation of roughness heights in the overlay of traces on a surface machined by air-plasma surface cutting are analyzed. By finding a finite number of trace overlay options, opportunities are sought to reduce the roughness heights (h) and to obtain a higher quality surface after plasma surface cutting. The machined socket is made of steel 45. In the article, the scheme of formation of the roughness is shown and the maximum depth of penetration in plasma cleaning is calculated. The height of the bumps was found to vary proportionally to the feed.

A geometric model is built in SolidWorks CAD system to confirm the theoretical calculations. An experiment is conducted with different overlap distances from 0.1 to 4 mm to examine the resulting roughness. Its height is measured every time. Due to its variety, Design Study (capability to perform parametric optimization) is used to obtain faster results and automate geometric modeling. It is necessary to introduce variables, constraints and optimization objectives. The software offers an option without inputting targets - different configurations of the geometric pattern are played out. It is this option that is used in the present study. The only variable here is the distance between the individual channels. For each of the resulting combinations, the distance h is monitored. The results are obtained in tabular form.

Summarizing all the results obtained, it can be said that it is possible to predict with sufficient accuracy the magnitude of the roughness heights in the overlay of the traces after air-plasma surface cutting. Based on the simulation, a variant with the smoothest possible surface can be selected. As a result of experimental, theoretical and simulation studies, it can be argued that up to some feed value, there is an increase in performance, after which no significant increase in performance is noticed, even if the feed is increased, but the surface quality starts to deteriorate.

Summary of report [Г8.12] from the list of publications

Vasilev Gr., M. Konsulova-Bakalova, "Methods for Determination of Cooling Mold System for Production of Plastic Parts with Use of CAE System – Simulation by SolidWorks, Mechanical engineering and technologies, Issue 1, ISSN 1312-0859, 2011, стр. 57-60pp

Reference in the original language: Василев Гр., ***М. Консулова-Бакалова****, „Методика за определяне охлаждащата система на шприцформи за изработка на пластмасови детайли при използване на CAE системата SIMULATION на SolidWorks, сп. Машиностроителна техника и технологии, бр.1, ISSN 1312-0859, 2011, стр. 57-60стр.*

This paper proposes a methodology for the selection and quality inspection of injection mold cooling systems. A prototype of the product was developed in SolidWorks environment and a

simplified model of the injection mold was made for its production. Based on known laws of thermal engineering and finite element method, thermal analysis was performed using SolidWorks Simulation with and without the presence of a cooling system. From the comparison of the results in the two cases, one can judge the efficiency of the cooling system.

In order to reduce significantly the time of the injection molding, the cooling channels are made in the mold. The coolant which circulates and removes excess heat is then introduced into them. Thermal processes are influenced by the size and placement of the channels. Their other role during the filling stage is to maintain the temperature of molten plastic higher than that of solidification. With the help of CAE systems, it is possible to simulate the injection molding process and specify the best option for the type and layout of the cooling system.

This paper proposes an approach to investigate the shearing process, especially the cooling channels. In order to perform the temperature analysis, initially conductive heat transfer is used. In this case, it is necessary to calculate the heat transfer coefficient using the Nusselt coefficient. Its calculation is shown in the publication.

The methodology involves modelling the workpiece for which the formers are being designed. A three-dimensional model is created in SolidWorks. Sensors are also provided in the modelling stage to track the temperature change as the workpiece cools. The creation of the formers themselves is also explained as part of the creation of the simulation model. Cooling channels have been added to them. A finite element analysis follows. It is conducted in two stages. The first models the filling of the mould with molten material. The boundary conditions are described. At this stage, when reviewing the results, the temperature on the forming surfaces and in the melt is monitored to avoid incomplete filling of the cavity.

However, the goal of the methodology is on the second analysis - the cooling time and then the time of removal of the workpiece from the mold. Thus, two sequential thermal analyses are formed. The second thermal analysis uses the results of the first as initial conditions. This is possible thanks to the settings provided by the CAE system.

There are formulas in scientific papers which calculate the location of cooling channels. In this paper, however, it is intended to do so experimentally. A preliminary thermal analysis without cooling channels is carried out. The temperature distribution in the mold, especially around the cavity, determines where the channels should be located. Some design parameters of the cooling system are selected and the heat transfer coefficient is calculated for them using the formula given in the article. Next, the actual simulation analyses are conducted to simulate filling and cooling.

The described methodology is applied to an example workpiece - the lid of a dehumidifier. The results obtained for the temperature distribution at the end of cooling and the results from the previously added sensors are attached.

Many more specialized and suitable injection molding research software products are known. However, in most cases, they have a very high price. A smaller company can hardly afford such software. The paper shows a methodology that can be implemented with a mid-range software product without the presence of specialized fluid simulation modules. This methodology allows the assessment of the solidification behavior of the plastic during the filling of the mold, to avoid unfilled areas of the workpiece. The instrument designer obtains information about the thermally loaded zones, based on which he constructs a cooling system. Finally, the time to remove the finished part from the injection mold can also be determined.

Konsulova-Bakalova M., *Zlateva P., Argirov, Antonov G., "Simulation Analysis of Heat Transfer Processes in Welding of Bi-metal Plate", Mechanical engineering and technologies, Issue 2, ISSN 1312-0859, 2011, стр. 53-57pp*

Reference in the original language: ***Консулова-Бакалова, М.,*** *Златева, П. Г., Аргиров Я., Антонов Г., Симулационен анализ за изследване на процесите на топлопренасяне при заваряване на биметална пластина, сп. Машиностроителна техника и технологии, бр.2, ISSN 1312-0859, 2011, стр. 53-57*

The technology of welding aluminum alloys to steel has been applied since the mid-20th century. Practice shows that this process is complex, necessitating the use of specialized methods to join the two materials. Bimetal plates (inserts) made from sheet materials of steel-aluminum-aluminum alloy are commonly used. Modeling the heat transfer process of a bimetal plate used as an intermediate insert for welding steel to aluminum alloy represents a complex procedure that combines mathematical description, approptiate physical circumstances and experimental confirmation. The article proposes the use of the SolidWorks Simulation software for this modeling process, driven by the desire to enhance the technological processes. Understanding the temperature distribution across the cross-sectional and longitudinal sections of the plate allows for the assessment of deformations and strains at the joint. This knowledge guarantees the creation of a quality connection between aluminum alloy and steel, as well as predicting the occurrence of cracks, unacceptable deformations, and residual strains.

Due to the rapid temperature increase and the movement of the heat source at the welding speed, the temperature field in the investigated elements owns an obvious non-stationary character. Therefore, obtaining an accurate solution for the general heat conduction equation poses significant difficulty. Numerical methods and software products are used to tackle this challenge. This can be considered as a step forward in automatization of the welding processes and achieving connections with high mechanical and operational characteristics.

The goal of this study is to create a suitable geometric model of a bimetal plate and apply the finite element method to determine the temperature distribution in the welding joint while welding aluminum alloy to a bimetal plate. This idea is implemented in a specific scenario, following the outlined algorithm: problem formulation and setting the goal of the simulation analysis; analyzing the task and selecting specific software; gathering input data for thermal analysis; creating a CAD model; conducting a simulation analysis; presenting and then analyzing the results.

Following this algorithm, a non-stationary thermal analysis is prefered for the investigation of the heat transfer processes in aluminum alloys with a bimetal plate during welding. Due to the complexity of the process of creating a welded joint and ensuring more reliable results, the task is divided into several smaller ones. The exact number of these tasks depends on the welding mode and the length of the joint. The parameters of the welding mode and the physical properties of the materials serve as initial data for the analysis.

The article presents the created 3D model within the selected software environment. The choice of time (duration) for conducting the simulation is justified. All necessary data for conducting the thermal analysis are provided. Due to the division of the task into smaller ones, a total of 15 thermal analyses are conducted, each subsequent analysis using the results of the previous one as initial conditions. The materials used, the system of finite elements and the simulation elements are the same for each analysis.

From all the results obtained from the simulations, the article describes the thermal distribution in the model 2s after the beginning of the welding, then 14s, and at the end 30s from the start, corresponding to the first, seventh, and last zone from the pre-defined zones resulting from dividing the task into smaller ones. The results are presented as a two-dimensional graph, where the abscissa represents the relative length of the welding joint and the ordinate represents the obtained temperatures. After 14s, all the elements of the object have a temperature above 80°C, and after 30s, even the coldest point has a value of 143°C.

It can be undoubtedly stated that the created simulation model adequately reproduces the temperature distribution during the welding of aluminum alloys, a technological process characterized by a powerful, moving heat source. The developed simulation algorithm allows for demonstrating the patterns of different welding technologies using software products, while changing the input parameters. Understanding the temperature field provides a basis for predicting the appearance of defects in the weld structure and the surrounding area, as well as the occurrence of unacceptable overall deformations and high residual strain values.

Summary of report [Г8.14] from the list of publications

Antonov G., Konsulova-Bakalova M., Argirov, Zlateva P., "Simulation Modeling of Process of Stress and Strain State During Welding of Bimetallic Plate", Mechanical engineering and technologies, Issue 2, ISSN 1312-0859, 2011, стр. 43-48pp

Reference in the original language: Антонов, Г., ***Консулова-Бакалова, М.,*** *Аргиров, Я., Златева, П. Симулационно моделиране на процесите на напрегнатото и деформираното състояние при заваряване на биметална пластина, сп. Машиностроителна техника и технологии, бр.2, ISSN 1312-0859, 2011, стр. 43-48*

The elaboration presents the application of an intermediate bimetallic plate(inserts) for welding steel to an aluminum alloy. The intermediate insert is obtained through plastic deformation and a pure aluminum layer is placed between the two materials. The distribution of the temperature gradient within the volume of the investigated object during the welding of aluminum alloys to a similar bimetallic plate becomes considerably complex due to the fact that heat spreads through different materials with different thermophysical and mechanical properties.

The complex nature of the formation of welding strains and deformations in conditions of non-stationary heat input and elastic-plastic behavior of the metal prevents a comprehensive reflection of the thermomechanical processes occurring in the metal during welding. Therefore, there is a necessity to use approximate methods for determining them through the application of modern software tools. The task of modeling the strained and deformed state processes in welding an aluminum alloy to a bimetallic plate is solved by conducting thermal and static analysis using SolidWorks Simulation.

It is known that unlike the temperature field, the strain field does not disappear after the complete cooling of the structure, meaning residual deformations and strains arise. The article provides a detailed explanation of the nature of welding deformations. The causes for their occurrence in welding an aluminum alloy to a bimetallic plate can be summarized as follows: non-uniform temperature field due to heat source movement; different coefficients of thermal expansion by different materials; significant change in thermophysical and mechanical properties due to a large temperature variation; occurrence of a thermal shock (sudden temperature increase) during welding. In the first part of the scientific paper, the residual plastic deformations causing a volume change in

the metal in the weld area are determined, and in the second part, the deformations of the entire structure caused by a volume change in the object are investigated.

The difficulty in solving such tasks lies not in their formalization but in the identification and dynamics of the temperature field distribution. The task has a theoretical solution, but it requires a substantial amount of input data and would consume a considerable amount of computational time. Simulation modeling is much more convenient for this purpose.

The analysis of deformations and strains caused by temperature effects requires prior thermal analysis of the investigated object from the start of heating (welding) to its complete cooling. The obtained results for the temperature field serve as input data for the static analysis of the strained and deformed state within the specified interval.

The welding time is determined by considering the length of the weld and the electrode travel speed. This is the time for conducting the analyses. As explained in another work by the team, due to the complexity of the task, it is expedient to break it into smaller parts to describe the electrode movement during welding. The diameter of the electrode determines the size of the zone forming each of the smaller tasks for which separate thermal analyses are conducted. In this case, however, a practical interest lies not in describing the temperature field but in assessing the strained and deformed state. Therefore, besides simulating the welding process, the cooling period after welding until the temperatures of the individual elements of the object are equalized, is also simulated, followed by cooling first to 100°C and complete cooling to the room temperature.

The article describes an algorithm for conducting simulations in accordance with the above-mentioned requirements. The results for strains and displacements at the beginning,in the middle, and at the end of the welding process are applied, followed by cooling to 100°C and then to the room temperature.

The discribed results fully correspond to the theoretical assumptions regarding the appearance and distribution of thermal strains during welding of the investigated model. Deformations at various points of the object can be determined from the diagrams. Figuring out the maximum overall deformations in welded structures is crucial for solving some issues during their assembly.

Summary of report [Г8.15] from the list of publications

Aneliya Stoyanova, Mariya Konsulova-Bakalova, Penka Zlateva, "Thermal analysis for determination of thermal processes after air-plasma surface cutting", Izvestia of the Union of Scientists - Varna, Series "Technical Sciences" - 1'2012, pp. 60-65

Reference in the original language: Анелия Стоянова, ***Мария Консулова-Бакалова****, Пенка Златева, Термичен анализ за определяне на топлинните процеси след въздушно-плазмено повърхностно рязане, Известия на Съюза на учените – Варна, Серия „Технически науки" – 1'2012, стр. 60-65*

The present study examines the issues related to the heat processes occurring during the heating of samples made from sheet material of steel C45, manually arc-welded with EN550 electrodes. The research investigates the influence of temperatures, heating time, and the geometry of the examined specimens.

Computer simulation was performed using software tools such as SolidWorks and COMSOL Multiphysics, both equipped with finite element analysis systems. These simulations provide insights

into the distribution of temperature over time and direction of heat flows within the thermal influence zone after the process of air-plasma surface cutting.

By studying the heat processes following high-temperature plasma surface heating, an important feature is that body temperatures change not only ib relation to the space but also over time. The practical interest in these heat processes arises from the fact that body temperature undergoes periodic changes due to the influence of high-temperature plasma in the cutting area.

To conduct the experiment, samples of steel medium-carbon structural quality C45 were prepared. The test samples were subjected to high-temperature heating in 40 different areas for the same time of about 2 seconds at every contact point. This method of processing welded samples with electrodes of various mechanical qualities leads to phase transformations in both the molten and adjacent zones. Additionally, a simulation analysis of the studied sample was conducted within the SolidWorks environment. Transition thermal analysis was used to study the temperature field parameters. For successful computer modeling and simulation of temperature and heat flow distribution in the part, input parameters such as the base material type, the welded metal layer, their thermophysical properties, and cutting surface conditions were introduced. The direction of heat flow propagation was presented for a 2-second dwell of the plasma torch at different sections of the specimen.

Based on the simulation modeling, results were obtained regarding temperature and heat flow distribution in the model, leading to a justified conclusion about the direction of heat flow distribution in the processed specimens. The demonstated results of heat process experiments during air-plasma surface cutting of C45 steel sheet material specimens welded with EN550 electrodes indicate that if heating time increases, there is a change in the heat flow within certain limits. By comparing simulation and experimental studies on air-plasma surface cutting of the specimens, it can be concluded that the simulation studies via the mathematical model adequately reproduce the processes of temperature field distribution in the real object. Determining maximum strains can make us predict the risk of crack formation or detachment of layers in the bimetallic plate. Determining residual strains after complete cooling in terms of direction and magnitude could help assess their impact on the working strains of the structure.

The demonstrated method for simulating heat transfer processes and evaluating the strained state during welding of aluminum alloys is of a universal nature. The use of software like SolidWorks enables experimentation with various welding technologies by varying the initial parameters of the modes or using different materials.

Summary of report [Г8.16] from the list of publications

Lefterov E., Konsulova-Bakalova, M., Thermal Analysis of Single – Cutting Drills, IX International Congress "Machines, Technologies, Materials" 2012, 19-21 September 2012, Varna, Proceedings Volume 1: Section Technologies, 63-66pp.

*Reference in the original language: Лефтеров Е. , **М. Консулова-Бакалова**, Топлинен анализ на свредла с една режеща пластина, 63- IX Международен конгрес „Машини, Технологии, Материали“ 2012, 19-21 септември 2012, Варна, сборник с доклади Volume 1: Section Technologies, 63-66стр.*

Single cutting tools have no guide parts and their performance depends on the deformation of the body as a result of the force and heat load during machining. This study focused on analyzing the

influence of the following parameters on the heat load: body shape and shape of the cooling channels; the shape of the seat of the cutting plate; type of operation performed by the instrument. The thermal analysis is based on the temperature value accumulated by experiments with respect to certain areas of instruments. The modeling was done by SolidWorks and allows us to get a complete picture of the temperature fields.

The modeling of the object to be investigated makes it possible to determine the influence of certain contractive features on the maximum temperatures of the cutting part and the fastening screw. The CAD model is simplified for the purpose of simulation analysis. This simulates the heat load of drilling a hole, enlarging holes and machining external rotary surfaces. The tool was strength tested for each variant and thermally for the first two. The results were obtained with different shapes of the bed walls for mounting the cutting plate, different contact ways of the fixing screw and distinct fixing.

Analyses are conducted in the presence of a smear-cooling fluid, which is simulated by defining forced convection in the thermal analysis. Thermal resistance was used to simulate incomplete contact between the plate and the bolt.

The results for the temperature distribution on the working surfaces are presented, and the maximum temperatures in the fastening screw are also tabulated. From the graphical and tabular results, it can be clearly seen that the case where the educator closes 90O concerning the bedding plane of the plate is more favorable. A clearance is formed between the insert and the tool, which helps to cool the insert faster. The most severe is the variant where the tool drills a hole. Then the whole cutting edge works. The behavior of fastening threaded joints in terms of their reliability requires additional metallographic studies and strength tests to determine the timing of their replacement or to change the material from which they are made.

The results of the study can be used to: optimize tool design; predict the quality indicators of the performed processing operations; evaluate the effect of cutting zone temperature on wear; choice of material for the fixing screws and the type of contact between the screw and the cutting plate.

Summary of report [Г8.17] from the list of publications

*Lefterov E., **M. Konsulova-Bakalova**, "Strength Analysis if Single-Cutting Tool for Combined Tooling", Mechanical engineering and technologies, Issue 1, ISSN 1312-0859, 2012, 36-40pp*

*Reference in the original language: Лефтеров Е. , **М. Консулова-Бакалова**, Якостен анализ на едноръбов инструмент за комбинирани обработки,"Машиностротелна техника и технологии, НТС, ТУ-Варна, Брой 1, ISSN 1312-0859, 2012г., 36-40стр.*

The single cutting tool with replaceable insert drill holes with diameters varying between 14 and 17 mm. Their design allows several technological operations. Since they have no guides, their body deforms elastically during operations. Also, the accuracy of the machined surfaces depends on these deformations. The present work is an investigation of the influence of all design parameters on the stresses and strains occurring in the tool under the action of cutting forces.

An algorithm optimizing the tool based on its design parameters is proposed. The choice of an optimization method is the crucial prerequisite for achieving the desired solution in optimization problems and must be independent of the nature of the object. In this case, a variation of the so-called experimental methods. The optimization itself was conducted using SolidWorks. A preliminary strength analysis is conducted to specify the optimization objectives. A set of variables are created to perform the best solution search and constraints are defined that characterize the optimization bounds. The software generates all possible options for combining the variables and selects the optimal option

according to the optimization objective. Due to the large number of combinations of design parameters, the problem is divided into several parts: optimization without the presence of an orifice for the lubricating coolant (LCF) alignment with variable parameters regarding the location and size of the chip channel; optimization without the presence of an alignment hole of the LCF with a variable radius of roundness of the chip channel with the results of the previous problem; optimization to determine the size and location of the LCF hole with the shape and size of the chip channel already determined. The paper describes the resulting algorithm in detail.

After conducting the first optimization analysis, the overall count of 29 combinations is obtained, some of which are constructively infeasible. The possible combinations are presented in a tabular form and also in a graph of the change in strains for the different options. When choosing the best option, the value of the voltages in the model is considered.

The refinement of the radius of roundness of the channels along which chips are released, which is the second optimization problem, is again split into parts because of the large volume of possible options. The channel itself is divided into several zones defined by the geometrical features of the CAD model and the optimization is done for each of them separately. The optimum values of the radii in the four zones were thus determined.

The last part of the optimization is to determine the channel location for the LCF. After numerous experiments, however, it was found that this had little effect on the stresses and strains in the tool. It is recommended that the exact location of the IOT hole be determined after a thermal analysis is conducted.

The proposed optimization algorithm can be used in determining the optimal design parameters of cutting tools. In this case, the advantage of using a CAD/CAE system is not only the relatively quick finding of the best solution for the structure but also the simultaneous calculation of the strains in the different variants of the structure. Thus, the trends in the variation of the strength properties of the tool as its parameters change can be tracked.

Summary of report [Г8.18] from the list of publications

***Konsulova-Bakalova M.**, G. Vassilev, Aplication of Solidworks Simulation for Design of cooling system for injection molding, IX Международен конгрес „Машини, Технологии, Материали“ 2012, 19-21 септември 2012, Варна, сборник с доклади Volume 1: Section Technologies, стр.31-34*

The cooling system in injection molding is crucial and affects the production cycle time. This is directly related to price and affects the quality of the parts. For this reason, the main objective of this paper is to determine an optimal design for cooling channels using thermal analysis. The workpiece model and the injection mold are designed in SolidWorks. The cooling time of the workpiece is optimized by using cooling channels that follow the shape of the workpiece. Comparison of channels of different cross-sections - circle and ellipse using SolidWorks Simulation thermal simulation software is made. The results are presented in the form of temperature, heat flux and cooling time distributions and transient thermal analysis is used to calculate them. The results show a reduction in production cycle time and an increase in the quality of the parts produced.

To arrive at the type of cooling system proposed, three different types of cooling are considered in the paper - standard, with channels following the shape of the workpiece and dynamic temperature control. The advantages and disadvantages of each are highlighted.

An important task in the construction of cooling systems is not only the selection of an appropriate method for their construction but rather the development of a method that will apply to products of arbitrary geometric shapes. Some authors propose to divide the object into small zones with a simplified shape and proceed with the construction of cooling channels after analyzing each shape. They are then merged into one system. Such an approach is justified for parts of very complex shapes. A compromise option that ensures good product quality, relatively short process times and not very high molding tool costs are cooling systems with channels that follow the shape of the workpiece. The cross-sectional shape of the cooling channels is vital for improving production parameters. Therefore, experiments with a circular cross-section and profile channels (part of a circle) were conducted. It has been proven that the heat transfer from the molten material is faster with such channels.

For a preselected workpiece, a cooling system is designed with channels following the shape of the workpiece. Parameters such as groove bore diameter, groove spacing, and workpiece to groove spacing are selected according to values recommended in the literature. The coefficient of thermal conductivity was also calculated, as has been done in previous work by the team.

Appropriate thermal analyses were performed for both types of channel cross-sections. The results for the temperature distribution in the model are shown, as well as the sensor results for the period of the analysis. It can be seen that using a cooling system that follows the shape of the workpiece results in uniform cooling of the particular workpiece. This improves product quality and protects production from defects and waste. These advantages justify the higher price of the molds. Furthermore, the continuous development of prototyping technologies further facilitates the production of the proposed cooling. In order to verify the effectiveness of any new type of cooling, it is necessary to evaluate the performance of the new method in addition to proving the quality of the parts produced. Injection molding productivity depends mainly on the cooling time of the workpiece. In our case, the temperature from which the workpiece can be removed is 80^{O}C. In the circular channel version, this temperature is reached after 15 seconds. In comparison, temperature with the elliptical-shaped channels is achieved after 9 seconds. This result is due to the larger heat flux in this case. It turns out that using elliptical channels can reduce cooling time by 40%. An additional advantage is the more even temperature distribution in the model when using them.

Summary of report [Г8.19] from the list of publications

Mariya Konsulova-Bakalova, *Modeling of Thermal Load on Power Supply, Third International Scientific Congress 50 years of TU-Varna, Proceedings Volume IV, 2012, pp. 50-54*

Reference in the original language: ***Мария Консулова-Бакалова****, Моделиране на топлинното натоварване на захранващ блок, Трети международен научен конгрес 50 години ТУ-Варна, Proceedings Volume IV, 2012г., стр. 50-54*

Every machine or mechanism gives off some heat during its operation. This applies to the machines that surround us in our everyday life and to the equipment involved in various production areas. More often than not, if the necessary measures are not taken, the temperature can reach high values. By doing so, the appliance, machine or mechanism drastically shortens its life. There is talk here of loss of resources and even sometimes of danger threatening workers.

The object chosen to demonstrate the methodology is a power supply unit even so it can be used for almost everything. The power supply unit was removed from a PC case, yet the electrical connections between the units were retained in order to examine the operation of the power supply

unit under typical load. Thermocouples are installed in the power supply box to measure the temperature at specific points. The purpose of the experiment is to obtain the temperatures of the elements during their standard operation. This avoids the need to use a specialized product of a higher class for the simulation analyses, which would be of the "multiphysics" type - taking into account different physical processes - magnetic, electrical, fluid, etc. For greater accuracy, a series of measurements were carried out.

In parallel with the real-world experiment, a three-dimensional model of the object was created using SolidWorks. The box is not an object of study and therefore is not used in the initial analyses. An air detail was created in addition to the electronic elements themselves for the purposes of the primary thermal analyses. Its purpose is to ensure the distribution of heat from the heating parts to other parts of the circuit.

Firstly, a primary thermal analysis is performed. The goal is to obtain the temperature distribution in the model during the ordinary operation of the device. The experimentally measured temperatures are used. After reviewing the results, it is noticeable how the heated elements give it off to the surrounding modules involved in the circuit of the power supply unit. The resulting temperatures threaten the regular operation of the device. In such cases, additional cooling in the form of a fan is used. Its correct selection should ensure the expected operation of the power supply unit.

Fluid analysis follows. Through it, a suitable option for the operation of the fan was selected, namely - the fluid inlet is the rear grid wall of the power supply unit, and the outlet is the opposite side of the box, where the fan itself is located, provides significantly better ventilation of the elements. The practice has also proven this method efficient from the point of view of dusting the components in the power unit, which additionally leads to undesirable effects.

A possible approach to solve problems related to the thermal load of different apparatus is demonstrated through the presented example. Although the sample is from the field of electronics, there is a better way to design any facility or device. The main points to be observed in such tasks are:

- Proper object model creation. The model should be as close as possible to the physical product so that it describes its main characteristics accurately enough and, at the same time, has a relatively simple geometry to make it possible to conduct simulation analyses;
- Selection of suitable materials - the physical properties to be assigned to the models depend on them;
- Careful selection of initial conditions - they determine the correctness of the whole simulation analysis;
- Appropriate finite element mesh tuning - this determines the degree of accuracy of the calculations;
- In-depth analysis of the results obtained;
- Conduct additional analyses to improve the virtual model as needed.

Summary of report [Г8.20] from the list of publications

Konsulova-Bakalova M., *G. Vasilev, A Method for Thermal Modeling of Injection Molding, International Congress "Machines, Technologies, Materials" 2013, 18-20 September 2013, Varna, Proceedings Volume 2: Section Machines, Section Technologies, pp. 27-30*

Reference in the original language: ***Консулова-Бакалова М****., Гр. Василев, „Методика за топлинно моделиране на инструментална екипировка“, X Международен конгрес „Машини,*

Технологии, Материали“ 2013, 18-20 септември 2013, Варна, сборник с доклади Volume 2: Section Machines, Section Technologies, стр.27-30

In the production of plastic products by injection molding, the following stages can be considered: filling the mold cavity with a liquefied material - polymer; a holding phase to compact the mold; the stage of cooling the melt until it solidifies and reaches a temperature suitable for removal from the mold; removal of the workpiece from the die; cooling outside the matrix.

When designing injection molds, it is vital to investigate the individual stages and their influence on the quality of the manufactured products and the productivity of the injection molding process. For this purpose, specialized software products have been developed that simulate the entire process in detail. However, it can also be modeled using simpler, non-narrowly profiled automated design systems. The paper demonstrates a methodology for investigating the thermal loading of tooling using SolidWorks Simulation and then verifies the results using a specialized product.

To illustrate the methodology, a part with a relatively complex geometric shape is selected. Thermal modelling in SolidWorks involves three stages: filling the mould; retention and cooling stage. These three stages are defined by three separate non-stationary thermal analyses. Their parameters, such as times and temperature of mould injection have to be selected according to the material to be injection moulded. A conventional cooling system is designed with straight channels which are located on one side of the product. The channels have a circular cross-section. The diameter and position of the grooves about the workpiece and to the workpiece are adapted to the wall thickness of the model.

Moldex 3D specialized software of CAE type was used to verify the results obtained by the proposed methodology. The product is used to design and simulate the injection moulding process.

A method for investigating temperature distribution in tooling during injection molding is demonstrated by conducting simulation studies using SolidWorks Simulation. This approach is helpful when designing an outfit and determining the parameters of the cooling system that is part of it. Of course, powerful software products such as SimpoeWorks, Moldflowand Moldex 3D are suitable for such research. However, they cost a lot and require prior training of the personnel who will use them. Through the experiments, it has been proved that the designer can early assess his equipment in a familiar CAD system, where the creation of the 3-D models, forms the drawing documentation.

Summary of report [Г8.21] from the list of publications

*Lefterov E., **Mariya Bakalova**, Modeling of contact phenomena in the cutting zone at machining of holes, Academic Journal of Manufacturing Engineering, Vol.11, Issue 3/2013, ISSN 1583-7904, p. 114-119*

This paper presents the results of investigations on the deformation processes and chip formation when machining holes with a diameter of less than 15 mm with drill bits with replaceable inserts. The data obtained served as the basis for developing a chip-breaking strategy for cutting to produce a variable-thickness chip.

The machining of holes with replaceable insert drill bits is characterized by a significant change in cutting speed along the cutting edge. This results in the appearance of some features related to chip formation and contact phenomena during cutting. Research in this direction offers the possibility of solving the following technological problems: developing strategies for reliable chip formation; control of the chip separation direction. The publication describes the processes of chip formation in

this type of tool. In order to develop a chip-breaking strategy, it is necessary to consider the shape and parameters of the cutting inserts. The contact zones which are essential for the phenomenon under study of the cutting process are indicated in the paper.

Summary of report [Г8.22] from the list of publications

Toteva P.K., Bakalova M.I., Automated Selection of Fits in Rolling Bearings, Proceedings "Contribution to the Development of Technological Entrepreneurial Spirit and Orientation of Engineering Research towards the Development of Knowledge-Based Economy and Innovation", Varna, 2014, ISBN 978-954-760-316-5, 166-170pp

Reference in the original language: Тотева П.К., ***Бакалова М.И.,*** *Автоматизиран избор на сглобки на търкалящи лагери, Сборник научни доклади „Принос за развитие на технологичен предприемачески дух и насоченост на инженерните изследвания към развитие на икономиката, базирана на знание и иновации“, Варна, 2014г, ISBN 978-954-760-316-5, 166-170стр*

Reliability, rotational accuracy, durability, high-speed performance and contact strength of the products depend on the correct choice of rolling bearing assemblies. The purpose of this paper is to review and analyze the methods for selecting rolling bearing assemblies and to develop an algorithm and program for automated assembly selection.

The paper shows the algorithm for selecting rolling bearing assemblies. The program is implemented using the Matlab product. It works in dialog mode and the reference data for selecting assemblies is stored in "*.xls format".

A selection of rolling bearing assemblies is made by the methods considered.

A comparison of the methods considered in the paper shows that the highest tightness is obtained by applying the method by selecting an assembly for circumferentially loaded inner sleeve and shaft, according to the relation proposed by A. Palmgren, and the lowest by the analytical selection of prototypes for rolling bearings.

The developed algorithm and program enable a quick selection of a model according to the selected methodology depending on the bearing type, the size and nature of the radial load and the operating mode of it.

Summary of report [Г8.23] from the list of publications

Konsulova-Bakalova, *M., Gr. Vassilev, "A Method for processing scanned images in SolidWorks", Scientific Proceedings, Volume 53, Series 2 "Mechanics and Mechanical Engineering Technologies", ISSN 1311-3321, 2014, 48-53pp.*

Reference in the original language: ***Мария Консулова-Бакалова****, Гр. Василев, „Методика за обработка на сканирани изображения в средата на SolidWorks“, Научни трудове, Том 53, серия 2 „Механика и машиностроителни технологии“, ISSN 1311-3321, 2014г., 48-53стр.*

There are a large variety of methods for non-contact data collection on physical objects. Non-contact devices are laser, optical and photocell array sensors [1]. Usually, some source of light and then a receiver of light is used to gather information. Non-contact methods produce images of cross-sections and point clouds that represent the object's geometry. The results are calculated by triangulation, time to reach it and image processing algorithms.

Regardless of the scanning technique, after the object data is collected, the processing of the polygons forming the enveloping surface or point cloud follows. Information about the object's geometry and such, collected as background noise, must be sifted out during this phase. On occasions, it is necessary to rotate the workpiece and scan the object from a different point in order to achieve a more accurate representation of the surfaces.

Generating CAD models from scanned data is a complex process because it is necessary to harness all the resources of the modeling software to achieve an accurate model of the surface of the physical part. It is necessary to use the information obtained during the scanning of the objects in the most appropriate way. The accuracy of the processing depends on the application area of the scanned models - whether only a surface model or a solid body is needed with all its features and additional engineering information. Here we will describe the stages that are gone through when processing a scanned image using SolidWorks.

A DAVID Structured Light Scanner SLS-2 3D scanner was used to scan the parts used for the examples in this publication. The scanned pattern is obtained as a polygonal grid. Converting the polygon mesh into a surface model is done with the SolidWorks CAD system.

A scan of an object with precise dimensions - a flat-parallel plate with dimensions 40±0.001 - was made beforehand. The resulting scanned model was converted to a surface model using SolidWorks and a control measurement was taken.

The article presents the sequence of actions that are performed in SolidWorks. The presented methodology for processing scanned images using SolidWorks can be used to solve practical problems related to the creation and processing of three-dimensional models.

Summary of report [Г8.24] from the list of publications

Vassilev, G., Petrov, I., ***Konsulova-Bakalova, M.****, "Simulation modeling of an aspiration seed cleaning machine module", Scientific Conference of Ruse University "Angel Kanchev", Scientific Proceedings, Volume 53, Series 2 "Mechanics and Mechanical Engineering Technologies", ISSN 1311-3321, 2014, 54-59pp.*

Reference in the original language: Гриша Василев, Иван Петров, ***Мария Консулова-Бакалова****, „Симулационно моделиране на аспирационен модул на семепочистваща машина“, Научна конференция на Русенски университет „Ангел Кънчев“, Научни трудове, Том 53, серия 2 „Механика и машиностроителни технологии“, ISSN 1311-3321, 2014г., 54-59стр.*

The aspiration modules of the seed cleaning machines work on the aerodynamic principle. The separation of materials by the aerodynamic method is based on the property of materials to resist airflow. Different materials caught in an airflow rise the lower their gravity is or the smaller the aerodynamic force. Aerodynamic separation is achieved by air systems with vertical, horizontal and inclined airflow and the same is configured by fans, air ducts, air chambers and settlers. In the air ducts, only the separation of the outlet mixture takes place and the same is connected to the inlet or outlet of the fan. In the first case, the fan forces airflow, while in the second a suction flow is created. In the settling tanks, light impurities are separated from the airflow. To solve the formulated problem, the paper proposes a multi-step methodology.

The first step is to create a simulation model. It includes the CAD model but in a simplified form. The goal is to reduce computational time but still preserve the fundamental geometric elements involved in the study. Preliminary fluid analysis and selection of a rational design follow. After

completion of the fluid simulation, sections of eddies and turbulence are observed. These regions will be one of the design sites for the rational design.

Based on the results obtained, a rational design is obtained by observing the following requirements: reducing the flow angles of the fractions under study in order to reduce the drag and bounce of the product; extending the working channel and change of the angle for smooth passage of the airflow from the discharge zone in the working channel to the settling chamber.

The final step, the final fluid analysis, is conducted at three airflow control valve configurations. It is noticeable that the eddy zones have disappeared and the flow is laminar. Therefore, the design modification made can be considered to be optimal.

The developed fluid analysis methodology allows to draw some conclusions. By means of the integrated Flow Simulation software in the SolidWorks CAD system, it is possible to perform simulation modeling of the suction module of a seed cleaning machine. It is possible to choose a rational design in terms of laminar flow formation. For specific input values of the fractions involved in the analysis, the optimum position of the valve regulating the airflow can be determined for their proper separation. The application of simulation modeling allows the designer to optimize the design at the design stage, which in turn is a prerequisite for rapid implementation of the product in production.

Summary of report [Г8.25] from the list of publications

Skulev H., T. Mechkarova, M. Bakalova, Simulation modeling of the process of stress and strain in superficial gasplasma nitriding using indirect torch, Mechanical Engineering and Technology, issue 1, ISSN 1312-0859, 2014, pp. 3-7

Reference in the original language: Скулев Хр., Т. Мечкарова, ***М. Бакалова****, Симулационно моделиране на процесите на напрегнато и деформирано състояние при повърхностно газоплазмено азотиране чрез използването на индиректен плазмотрон, сп. Машиностроителна техника и технологии, бр.1, ISSN 1312-0859, 2014, стр. 3-7*

Surface plasma nitriding is utilized for surface treatment of components with the aim of altering their operational properties. Often, it is applied to samples made of titanium and titanium alloys. The resulting surfaces are protected against corrosion, erosive impact of high-temperature gas streams, wear resistance, etc. The article's objective is to determine the final residual strains formed after surface thermochemical treatment using an indirect plasma torch on details made of titanium and titanium alloys. This is directly linked to assessing the risk of crack formation or failure.

High-temperature heating induces the emergence of transient and residual strains within the products. Obtaining precise solutions for determining these strains is related to understanding the influence of factors such as time and surface layer temperatures. These parameters, in a wide range, alter the thermo-physical and physico-mechanical characteristics of the metal. Solving this problem involves simplifying the metal's properties, the heat exchange conditions, the initial and boundary conditions, as well as the geometric shape of the treated components.

The article describes the problem setup – dimensions of the test specimen, properties of the materials used, initial conditions of thermal analysis. To simulate the process of surface plasma nitriding, non-steady-state thermal analyses are conducted with exposure times of 10, 20, and 30 seconds.

For the simulation study, a three-dimensional model of a Ti-6Al-4V sample is created in SolidWorks. The model aims to comprehensively represent the real object while being simplified enough to allow simulation. After conducting the thermal analyses under the conditions described in the article, a static linear analysis is conducted. The results for strains, displacements, and safety factors are presented. Static analysis results for various distances between the torch and the specimen are also introduced in a table. The results graphically demonstrate that strains at points on the model's surface and within the specimen remain below the material's allowable limit of 172.34 MPa.

During the heating process, the highest strains are concentrated in the central zone of the specimen. This is explained by the concentration of heat impact due to the Gaussian distribution of temperatures in the plasma jet. The deformations occuring during gas plasma nitriding do not reach critical values of 10 to 18%, staying within the range of up to 9%.

The results demonstrated in the simulation analysis comletely correspond to the theoretical assumptions regarding the occurrence and distribution of thermal strains in surface plasma nitriding using an indirect plasma torch. Thanks to the simulation, maximum strain values and deformations are established for all points within the object's volume. These results enable assessing the magnitude of residual strains and predicting their impact on the structural working strains.

Summary of report [Г8.26] from the list of publications

Skulev H., T. Mechkarova, M. Bakalova, Study heat transfer in the models of Ti-6Al-4V nitride indirect torch for stratification, Mechanical Engineering and Technology, issue 1, ISSN 1312-0859, 2014, pp. 7-13

Reference in the original language: Скулев Хр., Т. Мечкарова, ***М. Бакалова****, Изследване на топлопренасянето в образци от Ti-6Al-4V азотирани с индиректен плазмотрон за* напластяване, сп. Машиностроителна техника и технологии, бр.1, ISSN 1312-0859, 2014, стр. 7-13

Building upon previous work by the team, the article presents the development of a computer simulation model through the software SolidWorks Simulation for the process of nitriding Ti-6Al-4V samples using an indirect plasma torch. The objective is to determine the optimal operating conditions for surface gas plasma nitriding and to establish their influence on temperature and cooling rate.

A schematic overview of the apparatus for plasma cladding and the general appearance of the plasma torch are provided. Thermal couples are placed on the titanium alloy samples according to a specified scheme, arranged in three rows. The idea is to cover as much of the sample as possible to accurately determine the temperature distribution experimentally.

Through a computer experimentation with a simulation analysis is determined the temperature distribution in the different thermally treated zones. Sensors are placed at the same locations as in the real experiment. Comparison between the experimental data and those obtained from the computer simulation shows a significant resemblance. Further clarity is achieved by graphical presentation of sensor data in a two-dimensional space, highlighting the proximity of the results.

As an additional aspect of the research, a microstructural analysis of the samples is conducted. It is observed that the structure begins as homogeneous and then becomes non-homogeneous. The acquired data is valuable in selecting suitable technological parameters for gas nitriding.

Overall, the summary of all the results indicates that the deviation between the computer model and the reality is within a few percent. This supports the claim that the model is adequate and can be used in subsequent tasks.

Summary of report [Г8.27] from the list of publications

*Naskova P., **Konsulova, M**., Malcheva, B., Plamenov D., "Mathematical model for determining the influence of diferent physico-chemical factors on the number of microflora in the anthropogenic soils", Journal of Science "New Knowledge", Year 6, Issue 4 (2017), ISSN 2367-4598 (Online), ISSN 1314-5703 (Print) - 87-102 pp.*

*Reference in the original language: Павлина Наскова, **Мария Консулова**, Бойка Малчева, Драгомир Пламенов „Математически модел за определяне на степента на влияние на различни физико-химични фактори върху числеността на общата микрофлора в антропогенни почви“, списание за наука „Ново знание“, година 6, бр.4 (2017), ISSN 2367-4598 (Online), ISSN 1314-5703 (Print) – 87-102 стр. DOJA*

The publication presents the results of a study of the general microflora in urbogenic soils in the city of Sofia. The influence of four main factors on the numbers of the total microflora was analyzed: the sampling depth, humidity, temperature of the soil and the lead content. Regression and correlation analysis was conducted in which the statistical significance of the coefficients in the mathematical model was checked in the case of a one-factor model and one with all factors. The behavior of the model with different volumes of data samples was investigated and an optimal variant was selected.

Mathematical models are useful tools because they can simulate the complex interactions between different soil processes, anthropogenic factors and microbial activity. The sensitivity and response of the ecosystem components under consideration to specific changing environmental and climatic conditions can be predicted, but the model can also help identify significant data and knowledge gaps in the field as they actually exist.

In the specific development, the degree of influence of four factors: depth of sampling, humidity and temperature of the soil, as well as the concentration of lead in the soil, on the number of the general microflora was determined. The goal is to create an adequate mathematical model based on experimental data obtained to determine the total number of microflora in the soil, which will be trained and then used for an indirect, albeit approximate, assessment of the studied signs. Correlation and regression analysis was used to create the model.

The samples were taken in June, September and November 2008 from 7 soil sampling points in the city of Sofia. Sampling points are chosen to represent the objective state of the soil as accurately as possible depending on the problem under consideration.

The main task of the development is to find a mathematical model for predicting the number of total microflora in urbogenic soils contaminated with heavy metals based on previously collected empirical data. Through mathematical analysis, it is investigated whether there is a relationship between the factors (sampling depth, soil humidity and temperature, and lead concentration in the soil) and the number of total microflora. It is further assessed whether each of these factors is significant or can be excluded from the model.

After carrying out the experiments with the models, it was established that the quantitative indices of the microbial mass contained in the studied soils: the total amount of microflora, the distribution along the profile and the oculotropic structure of microcorneas are key distinguishing

marks of anthropogenic soils and are criteria for their ecological assessment. The change in the number of microorganisms is reliably related to all the physicochemical parameters of the studied soils. Dependence of the measured quantity – number of microflora on the studied factors – sampling depth, soil temperature, humidity and lead content was established. This conclusion is made based on the calculated correlation coefficients. It was found that the factor of probing depth has the most vital role in the microbiological activity. The created mathematical model was tested and the obtained results based on the mathematical work were compared with the experimental data. The obtained absolute and relative error values prove high reliability.

Summary of report [Г8.28] from the list of publications

***Konsulova, M**., Naskova P., Malcheva, B., Plamenov D., "Combining statistical criteria for determing microflora in the soil", Journal of Science "New Knowledge", Year 6, Issue 4 (2017), ISSN 2367-4598 (Online), ISSN 1314-5703 (Print) - 103-113 pp.*

*Reference in the original language: **Мария Консулова**, Павлина Наскова, Бойка Малчева, Драгомир Пламенов, „Комбиниране на статистически критерии при определяне на числеността на почвената микрофлора“, списание за наука „Ново знание“, година 6, бр.4 (2017), ISSN 2367-4598 (Online), ISSN 1314-5703 (Print) – 103-113стр. DOJA*

The present model shows synthesized criteria for evaluating the informational value of diagnostic features – sampling depth, soil moisture, soil temperature and lead content about the content of total microflora at 0-15cm and 15-40cm depth. Two state classes are formed, the minimum admissible set of controllable signs is determined, which at the same time provides the best separation of states.

The proposed statistical approach for evaluating the separating properties of indirect features is a reasonable basis for obtaining criteria for determining the utility of features in the future recognition of two or more recognizable alternatives. Combining the statistical evaluation criteria are motion procedures close to gradients is a good basis for determining optimal feature sets for future indirect recognition or prediction. Specifically, the obtained results show that the most informative for indirect assessment of the number of soil microflora is the combination of two diagnostic signs: sampling depth and soil temperature. In order to definitively determine the best sets of features to recognize the abundance of the soil microbial population, it is also necessary to combine this statistical approach with a specific recognition procedure: neural networks, discriminant linear and non-linear algorithms under known or unknown distribution laws of the indirect features and others.

Summary of report [Г8.29] from the list of publications

***Konsulova,** M., Naskova, P., Plamenov, D., Malcheva, B., Recognition and probability of migrant microbiological activity by indirect signature, Journal of Soil Science, Agrochemistry and Ecology Issue 51, No 3-4, 2017, ISSN 2534-9864 (Online), ISSN 0861-9425 (Print), 12-20pp. - refereed and indexed (VINITI Reference Journal, CABI, eLibrary.ru, FAO: AGRIS, http://nacid.bg/bg/scientists/#posfrm)*

*Reference in the original language: **Мария Консулова,** Павлина Наскова, Драгомир Пламенов, Бойка Малчева, Разпознаване и прогнозиране на почвена микробиологична активност по косвени признаци, Списание „Почвознание, агрохимия и екология”, Брой 51, No 3-4, 2017, ISSN*

2534-9864 (Online), ISSN 0861-9425 (Print), 12-20стр. – реферирано и индексирано (ВИНИТИ Реферативен журнал , CABI, eLibrary.ru, FAO: AGRIS, http://nacid.bg/bg/scientists/#posfrm)

In this paper, a model for the recognition and prediction of soil microbial activity by indirect attributes is described, and four factors actively influencing microbial biogenicity are discussed. The model was built and trained based on analyses performed in urban soils in June.

Training and recognition procedures were carried out with different numbers of features: four features (depth of sampling, soil moisture, soil temperature, lead content), three features and two features, in the latter cases considering all possible combinations between the features. In analyzing the results presented, two objectives were taken as a starting point: to determine the indirect signs for the recognition of the condition class (amount of microflora) and to select the best ones; to establish the feasibility of predicting the amount of microflora with different combinations of traits over three to six months using a pre-trained algorithm. In this paper, the average recognition probabilities of the two-state classes are shown, which implies that the lowest values of 50% are obtained when recognition is denied and 100% when recognition is complete. The best recognition is given by combinations of two or three features involving feature-depth sampling. Graphical representation of the microbiota forecast data for June, September and November. The results show poor recognition of the amount of microflora for November. There, the correctly recognized data are 50% on three and four features.

A conclusion is drawn based on the results obtained. The involvement of the sampling depth attribute in all combinations presented for recognition is mandatory, and the soil lead content attribute is not informative for specific data. Predicting the amount of microflora for September using an algorithm trained with data from June is possible using the combinations: sampling depth, soil moisture, soil temperature and sampling depth and soil moisture. Forecasting for November is not reliable. This is explained by the changed conditions as a result of the accumulation of new biomass at the end of the growing season, the increased humidity as a result of higher rainfall and the drop in temperatures in November. Microorganisms are extremely sensitive their development is determined by the change of these and other factors. The specific statistical model for recognizing the state of soil microbiocenosis activity by indirect signs boils down to the reduction or elimination at certain periods of costly and time-consuming laboratory analysis procedures. The limits of correctness, reliability and practical applicability of the presented mathematical model are defined.

The data obtained show good validity of the model for September under the specific factors and laboratory results obtained. Due to changes in soil moisture and temperature and the accumulation of additional organic matter at the end of the growing season, the model does not give good results for November.

Summary of report [Г8.30] from the list of publications

***M. Bakalova**, "Application of SolidWorks Plastic in the Training in Mechanical Engineering", ANNUAL JOURNAL OF TECHNICAL UNIVERSITY OF VARNA, BULGARIA, vol. 1, no. 1, pp. 85-96, Dec. 2017. https://doi.org/https://doi.org/10.29114/ajtuv.vol1.iss1.37, ISSN 2603-316X (Online)*

This article presents an example of the application of SolidWorks in mechanical engineering education. The main characteristics in the design of parts intended for production by injection molding are indicated. Their recommended values are given and the way to calculate them is shown. The considerations, which are taken into account to determine its recommended values, are explained For

each parameter (such as wall thickness, rib thickness and wall slope). SolidWorks allows all of these recommendations to be applied when creating the parts. The publication also explains the simulation settings made in SolidWorks Plastics when simulating injection molding. Through a concrete example, it is indicated how to analyze the results obtained.

In the study of mechanical engineering, the study of the production of plastic products is a vital area. Using the dedicated app SolidWorks Plastics is very convenient and gives good possibilities to find defects that still exist in the design stages before an actual manufactured product. The proposed example provides an opportunity to explore more complex patterns and suggests ways to avoid problems in casting system design and setting the process parameters. Each stage of the design process can be considered a separate task and studied in more depth. The method would help teach students, who are familiar with 3D modeling with SolidWorks, new ways to perform simulations. Moreover, the material could be used as a reference in the design and simulation study of products by injection molding.

Summary of report [Г8.31] from the list of publications

Konsulova-Bakalova, M., *"Processing of data from complex objects through pattern recognition methods", ANNUAL JOURNAL OF TECHNICAL UNIVERSITY OF VARNA, BULGARIA, 2(1), 30 - 38. https://doi.org/10.29114/ajtuv.vol2.iss1.69*

In describing complex objects, we need methods that can reflect the complex interrelationships between components and sift out, if possible, the ones that are essential to the particular application. In this publication, pattern recognition methods are proposed to be used as a unified method for processing data from complex objects. The proposed algorithm is capable of recognizing the state of objects of a different nature. The given examples prove the practical applicability of the methodology, as they represent a solution to specific practical tasks.

A comprehensive algorithm has been developed to analyze and process the data from complex objects. The first stage of evaluating the ability to separate each of the multiple recognition features is useful in a laboratory setting, during the selection of a set of information channels. With multivariate analysis, training and recognition procedures have been proposed. It is also possible to obtain an estimate of the recognition quality according to the posterior error of the recognition. These results would be sufficiently indicative and can come in handy for both narrow specialists and a wider range of users.

An analysis was performed in the area of principal components. The presentation of the data in the coordinate system of the principal components gives a clear idea of the distance of the classes and a good completion of the general algorithm for the presentation and recognition of data from multi-channel gas analyzers. The procedures are efficient and can be used to process data from complex objects with different fields of application. One of the possible areas of application is the precise diagnostics of machines and equipment.

Summary of report [Г8.32] from the list of publications

Stoyan Slavov, ***Mariya Konsulova-Bakalova****, An algorithm for topology optimization of gear reducer housing elements, August 2019, MATEC Web of Conferences 287(1):01020, DOI: 10.1051/matecconf/201928701020*

In recent years, topology optimization methods have been increasingly used in many engineering fields and have already been successfully integrated into the design stage of various types

of products. An active area of research in this field is the definition of appropriate constraints in topology optimization models to facilitate the production of the optimized objects. In the present work, an algorithm for topological optimization (TO) of housing elements of gear reducers is presented by using the capabilities of CAD-CAE software for topological optimization. There are various software products, thanks to which maintenance can be carried out. In this case, SolidWorks is selected. All the data that is required to be entered in order to perform the MOT is discussed. They are mainly related to production constraints and functional requirements for the object of optimization. At this stage, special attention is paid to the fact that often as a result of TO, three-dimensional models with a specific shape are obtained, which can hardly be produced by convection means. Another feature characteristic of the housing details is the obtaining of an "open" model, which in the case of, for example, a gearbox housing would hardly hold lubricating fluid.

Based on all these features resulting from the specifics of TO, the article describes an eight-step algorithm for obtaining a fully functional model. The proposed algorithm takes into account the loads that occur during the operation of the reducer and the geometrical and manufacturing constraints of the manufacturing process of these housing elements. The steps are formed in relation to the specific task - optimization of the housing of a selected reducer, but in essence, they can be applied with small changes to other types of details.

The first step is to calculate the gear loads in different stages of the reduction gear to determine the reactions in the rolling bearings. For this purpose, basic design and functional characteristics of the reducer are used, such as transmission ratio, angle of inclination of the teeth, transmitted power, input speed, the largest distance between the axes of the shafts, etc. In principle, the calculations can be done manually using known methods or by specialized software products such as MitCalc. Step two is modeling and creating the 3D model of the hull which is done through SolidWorks. The following two steps prepare the model for maintenance. In step three, the material is set, the loads are entered in the bearing locations and the final conditions are defined for conducting a preliminary strength and vibration analysis. Next, the preliminary analyzes themselves are carried out, which are carried out after appropriate discretization of the model using the finite element method. If the results for the obtained stresses and strains are satisfactory, one can proceed to the next steps – setting up the input data for TO and starting the optimization itself. The paper explains in detail the considerations involved in introducing the optimization constraints and objectives. Sometimes the last two steps are repeated many times until the best possible optimized shape of the model is obtained. At that stage, it is possible to end the optimization process, but usually, the result needs further processing. This is what step seven is for. After it, it is advisable to repeat the strength analysis to evaluate the final shape of the hull.

In addition, an analysis is made in the article to study the impact of some TO-process parameters on the resulting optimized 3D model. For this purpose, one of Taguchi's methods for planning the experiment is used. It was found that the mesh size parameters and the part extrusion settings for cast parts have the greatest influence on the weight value of the optimized model. By reducing the size of the elements, the weight is reduced and, on the other hand, the maintenance time is significantly increased.

Based on the obtained results, it can be concluded that the proposed algorithm gives satisfactory results in optimizing the weight of the housing elements of the reducer of the studied type and configuration. By using the right combinations of TO parameters and manufacturing controls, a weight reduction of between 25 to 30% can be achieved, as well as simplifying the post-processing of optimized 3D models to their final design.

Summary of report [Г8.33] from the list of publications

*M. Stoyanova, **M. Konsulova-Bakalova**, Determining the surface quality obtained after thermal cutting, Conference: 6TH INTERNATIONAL BAPT CONFERENCE POWER TRANSMISSIONS'19 at: VARNA, BULGARIA, 2019, Machines. Technologies. Materials. Vol. 13 (2019), Issue 5, ISSN web 1314-507X, ISSN Print 1313-0226, pg(s) 234-237, https://stumejournals.com/journals/mtm/2019/5/234*

Surface roughness on components significantly affects their functional purpose. Research has been conducted to determine the impact of air plasma cutting on various materials on the shape and dimensions of roughness. The goal is to understand the effect on the operational properties of components and establish optimal criteria for evaluating surface roughness.

The main objective of this study is to determine the quality of the surface obtained after the thermal cutting of steel 41Cr4 (BDS EN10083-3); 40X (GOST 4543-71). The study also assesses the feasibility of direct arc welding of the cut edges without removing the metal layer first.

The accuracy of the real planar surface shape is characterized most comprehensively by the complex indicator of flatness deviation, and the accuracy of the surface profile shape is assessed by the indicator of straightness deviation.

The accuracy of the thermally cut specimens and the quality of their surfaces are determined after removing the slag and spatters resulting from air plasma cutting. Experimental measurements are conducted on a reference plate with an attached MITUTOYO electronic dial gauge to record deviations in shape and position. Measurements are taken on thermally cut samples, with 10 points measured at equal distances. Based on the measured profile deviations, graphical representations of the surface are constructed for both samples. Deviations in flatness, straightness, and parallelism of the surface for different experimental samples are observed from the graphical dependencies.

Reported values indicate that the largest profile deviation occurs in sample 1, as the end of the sample tends to be distorted due to molten metal flow after plasma cutting. The resulting profile has a conical shape. The reported cross-section shows a protruding form of the surface due to slight tapering of the sample edges caused by high temperature.

The article describes the measurement of roughness on specimens after plasma cutting. The relief roughness varies according to the depth of the cut into the base metal. It is minimal at the upper part of the cut walls and becomes maximal at the lower part. The change in roughness is also illustrated through macro-structural analysis.

From the roughness analysis, it's observed that the roughness isn't high in the case of plasma cutting on steel 41Cr4.

Further research should focus on optimizing cutting parameters to reduce surface roughness and streamline final surface treatment processes.

Summary of report [Г8.34] from the list of publications

***Mariya Konsulova-Bakalova**, Tatyana Mechkarova, A study of strength properties of welded copper plates and determining the crusher zone, 6TH INTERNATIONAL BAPT CONFERENCE POWER TRANSMISSIONS'19 at: VARNA, BULGARIA, Proceedings, VOLUME 3, ISBN 978-619-7383-12-6, p. 423-426*

This study aims to determine the strength properties of the material after welding thin copper plates in a shielded environment using an inert gas (argon) and a non-melting tungsten electrode by determining the crusher zone. The research is conducted on plates of industrial copper and brass, with

welding taking place under laboratory conditions. The welding process and techniques used are described in the publication.

A simulation model of the study object is created, utilizing CAD models of both the plates themselves and the resulting weld. To assess strains and deformations, thermal distribution in the model needs to be obtained. A preliminary thermal analysis is conducted in SolidWorks Simulation for this purpose. The welding process is non-stationary and occurs over a defined period, involving gradual electrode movement along the weld details until the weld bead is formed. Several consecutive thermal analyses, each using the results from the previous one, are employed due to this progressive welding. The cooling process is also simulated. The obtained results serve as input for a static linear analysis to determine strains, displacements, and deformations in the model. Simulation sensors measuring the computed values at specific points in the model are used to record the results. It is found that deformations do not exceed 10 to 18%, which falls within acceptable limits.

In addition to the simulation, a real experiment is conducted, with the conditions described in the publication. Based on the comparison of theoretical and experimental studies on welding thin copper plates, it can be concluded that simulation studies using the mathematical model adequately recreate strains and deformation distribution processes. Defects in the weld joint are observed when using a higher current (I=85A). Optimal conditions and the highest strength for specific samples are observed at a current of I=60A.

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