Summary of the main results and scientific contributions of Assoc. Prof. PhD Eng. Juliana Javorova

submitted for participation in a competition for “Professor” in the scientific specialty 5.1. Mechanical Engineering (Applied mechanics (incl. tribology) with teaching in German)

The scientific works include 54 publications, of which: 20 printed and 1 in-print publications in referenced and indexed in worldwide databases of scientific information and 33 in peer-reviewed journals or edited collective volumes.
In general, the publications can be conditionally divided according to the topic of the investigated problems in the following main areas: - Hydrodynamic lubrication of journal bearings; - Biotribology; - Friction and wear in various tribological systems; - Study of mechanical and tribological characteristics of materials in industry; - Technical mechanic; - Studies of other current engineering problems.

I. HYDRODYNAMIC LUBRICATION OF JOURNAL BEARINGS
(A3, A5, A6, A8, A9, A11, A12, C1, C2, C3, C6, C9, C14, C15, C18, C20, C21, C24)

Research in this direction (representing a significant part of the author’s publications) can be considered as a development of the main problem of the elastohydrodynamic (EHD) theory of lubrication, studying the process of hydrodynamic (HD) lubrication in the conditions of elastic contact.

The object of research is the steady-state or nonstationary movement of an isoviscous/viscous lubricant, considered as a Newtonian/non-Newtonian fluid under isothermal conditions/adiabatic thermodynamic (TD) regime in the radial sliding HD bearing system with finite dimensions under the assumption of deformability of the applied on the neck or sleeve of bearing a thin elastic coating.

The main goal is a qualitative and quantitative study of the influence of factors neglected in the classic HD theory of lubrication (such as: inertial forces of the flow of the lubricating fluid in the bearing clearance; turbulent effects; surface roughnesses; non-Newtonian behavior of the lubricant) above all on the values off HD pressure distribution in the fluid film of the bearing, as well as on the values of the main operating characteristics of the bearing.

To achieve the goals of the research, a precise mathematical model is created, assuming the development and simultaneously solution of the following basic equations: HD equations - generalized Reynolds equation for the HD pressure distribution of in the fluid film ; equation for the geometry of this filmr; structural equations defining the rheological model of the oil; equations of the theory of elasticity to determine the contact deformations of the antifriction elastic coating. Depending on the specific formulation of the task, in the various studies, models are developed and/or solved, including a different number of equations from those listed above.

As working hypotheses, the generally accepted in classical HD theory of lubricants are used, based on which, from the general Navier-Stokes equations for the viscous fluid flow, the generalized Reynolds equation for HD pressure distribution in the fluid film is obtained, taking into account the specifics of the problem.

The obtained partial differential equations are solved numerically with the FDM established in this field and application of an iterative procedure. Due to the lack of suitable and available ready-made software given the specifics of the models, a separate program code developed in Fortran was created for each of them.

The theoretical research is carried out using known methods of hydrodynamics, the theory of elasticity and plasticity, solid body mechanics and the theory of stability.

Solutions and numerical experiments are implemented with methods and procedures based on numerical analysis and programming theory.

In view of the practical applicability of the presented solutions, in some of the studies, the values of basic bearing characteristics were also calculated, such as: coefficient of bearing capacity of the oil layer - Sommerfeld number, position of the center line (angle of deviation), necessary flow rate for normal functioning of bearing and resultant frictional force (coefficient of rolling resistance; coefficient of friction).

The most important creative moments and results in this direction include the creation of:

- derivation of the modified Reynolds equation for a finite-length bearing for the case of a pseudoplastic or dilatant fluid described by the cubic model of a non-Newtonian lubricant;
- creation of a mathematical model of an EHD bearing, lubricated with a non-Newtonian fluid, described by the Rabinovich model;
- creation of a mathematical model of a journal bearing with finite dimensions taking into account the inertia and turbulence effects of fluid film in the conditions of elastic contact;
- in the problem of determining the stability limit of the system, the following were simultaneously solved: - a generalized Reynolds equation for the distribution of HD pressure in the fluid film; - equations of the theory of elasticity to determine the contact deformations of the anti-friction coating; - differential equations of motion of a rigid balanced rotor at small displacements of the shaft center from the position of stable equilibrium.

In relation with the development of a dissertation under the guidance of the candidate, an experimental test rig of a journal bearing with replaceable bushings with different mechanical characteristics of the material was created in order to take into account the effect of the deformability of the coating (the elastic part of the task).

Review papers are also presented.

There is a defended dissertation on the subject of this direction.

II. BIOTRIBOLOGY (A4, C27)

The publications in this direction are related to the implementation of project activities under the CEEPUS program: CIII–BG–0703-11-2223

The (A4) paper proposes a new model for lubrication of the hip joint with hyaluronan solutions, considering the squeeze film process of non-Newtonian fluid between rigid spherical surfaces. The rheological model that approximately describes the behavior of the synovial fluid is the power law model. For the considered case, the pressure distribution, the load capacity, the film thickness and the friction coefficient have been determinated. The conclusions of the paper offer an explication to the development of the osteoarthritis and to the problems of the arthritic patients.

Keywords: Biotribology, Hip joint, Squeeze film, Non-Newtonian fluid

Main results: (A4):

- The proposed model for the lubrication of the hip joint approximate well enough the real behavior of the joint for healthy or arthritic patients, even both surfaces of the spherical bearing are rigid and not elastic and porous.
- It has been theoretically demonstrated that the behavior of the synovial fluid as a non-Newtonian fluid conduce to lower values of the friction coefficient and film thickness, comparative to the Newtonian fluid.
- The pressure distribution for the non-Newtonian fluid is more flattened and without prominent peaks like in the case of the Newtonian fluid. This conclusion offer an explication to the development of the osteoarthritis to the arthritic patients.

The paper (C27). briefly presents the essence of three-dimensional bioprinting of human tissues. Information is given about the steps of the basic process, the methods and materials used for this relatively new technology. Some successful applications of 3D bioprinting are represented and expectations for its future development are outlined. The need to integrate the seemingly diametrically

opposed medicine and engineering disciplines such as mechanical engineering and materials science to support this cutting-edge technology is emphasized.

Main results:: (C27)

- The importance of bioprinting as an impetus for new industrial convergence of medical professionals and engineers from different fields is shown.

I I I. FRICTION AND WEAR IN DIFFERENT TRIBOLOGICAL SYSTEMS

(A1, A2, A7, A10, C4, C7, C8, C10, C13, C16, C17, C30)

The publications in this field are related to activities on the following CEEPUS projects:
C III–BG–0703-11-2223, C III–RS–0304-01-0809, C III–RS–0507-01-1112

1) Wear of composite and nanocomposite coatings - (A1, A7, A.10, C16, A.2)

The group of articles (A1, A7, A10) presents tribological studies of metallic materials (brass and bronze) in comparison with different polymer composites, which are recommended for the repair or restoration of worn or damaged parts of the two metals respectively. Composite materials are polymer composites reinforced with metal particles and are often used in technical applications. The two groups of comparison materials (composites and metals) were tribologically tested under dry reciprocating friction conditions, in a sphere-on-plane configuration, using a CETR-UMT-2 tribotester (Bruker Co.). The tests are carried out under normal load in various variants up to 50N, at a distance of 100 m at an average sliding speed of 3.5 mm/s. The wear tracks are analyzed with a laser profilometer and the CETR-UMT-2 tribotester profilometric module.

The results of the analysis of the composite materials are compared with those obtained in similar tests for brass and bronze, respectively.

Main results::

- The depth, width and cross-sectional area of the wear tracks are significantly smaller for the composite material (a polymer matrix reinforced with Cu, Zn, Sn particles as well as various allotropic forms of SiO) than for brass, especially for the depth of the track, (A1).
- Adhesive wear is predominant in the case of composite materials and the main wear mechanism of brass and bronze is abrasive, (A1, A7, A10);
- The composite material has better tribological behavior (less wear) than brass under test conditions with reciprocating motion of dry friction sphere on a plane, (A1).
- for loading forces up to 40N, the polymer composite material behaves better than bronze, presenting lower values for depth, width and area of wear tracks; - for higher than 50N loading forcec, bronze has a better wear behavior than the polymer composite material (A7).
- The composite material Multimetal Messing has the lowest values for wear parameters such as: coefficient of friction, depth of linear wear and volumetric wear parameters (cross-sectional area, volumetric wear, volumetric wear intensity and specific wear rate) (A10);
- Moglice composite has good tribological characteristics and can be successfully used to restore brass and bronze parts (A10);
- Adhesive wear is the dominant wear process for all three composite materials - Multimetall Messing (used for repairing brass parts), Multimetall Bronze (used for repairing bronze parts), Moglice (for brass and bronze parts), (A10).
- A database was created of the variations of the coefficient of friction, linear wear, volumetric wear parameters, profilometric studies with SEM surface morphologies of the wear marks of the three composite materials studied. This allows their classification according to their tribological behavior. (A10).
- The experimental results strongly recommend the tested reinforced composite materials as good candidates for the repair of brass or bronze metal parts (A10).

An increasing of the wear resistance of injection molds leads to improvement in the living resources and reduction of the production cost. One of used steels for producing of components for injection molds is 1.2343 steel. In (C16) are presented results for wear resistance investigation of deposited Ti/TiN/TiCN/nc-TiCN:a-C/ncTiC:a-C/a-C nanocomposite coating on 1.2343 steel. The influence of the load on the wear intensity of the coating is investigated. The coating is applied on unhardened grinded specimens, hardened grinded specimens and hardened polished specimens.

Main results: (C16)

- Quality of the surfaces which are coated with (Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) coating is reflected on the coating wear. Coating on hardened polished surface gave minimal wear volume and maximal wear volume – coating on unhardened grinded surface. The wear intensity of (Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) coating applied on hardened polished surface is average 7 times less than that applied on hardened grinded surface and average 16 times less than that applied on unhardened grinded surface.
- It is recommended the most important elements and elements with intense wear of the injection molds to be hardened and polished then covered with (Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) coating.
- Roughness of the friction surfaces has an impact on the friction coefficient and wear intensity. In (Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) coating deposition process by magnetron sputtering method (UBMS) roughness of the coating is no different from that of the prepared surface before covering because in this process drops do not occur during coating deposition;
- The wear intensity of (Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C) coating applied on unhardened grinded surface is average 9.5 times less than uncoated surface; applied on hardened grinded surface is average 22 times less than uncoated surface; applied on hardened polished surface is average 210 times less than uncoated surface.

The object of study in (A2) is the working bodies of drilling machines in the mining industry, which are subjected to heavy wear during operation. The mechanisms and rate of wear depend on many factors - dynamic load with or without impact, abrasive properties - solid or lose, aggressive working ambience, etc. This work is dedicated to the study and research of the opportunities for improving the resource of the working body of machines and tools through applying wear-resistant composite coatings by on super advanced technologies - high velocity oxy-fuel coating spraying (HVOF). The obtained HVOF-coatings of super-alloys are very important and irreplaceable when applied for operation under conditions of high abrasion, erosion and cavitations. The paper aims a comparative study of abrasive wear and wear-resistance of HVOF-coatings deposited using four numbers powder compositions with matrices of Fe, Ni, W and Al_2O_3+TiO_2.

Main results:: (A2)

- It may be safely said that under conditions of abrasive wear the HVOF-coatings obtained by powder compositions with tungsten matrix show the highest wear-resistance A2

2) Tribological research on gear cutting tools - (C4, C7, C8, C10, C30)

Included here is a group of publications dealing with some tribological aspects of gear cutting tools, mainly for gear machining.

The hob milling process is one of the most important elements in the chain of gear mechanical machining, since productivity, final accuracy and quality of the gear depend heavily upon it. (C8). The same applies to operations of splining, production of chain, screw threads and etc. respect to point with low production flow durig production. C4). Research and development of optimal contstruction of cutting tools are permanently present as well as the optimal conditions of the process of hob millig wich is the most used one during the production of afore mentioned profiles.(C4).

Modern approaches of automated design and construction of cutting tools require a wide range of

knowledge by the designer (C7) - on geometry of cutting tools, materials used for its production, workability of workpiece material, kinematics and geometry of the machine at which cutting tool will be used, on a programming system for automation of designing and constructing , etc.

Applying anti-wear coatings increases the tribological resource of the tools. In this connection, in (C8) the complex process of cutting cylindrical gears by hob milling is analyzed. Subsequently, simultaneous investigation was carried out on gear cutting tools without and with anti-wear coating in production conditions.In (C10) the correlation between the parameters in the hob milling process and chipping occurrence on the tool is presented.

The hob miller wear is one of the utterly negative occurrences in gear serration. A distinction should be made between tools wear and the processes of wear (in princip) The reasons for the hob milling tools wear (i.e. the loss of the tools' cutting attributes) can be divided into four basic groups:

• tools wear along the cutting elements;
• chipping of the cutting edge of the cutting tool;
• breaking of the cutting tools elements;
• plastic deformation of cutting tools elements;

On the basis of the analyses presented, directions and suggestions for obviating the occurrence of chipping in hob millers have been reached. The occurrence of cutting edge chipping is present in a considerable degree and has a very unfavorable effect on the overall expenses of gear serration in hob milling.

The quality of the machining of gear serration is one of the conditions for achieving the required quality of the work-piece. In that relation in (C30) the methodology for the identification of topography of tool teeth and gear serration produced by uncoated and coated model and real hob milling tool is presented.

Research of the topography of the characteristic surfaces of the model hob milling tools has been performed on Talysurf-Taylor Hobson and Mytutoyo SJ30 devices for testing the roughness parameters. The methods of model research and regression analysis were used. High degrees of correlation were achieved for the roughness parameters.

Main results::

- It has been shown that a significant reduction in costs is possible by applying milling tools with a coating on the cutting elements as a result of reducing material wear (C8).
- The occurrence of chipping is more frequent in experiments in which cutting was uni-direction (C10). With the increase of the unit effective feed the occurrence of chipping is present in a smaller degree.
- The occurrence of chipping in the cutting regime and conditions used in the experiments did not depend upon the hob miller material and the machine on which it was machined (C10).
- The methodology for identifying the topography (2D analysis) of the tool teeth and gear serration is presented (C30). A methodology based on 3D topography analysis is under development.

3) Determination of the friction moment in bearing seals – (C17)

An identification problem for determining the moment of friction in a bearing seal is solved using the methods of calculus of variations. The frictional torque is defined as a function of the angular velocity.

4) Ensuring successful dissemination of knowledge and competences– (C13)

Looking at tribology from the modern point of view we could say that it is scientific concept with embraces processes at surfaces and interfaces, as friction, wear, lubrication, tightness in the contact zone (called also contact body or third body), generally revealing the interaction in contact. There are recently basic reasons for the growing importance of tribology: - the control of friction and wear leads to economical, ecological advance and sustainable development in industry; - it is very large energy saving factor; - and as one of the most important practical issue – it helps to

improve the reliability and quality, becoming thus a recognized topic acknowledged during the last thirty years as an important educational, scientific and technological conception.

In (C13) are presented the main educational and scientific aspects of the first CEEPUS project in the field of reliability, quality and tribology. Here are described the specific spheres of competence and contribution elements of all partner institutions as well as the planned activities to ensure successful dissemination of knowledge and competencies.

Main results:: (C13)

- Detailed information on the conceptual aspects of the first and so far only CEEPUS project in the field of reliability, quality and tribology is presented. Currently, the project consists of 26 partner institutions (universities) from 12 Central European countries and already has 11 years of successful activity.

IV. RESEARCH ON MECHANICAL AND TRIBOLOGICAL CHARACTERISTICS OF VARIOUS MATERIALS IN INDUSTRY

(B2, B3, B5, C5, C19, C22, C25, C26, C28, C33)

Most of the publications in this direction are related to the CEEPUS project: CIII–BG–0703-11-2223.

1) Mechanical behavior of structural polymers – (B2, B3)

Here, the mechanical behavior of rubber, rubber compounds and their vulcanizates is considered.

Industrial production comply not only with the properties of mixtures and vulcanizates, but very often and almost always with the cost of rubber products (B2). Therefore in modern recipes are added as primary reinforcing ingredients as well as those derived from worn tires and technical products. At the same time, there is a tendency to add to different kind of polymer composites a small quantities of ingredients very costly, but impart unique properties, such as various nanofillers, for example nanodiamonds. The presence of multiple functional groups on their surface leads to improve dispersion of the filler and improvement of strength deformation indicators. In (B2) , the influence of small amounts of nanodiamonds introduced into rubber mixtures and their vulcanizates intended for rubber products was investigated.

Main results::

- It was found that the addition of small amounts of nanodiamonds in elastomeric mixtures containing dehydrogenated hydrocarbons leads to an improvement in the elastohysteresis properties of the vulcanizates (B2).

In (B3), singular kernels are used to describe the experimental data on the creep and stress relaxation of viscoelastic solids over a large time interval. For that purpose, the loss factor (the ratio of the dissipated and the stored energy) under cyclic tire (rubber) loading as a function of stress and frequency is considered. In the constitutive law, the large deformations are introduced through the Ogden equation. Experimental results for butadiene nitrile rubber illustrate the applicability of the proposed approach.

Main results::

Experimental results for butadiene nitrile rubber illustrate the applicability of the proposed analytical approach to describe the tire (rubber) loss factor as a function of stress and frequency (B3).

2) Theoretical and experimental investigation of oils with/without additives – (C19, C22, C25)

A dissertation on the topic was defended by Assistant Prof. Eng. A. Majdrakova.

The usage of various modern devices and of many types of oils in different industry applications became a challenge for researches to find appropriate methodology for a better description and evaluation of oils rheological behavior. The paper (C19) presents the experimental design done for

measuring the rheological parameters for a transmission oil, by using 4 cones with different geometries on a Brookfield viscometer series CAP 2000+. The analyzed varying parameters are: soak time, number of points acquired during the measurements, maintenance duration at a speed level and influence of the temperature on the measurements. The results of the tests and experiments materialize the rheological models for these cases and the dependency of viscosity by the temperature by using modern technology, in lubricant research domain research. The regression analysis method was used for data processing.

Results and contributions: (C19)

- A methodology was created to design an experiment to measure the rheological parameters for transmission oil, by using 4 cones with different geometries of a Brookfield viscometer;
- In order to perform significant rheological measurements, it is important to know the properties of tested lubricant, to understand the capabilities of the rheometer, to know the rheometer limitations and to correctly design the experiment.
- In the case of 75W90 transmission oil, on a Brookfield CAP 2000+ viscometer, the using of cone number 3 offers the best results, from the point of view of precision and confidence level.

A short description of the types of oils used in industry and transport, as well as their classifications is given in (C22). Some chemical structures of base oil components are shown. Types of additives for oils according to their functions are presented, with particular emphasis on the viscosity-index (VI) improvers.It is also described some basic aspects of studying the influence of this kind of additives on the oils behavior by means of experimental and analytical techniques and instrumentation. The aim of the paper is a brief summary of the theoretical basis for liquid oils and additives (with extensive literature reference) with subsequent determination of their rheological characteristics in experimental conditions (in another paper). The results of this complex study will be used as parameters for a computer simulation of a developed mathematical model for the lubrication of a hydrodynamic radial journal bearing.

Results and contributions: (C22)

- The provided detailed literary reference makes this study a good basis for further theoretical and experimental studies of oils with VI additives.

Viscosity index improvers reduce the lubricant's tendency to change viscosity with changing temperature. Various kinds of lubricating oils blended with this type of additives exhibit typical non-Newtonian properties. In (C25) it was studied experimentally the effect of these additives on the rheological characteristics of mineral oils. The tested oil is AN46 /viscosity grade ISO VG 46/ type with the additive Polybuten 30 (PIB30). At the experiment a rotational viscometer type cone-plate for measurements at a medium to high shear rate is used.

Main results:: (C25)

- The studied samples of mineral oil with different concentration of the polymeric thickening additive have a typical behavior of pseudoplastic fluid - with an increase of the shear rate a decrease in viscosity and an increase in shear stress are observed.
- The effect of increasing the concentration of the additive is expressed by an increase in shear stress and viscosity.
- The tested lubricants have typical thixotropic properties.

3) Summary of some tribological applications of graphene – (C26)

The work aims at presenting the relatively new material graphene, which is of great interest due to the favorable combination of remarkable mechanical, thermal, chemical and electrical properties, as well as its expected wide application in the near future. Brief information on the history of its discovery, its structure and properties, some major applications to date, and expectations for future research are

provided. Particular emphasis is also placed on the outstanding tribological characteristics of graphene, which increase its attractiveness for application in micro and nano devices and systems.

4) Study of mechanical properties of steels and alloys at phase transition (C5, B5, C28, C33)

The publications in this group describe some of the researches to obtain and characterise dual-phase alloys and steels, respectively. For research on steels are presented the results of the dilatometric analyses performed on specimens made from three of the alloys used in the research. As a result of these researches, the temperatures of the critical points in solid-state phase transformation were identified and the influence of the initial structures and of the grain size index on these temperatures was established. For the dual-phase steels with low manganese content, by tensile testing, the ultimate tensile strength and the total elongation are established.

V. TECHNICAL MECHANICS (B1, B4, C12, C23, C32)

1) Kinematics and dynamics of the flight of sports balls – (B4, C23)

The 3D flight of a golf ball at taking into account the Magnus effect is studied in the paper (C23). For this purpose it is composed a system of six nonlinear differential equations. To determine the spatial orientation of the ball the rotations around all three axes are given by the so-called Cardan's angles instead of classical Euler's ones. The high nonlinear system differential equations are solved numerically by a special program created in the MatLab environment. It is founded the laws of motion, velocities and accelerations on all six coordinates, as well as the projections of trajectory on the three coordinate planes. The presented analytical base and results in the paper can be used in the field of fluid overflow of bodies. They are also useful for active golfers.

In paper (B4) the trajectories of a soccer ball for the most important kicks in the football game - a corner kick and a direct free kick are studied. The soccer ball is modelled as an ideal rigid hollow spherical body with six degrees of freedom, which performs a general motion in an immovable air environment with constant parameters. The ball 3D orientation is determined by the three Cardan angles. The aerodynamic forces and moments with which the air environment acts to the ball are taken into account. Two of the most dangerous areas of the football goal are defined. Differential equations which describe the motion of the soccer ball are solved numerically by MatLab-Simulink.

Main results: (C23 , (B4)

- A mathematical model of the flight of sports balls (for golf and soccer) was created, including the equations of kinematics, dynamics and fluid mechanics .
- The differential equations of highly nonlinear systems are solved numerically by original programs created in the Mat Lab-Simulink environment.
- All possible kinematic characteristics of the soccer ball flight, as lows of motion, linear and angular velocities, linear and angular accelerations and trajectories are obtained.
- The effects of several initial parameters, as velocities and angles, on the ball flight in the golf and soccer are studied.
- Based on the analysis of the results, the recommended values of initial parameters for successful corner and free kicks are found.

2) Damping Characteristics of Polymer-Concrete Outrigger – (B1)

The work (B1) aims to further develop an already created new technology for polymer concrete (PC) structure, which are intended for use as construction materials, for example body parts of metalworking machines. A mechanism was found here (a model was built) for comparing such materials

with different PC structures in order to achieve good damping characteristics. The experiments are done on vertical cantilever prismatic beams with dimensions in mm 30x30x350. At the initial moment of time, the end of the beam is impacted by a special hammer. Special equipment measures the vibration of the end point after impact. The transverse vibration of a PC outrigger is investigated as a continuous medium under the action of an initial impulse load at the end of the beam and an inelastic resistance. Analytical solutions for a continuous impulse of force are derived and numerical results are presented. The established model allows identification of the modulus of elasticity of the cantilever beam material.

Main results: (B1):

- A non-homogeneous differential equation for transverse oscillations of console beam is derived.
- A theoretical solution for the transverse oscillations of a cantilever beam under transverse impact load is found.
- The velocity and displacement at the beam endpoint from experimentally measured acceleration are obtained.
- The established model allows identification of the elasticity module of the beam material
- It is created a mechanism for comparing the damping characteristics (coefficient of relative damping, logarithmic decrement of damping) of PC structures, which are used as construction materials

3) Solution of specific problems in the field of Theoretical mechanics – (C12, C32)

The solution of two specific problems from theoretical mechanics (from statics and kinematics) using modern software products is shown here in detail.

It is known that the automation of engineering solutions requires handling the apparatus of matrix calculus. (C12) presents the algorithm for solving a planar, statically determinated joint-rod structure (truss) in matrix form, and subsequently the numerical solution of a truss with specific dimensions and load is shown. The method used differs from the classical ones, but its application simultaneously with accessible software applications provides an opportunity to automate the calculation process.

In (C32) a solution to the problem of determining the kinematic characteristics of the complex motion of a point using MathCAD is presented.

The current problem considers the complex motion of a point M on the surface of a circular disk such as the latter performs a plane motion. The disc rolls without sliding on a horizontal straight line. The problem is solved graphically for a given time interval. The part of the trajectory of the point M is shown. The values of the transfer, relative and absolute velocities are graphically shown. The same is done for the transfer, relative, Coriolis and absolute accelerations, as well as for their components. The above mentioned kinematic characteristics are determined for the same time interval. The problem is solved using the MathCAD application. In this way the complexity of the graphical solution by hand is overcome. The conventional solution of the problem, solved in the current paper, is related to some difficulties. These difficulties are easily overcome by using of the modern mathematical packages in dependences of the aim of the study. In the considered case, the program MathCAD package can be used to check the problem solved by the traditional way. The automated solution and the graphical editor of MathCAD provide control and optimization on the obtained results. Some adjustments in the initial data are possible in order to achieve certain values of specific kinematic quantities.

Main results::

- The contemporary teaching of all fields of mechanics at the universities is related to using the most advanced mathematical packages such as MatLab, MathCAD, Mathematica, Mathematica, etc

VI. STUDIES OF OTHER CURRENT ENGINEERING PROBLEMS

1) Topologies, modeling and simulation of elements of systems for renewable energy sources and electric vehicles - (B6, B7, B9, C29, C31)

Publications on this topic are related to activities under the project "KP-06-H27-8/2018: Methodology for Design and Analysis of Cyber-Physical Production Systems", NSF, 2018-22.

The use of renewable energy sources (RES) for electricity generation is one of the recent trends at the solving the problems of global warming and shortage of energy sources. These include photovoltaic systems, wind turbines, water turbines, energy storage devices, etc. All of them are environmentally friendly and do not emit carbon emissions. This group of publications presents new or modified topologies of high-tech energy converters as elements of RES systems (solar photovoltaics) and electric vehicle chargers, respectively. The computer simulation is performed on the model developed in the SIMETRIX software environment.

2) Professional realization of students who graduated from HTMU – - (C11)

Publications on this topic are related to activities under the project "ESTIA-EARTH: To Sustain the Women's Careers as Academics, Researchers and Professionals in Engineering, Computers and Sciences", 142418-LLP-1-2008-1-GR-ERASMUS-ENW, 2008-2011".

It was studied (C11) the realization of Bachelors graduated in Chemical Engineering at UCTM, Sofia. Additionally, an anylisis of gender depending criteria and indexes was made, applying the tools of the system for quality monitoring. Generally a well pronounced tendency for a successful professional start was detected. Female graduates usually took a lower position compared to their educational degree (15 % more often than men). It shows that there still is some traditional attitude of employers towards young female engineering graduates.

3) Application of statistical methods in engineering practice – (B8)

Publication on this topic ис related to activities under the project "KP-06-H27-8/2018", NSF, 2018-22.

The study (B8) focuses on statistical procedures for assessing the consistency between laboratory measurements of several parameters performed by different methods in different laboratories. The aim is to show that statistics is a powerful tool for analyzing measurement data and has a significant role in engineering practice. The subject of analyses is real data from the mining industry. These include measurements of the concentrations of flotation process products (content of copper in the ore, intermediate products, concentrate and waste) as well as the production of molybdenum (feed, concentrate and waste). In the paper, the statistical analysis data of parallel measurements of the above-mentioned parameters from three independent laboratories involves calculating a linear and rank correlation and analyzing how significant the influence of a laboratory factor is. Moreover, the study includes also one- and two-way analyses of variance of the same data from the same laboratories.