Annotations of the scientific works

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- **PhD dissertation**

Rupetsov, V. (2015). Increasing the wear resistance of parts and tools for production equipment in food industry, Author's abstract of the dissertation for the award of educational and scientific degree "doctor" in 5. Engineering sciences, professional field 5.1 Mechanical Engineering, Plovdiv, 2015.

The aim of following dissertation is:

Increasing the wear resistance of parts and tools for production equipment in food industry based on 1.2343 steel by applying hard coatings. To achieve the aim are determined following tasks: analysis of reasons for injection molds defection used in household refrigeration equipment parts manufacture; elaboration of methodology for experimental study of wear intensity and determination the tribological characteristics of hard coatings; design and construction of test stand for experimental study of wear intensity; experimental study the wear resistance of hard coatings on 1.2343 steel; conclusions.

To determine the wear intensity a volumetric method is used which consist in wear trace dimensions measuring and worn material volume calculating.

The following hard coatings deposited on steel 1.2343 are investigated:

- nanocomposite ncAlTiN/αSi3N4 coating;

- carbon based nanocomposite coating Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C;

- multilayer coating Ti/TiN/CrN-ml.

Three variable factors of the tribological system were selected which influence on the wear rate. They are the normal load, sliding distance and average sliding speed.

The final results are analyzed and conclusions are generated.

- **Monograph**

Rupetsov, V. (2020). Increasing in the Durability of Machine Parts and Tools by Coating Deposition, Paisii Hilendarski University Publishing House Plovdiv, ISBN 978-619-202-560-1.

The monograph is dedicated of the problem about the increasing in the durability of tools and parts by deposition of hard, wear-resistant nanocoatings. Types of wear and mechanisms of destruction are considered here. The emphasis is on the abrasive wear as the heaviest and most frequently occurring type of wear. Modern multilayer and nanocomposite coatings are analyzed, PVD methods and installations for their deposition are showed. The methods used in the monograph for the investigation of the physico-mechanical and tribological properties are described and data from the studies of the created coatings are presented. Recommendations are made to put the last into practice.

The monograph is intended for tool equipment specialists as well as for researchers working in the field of vacuum coatings. It could be useful for professors, PhD and common students in mechanical engineering at technical universities.

- **Book based on the PhD dissertation**

Rupetsov, V. (2018). Increasing the wear resistance of parts and tools of production equipment, ZEA – Print OOD, Smolyan, 2018, 136 p., ISBN 978-619-196-073-6.

This book is designated for specialists in the production of tool equipment - injection molds, as well as for researchers working in the field of vacuum coatings. It could be useful for PhD and common students in mechanical engineering at high technical schools.

The book is written on the basis of the author's dissertation for PhD graduation.

- **Annotation of articles**
- **Articles that are referenced and indexed in databases of scientific information.**

1. **Rupetsov, V.,** Mishev, G., Dishliev, S., Kopanov, V., Chitanov, V., Kolaklieva, L., Pashinski, Ch. (2017). Increasing in the wear resistance of injection molds made of 1.2343 steel using Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C nanocomposite coating, 13th International Conference on Tribology, ROTRIB'16, IOP Publishing, IOP Conf. Series: Materials Science and Engineering 174 (2017) 012064. https://doi:10.1088/1757-899X/174/1/012064

Injection molds used in production of plastic components are subject of heavy abrasion wear. The increase of their wear resistance significantly reduces the production cost. In the current work are presented research results of the wear resistance of injection molds made of steel 1.2343, coated with Ti/TiN/TiCN/nc-TiCN: a-C/nc-TiC:a -C/a-C. The study of the wear rate was done using the volumetric method and the influence of the trace length was investigated. The coating thickness, nanohardness, elastic modulus and adhesion were also tested. The coating was applied on unhardened ground specimens, hardened ground specimens and hardened polished specimens.

2. Dishliev, S., Mishev, G., **Rupetsov, V**., Kolaklieva, L., Pashinski, Ch., Minchev, R. (2016). Study of the properties of multilayered gradient TiAlSiN nanocomposite coating deposited on 1.2343 steel, Bulgarian Chemical Communications, Volume 48, sp iss. E, pp. 373 – 377, 2016, ISSN - 0861-9808, (ISSN 0324-1130).

The application of hard coatings in the machining industry has rapidly grown recently. Their variety is huge and each of them has advantages and disadvantages. The latter makes them suitable for certain and relatively limited purposes. Although one universal coating which is suitable for almost all kind of machining does not still exist, a coating which is close to this definition is discussed in this work: nc-$(Al_{1-x}Ti_x)N$/a-Si_3N_4. Its properties which are

important from a practical point of view are studied and an analysis of its wide application is performed here.

3. Kolaklieva, L., Rabadzhiyska, S., Kakanakov, R., Chitanov, V., Cholakova, T., **Rupetchov, V.,** Mishev, G. (2017). Evaluation of the Mechanical and Tribological Properties of Multilayer CrN/TiN Films Deposited at Low Temperatures, PROC. 30th INTERNATIONAL CONFERENCE ON MICROELECTRONICS (MIEL 2017), NIŠ, SERBIA, OCTOBER, 9th-11th, 2017 pp. 187-190, ISBN: 978-1-5386-2562-0/17. https://doi.org/10.1109/MIEL.2017.8190099

Multilayer CrN/TiN protective films were developed at deposition temperatures lower than 200 °C. The mechanical and tribological behaviour were investigated depending on the main technological parameters. The coatings exhibit high nanohardness of 31.3 GPa, excellent adhesion to the substrate and improved resistance to plastic deformations and elastic strain to failure resistance, impaling the enhanced toughness.

4. Cholakova, T., Chitanov, V., Kolaklieva, L., Kakanakov, R., Balashev, K., Ranguelov, B., **Rupetchov, V.,** Mishev, G. (2018). Study of the mechanical properties of Ti-and Cr-based multicomponent hard coatings, MATEC Web of Conferences 145, 02003 (2018) NCTAM 2017 – 13th National Congress on Theoretical and Applied Mechanics, UNSP 02003. https://doi.org/10.1051/matecconf/201814502003

TiCrAlN and CrTiAlN multicomponent coatings have been developed using closed-field unbalanced magnetron sputtering technique (CFUBMS) in a gas mixture of Ar + N_2. The nitrogen level was varied by using the feedback control of plasma optical emission monitor (OEM). An investigation into the effect of the CFUBMS process parameters on the properties of the coatings was undertaken. The main coatings parameters such as thickness, surface morphology, nanohardness, strength of adhesion and wear resistance were studied by means of ball-cratering method, atomic force microscopy, scanning electron microscopy, scratch tests and nanoindentation measurements. The study revealed strong dependency of the mechanical properties on the nitrogen flow rate. Analysis of the experimental results showed that Cr-based multicomponent coatings possess better mechanical properties than Ti-based coatings at a nitrogen flow rate of 21 sccm: higher value of hardness (≤ 31GPa) and higher scratch resistance (> 30 N).

5. Radulescu, I., Radulescu A., Ramalchanov, S., Yankov, S., **Rupetsov, V**. (2019) Experimental Researches concerning the Rheology of Cutting Fluids, IOP Conference Series: Materials Science and Engineering 514 (2019). 012007, https://doi.org/10.1088/1757-899X/514/1/012007

Cutting fluids are used to reduce the negative effects of the heat and friction on both tool and work piece. The cutting fluids produce three positive effects in the process: heat removal elimination, lubrication on the chip–tool interface and chip removal. This paper proposes to study the rheological properties of four different type of cutting fluids, as function

of their chemical and physical characteristics. The tests were performed using a cone and plate Brookfield viscometer, by determining the rheological parameters and the variation of the apparent viscosity with the temperature. This approach has been used to quantify the performance of the tested products and to compare products in the marketplace.

6. **Rupetsov, V**., Kolaklieva, L., Chitanov, V., Angelov, M., Raychev, R., Zlatanov, Z., Pashinski, Ch. (2019). Deposition and tribomechanical study of nanolaminate Ti/TiN/AlTiSiN/(AlTiSiN/TiAlSiN)n/AlTiSiN hard coating, IOP Publishing, IOP Conf. Series: Materials Science and Engineering, 618 (2019) 012047, SJR 0.192, https://doi:10.1088/1757-899X/618/1/012047

The application of Physical Vapor Deposition (PVD) hard coatings is one time-tested practice in the modern industry. Two of the main tendencies that promise a progress in this area are the combination of more chemical elements in one coating and the creation of nanolaminate structures. Since many combinations are possible in the design of the coatings, it could be expected they would have many different properties which are difficult to predict. In an attempt to work simultaneously in both of these directions, one nanolaminate Ti/TiN/AlTiSiN/(AlTiSiN/TiAlSiN)n/AlTiSiN coating was developed and its mechanical properties were tested. The results obtained give a reason to believe that it could be widely practically applied.

7. **Rupetsov, V**., Dishliev, St., Pashinski, Ch., Mishev, G., Angelov, M., Kolaklieva, L., Chitanov, V. (2019). Tribomechanical Behavior of Nanolaminate Ti/TiN/TiCrCN/(CrCN/TiCN)n, Hard Coating, Journal of the Balkan Tribological Association Vol. 25, No 3, 610–616 Coatings – tribomechanical properties, ISSN 1310-4772.

A large number of the frequently used coatings for cermet cutting tools are not appropriate for precise high speed machining of aluminium alloys because of the material stratification on the cutting edges (build-up edge occurrence). This is a prerequisite for worse precision in the machining process and surface quality degradation. Concerning this problem, an innovative nanolaminate Ti/TiN/TiCrCN/(CrCN/TiCN)n hard coating was developed by Closed Field Unbalanced Magnetron Sputtering, which is subject of this research. The coating was deposited on WCCo alloy and had thickness of 2,150 μm. The coating's superlattice structure was built at temperature of 290 °C and pulsed bias voltage of -90 V. It consisted of 133 bi-layers (period of ca. 12,4 nm, ratio of 1:1). The main tribomechanical properties of the coating – hardness, wear resistance, adhesion, coefficient of friction and modulus of elasticity were examined in details. Mills with the mentioned coating were used in real manufacturing process and build-up edge was not observed in comparison to the uncoated mills used in the same working mode. As a result, the accuracy of the dimensions and quality of the surfaces were improved.

- **Science Articles in unreferred journals with peer review or in edited collective volumes.**

8. Rupetsov, V. (1999). Modernization of a universal milling machine for implementing a spherical surface milling scheme (in Russian), Journal of the Technical University at Plovdiv, vol. 6 "Technical Sciences", pp. 163-167, ISSN 1314-5258 (print), 1310-8271 (online).

The article describes the design changes to a universal FNC 25F3 milling machine, through which a rotary motion with selectable speed of the workpiece held in the chuck of a dividing apparatus can be realized. The longitudinal translational motion of the table can be switched off or, if necessary, to be kinematically connected to the rotation spin. These design changes expand the technological capabilities of the machine for processing rotary profile surfaces.

В работе описаны конструктивные изменения универсального фрезерного станка FNC 25E3, через которые создаётся возможность для реализирования вращательного движения с избираемой частотой вращения заготовки, установленной в патроне универсального делительного апарата. Поступательное движение продольного стола можно выключит или связать кинематически с вращателным при необходимости. Эти конструктивные изменения расширяют технологические возможности станка для обработки ротационных профильных поверхностей.

9. Rupetsov, V. (1999). Analysis of the design of the KL 160 bandsaw teeth flattening machine and a proposal for its improvement (in Bulgarian), Smolyan - 1999: Proceedings of the Scientific Conference, June 12 - 14, 1999, Smolyan, Department of Woodworking Machinery and Technologies, Plovdiv University „Paisii Hilendarski", Technical College Smolyan, pp. 9-19, ISBN 954-91073-1-0.

An analysis of the design of the KL 160 bandsaw teeth flattening machine was made and some flaws were noted. It is argued that teeth with different heights cannot be flattened with it. It was recommended to the client to offer three modifications of this device - respectively for heights h = 10; 12; 15 mm. In the three variants, the coordinates of the center of the shaft relative to the center of the body are different depending on the height of the teeth. It is suggested that the profile curve of the shaft be performed along the Archimedean spiral.

10. Rupetsov, V. (2000). Work protection of the cutting band of the block band saw type BB 110 (in Bulgarian), Scientific conference with international participation „Smolyan - 2000": Proceedings, Department of Woodworking Machinery and Technologies, University publishing house Paisii Hilendarski, pp. 168-170, ISSN 1313-9061.

A newly created safety unit is presented, moving with the upper belt guide and covering the working part of the belt above the log. This structural unit can be mounted on block band saws with belt drive wheels from 1000 to 1250 mm. The principle of operation can be applied

to all types of block band saws. The proposed design solution allows work without accidents with the abovementioned machines.

Arbeittschutz des Schneidbandes der Blookbandsäge Typ BB 110

Zusammenfassung: *Es wird eine neu konstruierte Arbeittschutz für den Schneidenden Teil des Bandes der Blookbandsäge vorgestellt. Diese konstruktive Einheit kann an Blokbandsägen mir Umlenkrädern von 1000 bie 1250 mm angebracht werden. Der Wirkprinzip kann bei allen Typen von Blokbandsägen angewandt werden. Die vorgeschldgene konstruktive Lösungerlaubt ein unfallfreies Arbeiten mit den o.g. Maschinen.*

11. Stanev L., Slivarov O., **Rupetsov V.,** Cholakov D. (2000). Concerning some characteristic peculiarities in modeling the process white testing the details from the valve-cylinder group (in Bulgarian), Scientific conference with international participation „Smolyan - 2000“: Proceedings, Department of Transport equipment and technologies, University publishing house „Paisii Hilendarski“, pp. 47-53, ISSN 1313-9061.

The subjects of the article are the basic stages and characteristic features in the technical condition of the parts of the piston-cylinder group when stand CC-1 tested.

A diagram of the sequence and the interrelation when testing the parts of the piston-cylinder group has been made. It shows the most important requirements needed when specifying the parameters of the technical condition of the parts before and after the test, as well as, the control over then during the test.

12. Kamenarov, G., **Rupetsov, V**. (2002). Surface heat treatment of cylindrical parts by the MBL - H method (in Bulgarian), Smolyan 2002: Proceedings of the scientific conference, June, 24-26, 2002, Smolyan: Department of Mechanical Engineering and Transport - Smolyan, Plovdiv University "Paisii Hilendarski", Technical College Smolyan, pp. 155-162, ISBN 954-91073-5-3.

The article describes the MBL-H method (magnetically moving arc with auxiliary electrode) with auxiliary electrode) used for the purpose of (rapid) thermal surface hardening and technological values are reported. Comparisons have been made with laser and electron beam hardening and other possible applications have been pointed out. The article contains typical Haerte-Veg courses, as well as material structures created using this method.

Es wird die Methode MBL-H (magnctisch bewegter Lichtbogen rnit Hilfselektrode) zum Zweck der oberflaechen-Schnellhaertung beschrieben und technologische Werte mitgeteilt. Es sind Vergleiche mit der Laser- und Elektronenstrahlhaertung vorgenommen worden und auf weitere Anwendungsmoeglichkeiten hingewiesen. Der Artikel enthaelt typische Haerte-Veg-Verläufe, sowie durch diese Methode entstandene Werkstoffstrukturen.

13. Mishev G., Dikov R., **Rupetsov V**. (2003). Study of the technological parameters of machining on the frictional force in the guideways of metal cutting machines (in Bulgarian), Smolyan-2003: Proceedings of the scientific conference, June, 21-22, 2003, Smolyan: Department of Mechanical Engineering and Transport - Smolyan, Plovdiv University "Paisii Hilendarski", Technical College Smolyan, pp. 66-74, ISBN 954-91073-6-1.

The influence of the normal force and the roughness of the contact surfaces on the friction force in the machine tool guides was investigated. An experimental stand was designed. A methodology for the experimental determination of tangential contact deformations under static loading of the support is proposed. The influence of the basic technological parameters of the metal-cutting machines on the tangential contact deformations respectively the friction force was determined experimentally, and corresponding quantitative dependences were derived.

14. Kamenarov, G., **Rupetsov, V.** (2004). Influence of mechanical fatigue on the processes of phase transformations during heat treatment in in the repair activities, (in Bulgarian), Smolyan-2004: Proceedings of the scientific conference, June, 26-27, 2004, Smolyan: Plovdiv University "Paisii Hilendarski", Technical College Smolyan, pp. 225-236, ISBN 954-91073-8-8.

The article deals with the influence of material fatigue on the phase transformations. Combined graphs and time-temperature-phase transformations have been created using high-speed dilatometry. These differ significantly from those of materials that haven't experienced fatigue. The quantitative differences depend on the level of the dynamic alternating load and on the number of amplitudes (cycles).

Zusammenfassung: *Die Thematik behandelt den Einfluss der Materialermüdung auf die Phasenumwandlungen. Mit Hilfe der Hochgeschwindigkeitsdilatometrie wunden ZTU (Zeit – Temperatur – Umwandlung) Schabilder erstelit. Diese unlerscheiden sich wesentlich von denen der unermüdeten Werkstoffzustand. Die quantitative Unterschiede sind abhängig vom Niveau der dynamischen Wechsellelastung und von der Anzahl der Amplituden.*

15. Kamenarov, G., Slivarov, O., **Rupetsov, V.** (2006). About the effect of pre-heating when welding rotational-symmetrical details, (in Bulgarian), Smolyan - 2006: Proceedings of the Eighth Scientific Conference, June 24-25, 2006, Smolyan: Plovdiv University "Paisii Hilendarski", Smolyan Technical College, pp. 206-208, ISBN - 954-91877-1-3; 978-954-91877-1-7.

In the repair sector, the rules that apply to connection welding are often adopted uncritically. This applies in particular to the application welding of rotationally symmetrical parts made of heat-treatable steels. This type of welding is subject to its own rules which are reported here.

Zusammenfasuhg: *Im Instandsetzungswesen werden, oft gültige für das Verbindungsschweißen Regeln unritisch übernommen. Das gilt insbesondere Für das Aufiragsschweißen von rotationssimmetrischen Teilen aus Vergültungsstählen. Diese Art Auftragsschweißen unterliegt ihre eigene Regeln, fir die hier berichtet wird.*

16. Paskaleva, K., **Rupetsov, V**., Ilchevska, A., Lyubomirov, Sl. (2007). Computer modeling of involute gearing, (in Bulgarian), Ninth International Scientific Conference Smolyan - 2007, 23-24 June: Proceedings, Plovdiv: University publishing house „Paisii Hilendarski“, 2007, pp. 78-85, ISBN - 978-954-91877-2-4.

The program shown in this article allows for better understanding of the involute gear curve. The ability to visualize involute gear meshing allows more realistic concepts to be formed and makes it easier for the students to understand the process of creation of the involute curve and the parameters of the involute gears. The body of the program shown here will be a part of a global system for a computerized training course in Manufacturing Design, which is the main purpose of the authors of this article.

17. Slivarov, O., **Rupetsov, V.** (2009). Particularities of the recovery of the differential mechanism of a off-road vehicle, (in Bulgarian), Scientific conference with international participation Smolyan 2009: Proceedings, Smolyan: University publishing house „Paisii Hilendarski“, 2009, pp. 176-183, ISBN 1313-9061.

The differential mechanism is a high load machine unit. It is designed to withstand extreme loads, provided that it is operated and maintained in accordance with the requirements of the manufacturer.

The article deals with the problem of restoring a differential mechanism for which maintenance and operating conditions have not been met.

A technological process (for custom made elements) is proposed for the repair of defective elements of a differential mechanism.

18. Dishliev, S., **Rupetsov, V**., Mishev, G., Angelov, M., Pashinski, Ch. (2014). Research the Wear Resistance of Multilayer Nanocomposite Coating Ti/TiN/TiCN-ml on 1.2767 Steel, BALKANTRIB’14 8th International Conference on Tribology 30th October - 1st November 2014 Sinaia, Romania, pp. 529-536, ISBN 978-973-719-570-8.

Injection molds for plastic products production are subject of intensive wear. Increasing their wear resistance leads to improve the living resources and reduce the production cost. For injection molds production in "Arexim Engineering" – Smolyan/BG mainly 1.2767 steel is used. In the current paper are presented results of the wear resistance investigation for Ti/TiN/TiCN-ml multilayer nanocomposite coating on 1.2767 steel. The influence of the velocity, trace length and 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.

19. Pashinski, Ch., Angelov, M., **Rupetsov, V**., Petrov, D., Shindov, P., Dishliev, S. (2014). Arc Bond Sputtering Equipment for Deposition of Innovative Industrial Coatings, IV International Conference Industrial Engineering and Environmental Protection 2014 (IIZS 2014) October 15th, 2014, Zrenjanin, Serbia, pp. 356-361, ISBN: 978-86-7672-234-1.

The deposition of coatings is widely used in the modern industry. The pursuit of a high quality and an environmental friendliness increasingly extends the application of the PVD technology. This article describes one designed and manufactured equipment for Arc Bond Sputtering deposition which is able to create coatings with valuable industrial properties. Its most important assemblies are shown and the principles in its design are explained. At the end two promising coatings deposited by this equipment are described: a nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and a superlattice Ti/TiN/CrN-ml. Their experimentally determined value of the wear rate is comparable with the best known results for similar coatings.

20. Rupetsov, V., Dishliev, S., Mishev, G., Majchrowski, R., Pashinski, Ch., Javorova, J. (2015). Research The Wear Resistance of Nanocomposite Coating Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C on 1.2343 Steel, Journal The 18th International Conference TEHNOMUS New Technologies and Products in Machines Manufacturing Technologies, 8 - 9, may 2015, Suceava, Romania, pp. 352-357.

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 the current paper 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.

21. Rupetsov, V., Kolaklieva, L., Kopanov, V., Chitanov, V., Pashinski, Ch., Dishliev, S. (2015). Determination of tribological parameters of Ti/TiN/CrN ml coating applied on 1.2343 steel, Journal of Food and Packaging Science, Technique and Technologies, Year IV, №6, pp. 91-95, ISSN 1314-7420 (ISSN 1314-7773).

The requirements of the industry in terms of hard coatings increase constantly. Nowadays, one of the most promising trends is the creation of nanolaminates: multilayer coatings in which the single layers have a thickness of several nm. Such a coating is considered here: Ti/TiN/CrN-ml by examination of its tribological and mechanical properties which are the most important for its practical suitability. The obtained results indicate that this coating could fully satisfy the present needs of the industry.

22. Rupetsov, V., Dishliev, S., Minchev, R., Michev, G., Lanchev, I., Angelov, M. (2015). Reasearch the wear resistance of multilayer coating Ti/TiN/CrN-ml deposited on 1.7034

steel, (in Bulgarian), Tribological Journal BULTRIB Vol. 5, 2015, pp. 68-75, ISSN 1313-9878.

Increasing the living resources of the machines and apparatus is of particular importance for the economic performance of companies in the mechanical engineering and food industry. The current work refers to wear resistance investigation of multilayer nanocomposite coating Ti/TiN/CrN-ml, deposited on 1.7034 steel. The proposed methodology for experimental investigation used "Ball on Flat Sliding Wear Test" friction system. The coating Ti/TiN/CrN-ml is applied by PVD method. Experimental studies were conducted to determine the effect of normal load on the wear intensity. On the basis of the results relevant conclusions and recommendations were made.

23. Mishev, G., **Rupetsov, V.,** Paskaleva, K., Dishliev, S. (2016). Factors affecting the accuracy of positioning of rectilinear motion systems, XV International Scientific Conference "RE & IT - 2016, Smolyan – Bulgaria, Conference proceedings Vol. 1, publishing House „Imeon" Sole-owner, 2016, pp. 67-70, ISBN 978-619-7180-78-7.

In the current paper in-depth theoretical investigations of factors affecting the accuracy of positioning of rectilinear motion systems into production machines are made. The results analysis of researches are particular importance for CNC machine tools.

24. Rupetsov, V., Minchev, R., (2016). Experimental Calo Tester for the coating thickness measurement, XV International Scientific Conference "RE & IT - 2016, Smolyan – Bulgaria, Conference proceedings Vol.1, publishing House „Imeon" Sole-owner, pp. 188-191, ISBN 978-619-7180-78-7.

The properties and quality of the mono- and multilayer coatings are largely depended on the thickness of the incorporated layers and the total coating thickness. This work presents one construction of a stand – calo tester which is designed for coating thickness measurement using a local abrasion made by a rotating steel sphere. The purpose of this stand is a determination of the thickness of coatings which are applied on prismatic test samples whose surfaces are made by the same technological regimes applied for the practically used details in order to achieve the same hardness and roughness. The coatings on the details and test samples are applied simultaneously: in a single batch processing.

25. Ramalchanov, S., Yankov, S., **Rupetsov, V**., Radulescu ,A., Radulescu, I. (2019). Experimental Research on the Rheological Properties of Cutting Fluids, Journal of Physics and Technology, Volume 3 (2019), Issue 1, pp. 72-77 ISSN 2535-0536.

Cutting fluids are an important part of the machining and manufacture processes of almost all metal components and end products. The fluids are applied on the interface between the cutting tool and the work piece, and they are used in order to remove the heat generated during the process, reduce the friction, and help flushing the chips away. In this paper we are studying the rheological properties of four different types of cutting fluids,

concerning the variation of the viscosity with the temperature. The tests were performed on a Brookfield Cap 2000+ viscometer, using cone plate geometry.

26. **Rupetsov, V**., Pashinski, Ch. (2019). Laboratory equipment for investigation of friction variator (in Bulgarian), TechCo - Lovech 2019 Scientific Conference, Proceedings, Volume I, Vasil Aprilov University Publishing House - Gabrovo, pp. 115-120, ISSN 2535-079X.

The stepless regulation of the rotation frequency allows changing of the speed mode without stopping the working machine, improving the technological process, shortening the operating and auxiliary time, enables automation of the machine control. In this work one construction of a designed and assembled laboratory test stand is considered. It studies the kinematic characteristics of a friction variator and the properties of the energy transfer with this kind of propulsion. One friction gear scheme with a single variable wheel is used. A methodology for conducting of the study is presented.

27. Rupetsov, V. (2019). Comparative Assessment of the Wear Resistance of Nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and Nanolaminate Ti/TiN/CrN-ml Coatings, TechCo - Lovech 2019 Scientific Conference, Proceedings, Volume I, Vasil Aprilov University Publishing House - Gabrovo, pp. 121-126, ISSN 2535-079X.

In this paper, one comparison of the wear rate of a nanocomposite Ti/TiN/TiCN/nc-TiCN:a-C/nc-TiC:a-C/a-C and a nanolaminate Ti/TiN/CrN-ml coatings applied on 1.2343 steel substrates is made. This material is used to produce plates and inserts for injection molds, augers and matrices for Al, Mg and Zn alloys working. The both coatings were deposited by Closed Field Unbalanced Magnetron Sputtering (CFUBMS) using HVP100RHD industrial equipment. The wear rate was assessed by a linearly reciprocating Ball-on-Flat sliding wear test while the experiments were carried out under dry friction condition. The comparative assessment is performed at constant parameters: average sliding speed, sliding distance and variable parameter: normal load of the counter-part. The areas of the most effective application of the two coatings are clarified in respect to the preparation of parts for molds.

- **Textbook**

Rupetsov V., Dikov R. (2019). Mechanical Engineering Technology, Technological Processes for the Processing of Types of Parts and Assembly of Products, ZEA – Print OOD, Smolyan, 2019, 196 p., ISBN 978-619-196-083-5.

The textbook describes the technological processes for processing types of parts: body parts; levers and forks; shafts; spindles; running screws; bushings, discs and flanges; gearing elements; details with profile surfaces. The peculiarities of designing devices for fastening the details are discussed, as well as the design of technological processes for assembling the

products. The material was developed by the authors in nine chapters, as follows: Assoc. Prof. Eng. Ruslan Dikov - Chapters 1, 2, 8 and 9; Senior. Assist. Prof. Eng. Velko Rupetsov - Chapters 3, 4, 5, 6 and 7.

The textbook is intended for students in the specialty "Mechanical Engineering and Technology" and corresponds to the syllabus in the discipline "Mechanical Engineering" part II according to the current curriculum of the specialty.

The textbook can be used by students from other specialties in the professional field 5.1 "Mechanical Engineering", as well as by engineers and specialists working in the sector of mechanical engineering. It is approved by the Department of Mechanical Engineering and Transport of the Paisii Hilendarski University of Plovdiv, Faculty of Physics and Technology (Minutes No. 7 / 09.03.2019).

- **Manual for Laboratory Exercises**

Rupetsov, V., Dikov, R. (2016). Manual for Laboratory Exercises in Mechanical Engineering Technology, Part One, ZEA - Print Ltd., Smolyan, 2016, 150 p., ISBN 978-619-196-037-8.

The manual contains 15 exercises corresponding to the topics in approved syllabus in the discipline of Mechanical Engineering Technology, Part One. Each exercise includes a theoretical part, methodology and practical instructions for conducting the exercise, questions and discussions.

The manual is intended for students in the field of Mechanical Engineering and Technology from the Technical College of Smolyan, Paisii Hilendarski University, but can also be used by practitioners. It was approved by the Department of Mechanical Engineering and Transport of the Smolyan Technical College (Minutes No. 22 / 10.10.2016).

The topics are developed as follows: Senior Assist. Prof. Eng. V. Rupetsov: 1 to 9, 11, 12 and 14, Assoc. Prof. Eng. R. Dikov - 10, 13 and 15.

- **Workbook**

Paskaleva, K., **Rupetsov, V**. (2016). Exercises in Engineering Graphics (Workbook), Book Boutique, 2016, Sofia, 62 pp., ISBN 978-954-92755-0-6.

The tasks in the workbook cover the basic material in Engineering Graphics and are thematically divided into exercises that cover the curricula in Applied Geometry and Engineering Graphics - II. The terms of the tasks are given textually and graphically and allow for the intensification of the learning process. Options for self-study exercises are provided.

The workbook is intended for students from higher technical education institutions.

- **Electronic course for students**

Rupetsov, V. (2010). Automated production of technical documentation with AutoCAD, Electronic course for students of the Faculty of Physics and Technology of Plovdiv University Paisii Hilendarski, Plovdiv (updated 2011, 2014 and 2019).

The essence of the course is the creation of skills, the accumulation of knowledge, the development of techniques to achieve the final product - drawing, editing, specification and printing of technical drawings, regardless of the object of design. The course includes:

- Getting to know the AutoCAD interface for 2D drawing. Change of the current settings and creation of your own environment in Ribbon mode and classic AutoCAD. Coordinate systems and their use. Ways to work with commands. Quick commands. Help modes. Measuring units.

- Basic element drawing commands - lines, circles, arcs, and all editing commands designed for 2D modeling. Selection methods.

- Working with layers and arrangement of the drawing. Preview commands.

- Block creation, insertion and Editing. Export to a drawing file and use of ready blocks.

- Creation, editing, or use of ready-made text styles and dimension styles. Text insertion, creating dimensions, hatching.

- Preparation of technical drawings for printing.

- Links to other programs. Insertion of Xref and bitmaps. Working with PDF.

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