

ALMOST 60 YEARS OF TRIBOLOGY AT THE FACULTY OF MECHANICAL ENGINEERING, MILITARY UNIVERSITY OF TECHNOLOGY

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Abstract

The beginnings and development of tribology at Military University of Technology are discussed in this paper. The origins of tribology in Poland and at the Military University of Technology are described. The surnames of people, who were present at the birth of this field of science, who were creators of tribology in Poland and who were precursors of teaching students of the Faculty of Mechanical Engineering, MUT, the basics of tribology, are mentioned. The development of science and education at the Faculty of Mechanical Engineering is characterized. The development of the range and standard of science research at the Department of Tribology, Surface Engineering and Service Fluids Logistics, which is possible thanks to the modern testing equipment bought in the last ten years, is presented. There are e.g. UNMT research set (Universal Nano-Micro Tester) made by CETR (USA) for characterizing mechanical and tribological properties of body surfaces; T-02 four-ball tester, KSV 701 tensiometer for evaluation of the surface – energy properties of liquid, FTIR spectrofotometer with IR microscope, stand for the laser spreading of oil microcontainers, automatic set for testing low temperature properties of oils, NIKON research microscope with a set for image analysis, and others.

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1. Introduction

Tribology is the science of friction and the processes accompanying this phenomenon. Wear of the bodies in relative motion always accompanies the friction process. In order to minimise wear the surface lubrication, by means of various substances decreasing friction, is being applied. It may be stated that tribology is the science of friction, wear and lubrication of solid bodies in relative motion. The word “tribology” was used for the first time in so-called Jost Report published in March 1966. It was a report about research into state of the lubrication technique in Great Britain, performed by a group of experts working under Professor Peter Jost's management. For the first time in history the influence of the quality of machine parts lubricating on the national economy was evaluated. There was stated in Jost Report that the reason of significant financial loss resulting from the poor quality of the machine lubricating was very low level of the theoretical and practical knowledge of the machine users and the lack of experts in tribology. It was suggested to organize the tribology teaching and appoint research institutes for tribologic research works. These demands have been met — now in all major countries of the world technical education takes into consideration tribology basis, and advanced tribological research are carried out, and their results are being implemented in practice. In general, there are two, complementary branches of tribology, that is: theoretical tribology (general) and tribotechnology. The first one deals with the description of physical and chemical phenomena and processes, and the other ones within the areas of friction (tribological nodes). The second one concerns the practical applications of scientific

achievements of tribology, including new techniques and lubrication equipment. It should be emphasized that the scope of tribology is not limited to the friction processes in nature and technology.

The science of friction developed in its long history into tribology [1, 2] becomes more and more modern and efficient, both in terms of cognition and methodology. The importance of tribology is growing and it will be, particularly for the construction and operation of machines [3]. Developments of mechanical engineering will continue to improve the reliability and durability of machines, and also their ergonomics and economics. In this area the trends in the construction of motor vehicles are particularly spectacular. The trends assume continuous increase of the vehicles performance. On account of running out of raw material resources, including petroleum, the need to seek ways to reduce energy losses has a great importance. Therefore, for most tribologists the two imperatives, as they were in the early development of tribology, are the most important: 1) reducing energy losses due to friction, 2) increasing resistance to wear caused by friction. At the current stage of development of tribology solving these problems requires more and more precision and detail, which was possible thanks to the application of research methods in microscale and even nanoscale. Friction process is, in its nature, extremely complex, since —at the same time — mechanical, electrical, magnetic, chemical and other phenomena occur. They manifest themselves at different levels of the material structure and therefore must be considered (examined) at different scales: macro, micro and nano. The ones must be observed in millionths of a second, while the others require years of research and observation. Therefore it is understandable that the teams of experts and scientists of many disciplines have to resolve so complicated and intricate systems comprehensively. The Faculty of Mechanical Engineering of MUT had a lot of influence, and has it nowadays, on the development of tribology in Poland. The tribologists of the Faculty of Mechanical Engineering were co-originaors of this science in Poland and the precursors of teaching tribology in the academic dimension. Exactly at the Faculty of Mechanical Engineering of MUT the technical education of students, including tribological knowledge, started in Poland for the first time. It is appropriate to recall this fact in the year of the 60th anniversary of Military University of Technology.

2. The Origins of Tribology at the Faculty of Mechanical Engineering

We can safely say that the origins of tribology (even without the use of that name) at Military University of Technology are earlier than the creation of the faculty structure at the University (in 1959 — previously there had been separate courses, such as armour and mechanized forces, engineer forces, etc. which, when combined, formed individual faculties), and much earlier than the formal establishment of this science by Professor Peter Jost (in 1966). It may be also safely concluded that the father of tribology in Poland, at Military University of Technology and the Faculty of Mechanical Engineering is Prof. Stanisław Ziemia, Ph.D.,D.Sc.,Eng., a member of the Polish Academy of Sciences, Honorary Doctor of Military University of Technology, a university teacher at the Faculty of Mechanical Engineering, MUT. In 1950 when the foundations of Military University of Technology were put, Professor Ziemia described the problem of micro-slips during turning and their influence on rolling resistance, and a year earlier had begun studies on the anisotropy of sliding friction. In 1955, Professor Ziemia led to the establishment of the Group for Friction, Wear and Lubrication at the Committee of Mechanical Engineering of the Polish Academy of Sciences.

Professor Ziemia gather around himself a large group of young academic teachers and graduates of Military University of Technology interested in friction, wear and lubrication of machine parts, who affiliated their future with this field of science. They were mainly representatives of the Course of Armoured and Mechanized Forces. The need to implement their own research and secure the teaching process forced the scientific-academic teams of the Course

to design and build the laboratory and research stands, including special machines for testing the friction and wear processes. At that time there was a lack of normative studies on defining tribological test methods and recommending the use of appropriate tribotesters. Such standards were only published in the seventies and eighties. In the late fifties and early seventies there were built a number of tribological test machines, particularly in the Chair of Motor Vehicle Operation and Maintenance as well as the Chair of Motor Vehicle Repair— hence their names KEWAT and KRWAT, what are acronyms for the Polish names of the Departments and Military University of Technology. Sequentially numbered types of these machines had different purposes. They also gained recognition at other scientific centres in Poland [4]. Some of them, after successive modernizations, operate efficiently nowadays.

The level of development of the scientific-academic teams reached at the end of the fifties, and a large laboratory basis built with effort gave rise to the establishment, in autumn 1959, of the Faculty of Mechanical Engineering, which took, in a positive way, the whole organization of scientific teams and profiling mechanical specialities.

Already in the early sixties the academics of the Faculty of Mechanical Engineering defended the first doctoral dissertations on tribological issues supervised, of course, by Professor Stefan Ziemia. The first work was a dissertation by Janusz Janecki, titled “Investigation of Dynamic Loads Influence on Wear During the Reciprocating Motion” that was defended on 8 June 1961. The next was a dissertation by Michał Hebda, titled “Investigation of Properties of Subsurface Layers During the Process of Dry Friction”, defended on 26 September 1963. The third one was a dissertation by Jerzy Cypko, titled “Investigation of Some Phenomena Occurring in the Process of Lapping of the Pair of the Pin Made of 45 Steel and the Bushing Made of Lead Matrix Alloy, Under Various Speeds and Loads”, defended on 26 March 1964. Finally, the fourth one was a doctoral dissertation “Influence of Some Factors on the Process of Wear of the Pin-Bearing Coupling During the Lapping Period”, defended on 28 January 1965, by Franciszek Bieda.

As already stated, in 1966, with the announcement of Jost Report, the existence of a new interdisciplinary science called tribology began formally. During this period, the consecutive doctoral dissertations in the field of tribology, as well as the first postdoctoral works, were being prepared at the Faculty of Mechanical Engineering. The introduction of the programmes of mechanical engineers education, on the basis of the academic subject of tribology, were being prepared, too.

3. Development of Science and Education at the Faculty of Mechanical Engineering

The word “tribology”, already functioning quite well in the scientific environment of the sixties and seventies, could not get to the ministerial official documents concerning the science development and educational programmes, for many years. Only in the late eighties the word “tribology” came into use for specifying e.g. a specialization of a doctoral student or an academic preparing a postdoctoral thesis. In so-called educational standards for education of mechanical engineers it appeared even later. However, this fact did not interfere with the enormous growth of interest in this new field of knowledge, especially among mechanic designers and operators of motor vehicles.

Michał Hebda was the first one among the academics of the Faculty of Mechanical Engineering dealing with tribology, who got a postdoctoral degree for the monograph published in 1967, titled “Methods to Assess Properties of the Surface Layer”. Michał Hebda defined, in this work, the concept of the surface layer of the machine part and described the necessary methods of the assessment of that layer as an area of the tribological interactions. The next one was Janusz Janecki who got a postdoctoral degree in 1969 for the monograph titled “Influence of Heat Treatment of Phenol-Formaldehyde Plastics for Brakes for Changing Their Resistance to Abrasibility and Wear”. Both academics mentioned above did not defend their postdoctoral theses before the Faculty Council of the Faculty of Mechanical Engineering, MUT. Michał Hebda

habilitated at Academy of Mining and Metallurgy, and Janusz Janecki — at Warsaw University of Technology. The Faculty Council of the Faculty of Mechanical Engineering was thereby enhanced and became more favourable towards next postdoctoral theses in the field of tribology. In the seventies, another group of military academic teachers and doctoral students of the Faculty defended their dissertations before the Faculty Council of the Faculty of Mechanical Engineering, MUT.

In October 1971 Remigiusz Moraczewski defended his doctoral thesis titled “Influence of Fillers on Some Mechanical, Friction and Wear Properties of T-27 Polyamide”. Michał Hebda was his thesis supervisor. In July 1973, another doctoral student of Michał Hebda's, Kazimierz Spaliński, defended his dissertation titled “Investigation of Friction Properties of Friction Materials Used for Brake Pads Production”. In 1976, Włodzimierz Mróz completed his dissertation titled “Attempt to Use the Phenomenon of Generating the Electrical Potential During Friction Process for Evaluation of the Lapping Process” as part of the stationary doctoral studies. His thesis supervisor was Jerzy Cypko mentioned above. The stationary doctoral studies at Military University of Technology were developed very much in this period. In subsequent years defended doctoral dissertations were being realized in the existing form (i.e. within the statutory activities related to the official duties of the academics) and as part of the doctoral studies. The next doctoral thesis in the field of tribology was done just as part of the doctoral studies. It was a dissertation by Janusz Boruta, titled “Development of Criteria for the Behaviour of Oils Under Boundary Friction Conditions” defended in 1979. Professor Andrzej Wachal was his thesis supervisor. Starting from this dissertation, the next doctorates in tribology were being completed primarily by young researchers, recent graduates of the Faculty of Mechanical Engineering, working mainly in two units of the then Institute of Motor Vehicle Operation and Maintenance, managed by Prof. Michał Hebda, Ph.D., D.Sc., Eng. These units were: Department of Engine Fuels and Lubricants (Polish acronym: ZMPS), managed by Professor Andrzej Wachal, a chemist by education, a tribologist by avocation, and Department of Production Technology and Repairs of Motor Vehicles (Polish acronym: ZTPiNPM), managed by Reader Jerzy Cypko, mentioned above. In April 1979 Wiesław Pokorowski (ZMPS) defended his doctoral thesis. The title of this dissertation was: “Tribological Study of the Boundary Layer in a Quasi-Point Contact”. Professor Michał Hebda was his thesis supervisor. A year later, in April 1980, Tadeusz Kałdoński defended his dissertation titled “Influence of Fuel Purity on the Durability of Fuel Injection Equipment of Diesel Engine”, and his thesis supervisor was Professor Andrzej Wachal. The thesis supervisor of the next doctoral dissertation in tribology was Professor Wachal, too. It was a dissertation by Andrzej Kulczycki (ZMPS). The dissertation was defended in October 1981, and its title was “Mechanism of Effect of Sulphur Additives Under Mixed Friction Conditions”. Three years later, in March 1984, Jan Fabiszewski defended his dissertation, which was supervised by Reader Jerzy Cypko, titled “Analysis of Wear Processes of Crankshaft Bearings Made of Alloys of Tin and Lead Matrix”, while in December a long-awaited defence of the doctoral dissertation by Marian Machel (ZMPS) took place. The title of the dissertation was “Method of Evaluation of the Tribological Properties of the Gear Oils”. Reader Jerzy Cypko was a thesis supervisor of two consecutive dissertations in tribology. In the protocols of these defences there is still no specialization called “tribology”, although, like all ones mentioned previously, they belong to this field of knowledge. These dissertations were: by Wiesław Gołębiowski (ZTPiNPM), “Modelling Studies of Tribological Processes in Sliding Couplings with the Use of Generated Electric Potentials”, defended in December 1984, and the dissertation by Zbigniew Borsukiewicz (ZTPiNPM), titled “Modelling Studies of Tribological Processes in Plain Bearings Under Conditions of Input Force Changeable Cyclically”, defended in July 1987. In subsequent defences of doctoral dissertations a precise speciality name (“trybology” — after years of use spelled rather “tribology”) appeared, mostly within the framework of the scientific discipline “Construction, Operation and Maintenance of Machines”. In November 1987, Jerzy Korycki defended his

dissertation titled “Analytical Description of the Processes of Wear in the Model Friction Nodes”, which was supervised by Professor Andrzej Wachal. This was the last dissertation Professor Wachal supervised before retirement and finishing his work at Military University of Technology. Previously, Professor Hebda and Reader Cypko did the same. This way people who gave suitable level and direction of the development of tribology at the Faculty of Mechanical Engineering, MUT, left. Since then a distinct decline in getting doctoral degrees in tribology appeared. The situation slightly improved after several habilitation colloquiums and defences of postdoctoral theses before the Faculty Council of the Faculty of Mechanical Engineering. The dissertations were in succession: in May 1980, by Franciszek Bieda, titled “Durability of Rolling Bearings Conditioned by the Type and Condition of Flexible Lubricant”, which was unfortunately assigned to “Basics of Machine Construction” speciality, then in July 1985, the dissertation by Stanisław Kostrzewa (ZTPiNPM), titled “Analysis of Changes in the Structure of Alloys of Exploited Bearings” in “Physical Metallurgy” speciality, in June 1992, the dissertation by Kazimierz Baczewski (ZMPS), titled “Analysis of Engine Oil Filtration Process” counted among “Tribology, Fuels and Lubricants” speciality.

In 1993 two doctoral dissertations in tribology were defended by ZTPiNPM academics. Their thesis supervisor was Stanisław Kostrzewa mentioned above. In March 1993 Stanisław Kowalczyk defended his dissertation titled “Stability of the Bearing Alloy Structures and Its Influence on Selected Properties of Multilayer Bearings”, and in December 1993 Czesław Pakowski defended his dissertation titled “Influence of Electroplating Parameters on the Basis of Regenerative Properties of Ferro-Nickel Layers”. In July 1993 Edward Cypko (also from ZTPiNPM) defended the dissertation supervised by Professor Henryk Ziencik (a physical metallurgist). This work was titled “Analysis of Suitability of the Pin Restorative Layer for Interaction with the Multilayer Bushing”.

We had to wait over ten years (until 2006) for another, purely tribological doctoral dissertations. In the meantime, before the Faculty Council of the Faculty of Mechanical Engineering, there were three consecutive habilitations in “tribology” speciality. In 1995, Jan Senatorski (Institute of Precision Mechanics, Warsaw) got a postdoctoral degree for the monograph titled “Evaluation of Materials for Sliding Friction Nodes”, and in 1996, Tadeusz Kałdoński (ZMPS Head), for the monograph titled “Abrasive Wear in Tribological Systems of the Piston-Cylinder Type”.

The last, at the time of writing this paper, postdoctoral dissertation in “tribology” speciality, defended in June 2003 before the Faculty Council of the Faculty of Mechanical Engineering, was the monograph by Dariusz Ozimina (Kielce University of Technology), titled “Anti-Wear Surface Layers in Tribological Systems”.

One of the major reasons of the number of doctoral dissertation defences decrease, not only the tribological ones, in the last decade is the total lack of interest in the doctoral studies by the Ministry of National Defence, and so-called own resources, i.e., young officers – assistants. They got old long ago and almost all of them gained a doctorate in engineering. Currently the situation begins to improve thanks to functioning of open (civil) doctoral studies (3rd degree studies). However, Ministry of National Defence is not still interested in these studies and does not allow the officers to carry out full-time studies. The most active ones are trying to study externally at their own expense.

Two recent doctoral dissertations in “tribology” speciality were defended in 2006 and 2007 by officers from Department of Tribology, Fuel and Lubricants Logistics (formerly Department of Engine Fuels and Lubricants — Polish acronym: MPS). The first one is the dissertation by Artur Król, titled “Research and Analysis of Oils Characteristics in Terms of Selection for Lubrication of Porous Plain Bearings”, and the second one is the thesis by Bolesław Giemza, titled “Investigation and Modelling of Operating Characteristics of Porous Plain Bearings Impregnated with Flexible Lubricants”. The thesis supervisor of these dissertations was Tadeusz Kałdoński who

was nominated a professor by the decision of the President dated 30 June 2008, for his scientific achievements, mainly in the field of tribology. The next three tribological doctorates are being carried out by three youngest academics from Professor Kaldowski's team. The first dissertation relates to research and analyse of the energy-surface and tribological properties of ionic liquids (Tomasz J. Kaldowski) and the second one — research and analysis of the tribological properties of the boron nitride nanolayers deposited on various metal surfaces with the use of the laser ablation (Lieut. Krzysztof Gocman), and the third one – research and assessment of the electrorheological properties of lubricants (Lieut. Jarosław Juda). The above-mentioned titles of recent doctoral dissertations and the next charted research areas prove a significant qualitative change of the tribological research level. To realize such advanced research the apparatuses corresponding to the world standards are necessary, enabling implementation of tests not only at the macro level, but also the micro and nano ones. Tribological teaching laboratories equipment, where the MUT students gain theoretical and practical knowledge, also require constant upgrading and modernization.

At Military University of Technology many persons from various organizational units, especially from the Faculty of Mechanical Engineering, dealt and deal with the tribological issues. The reasons are obvious. For example, it is difficult to neglect the study of wear resistance of materials obtained with the use of new technologies forming the surface layer and the surface as itself. It is hard to ignore the presence of friction during structural analysis, interacting of movable machine parts, etc. The most complete, scientific and didactic dimension was given to tribology at the turn of the sixties and seventies of the twentieth century (the first time in Poland) in Department of Engine Fuels and Lubricants that was managed by Professor Andrzej Wachal that time. Colonel Professor Andrzej Wachal and the then Director of Institute of Motor Vehicles Operation and Maintenance, Colonel Professor Michał Hebda were forerunners of tribology teaching at the Faculty of Mechanical Engineering, MUT. Since then, the tribological engineering and master's theses were defended by dozens of graduates of the Faculty of Mechanical Engineering. In the early years these were very often design works needed for making a number of research stands, including KEWAT series tribological machines mentioned previously. On the next stage there were being more often realized the research works during which the partial, but weighty tribological problems, were being solved. Almost all subjects of tribological theses of students of the Faculty of Mechanical Engineering since its beginning are presented in Table 1. Since in the early days of MUT keeping detailed lists, allowing to find the thesis topic in a particular speciality, was not very “popular”, the presented list is certainly incomplete, and it is appropriate to apologize for it. The lack of that speciality, as mentioned above, was an additional difficulty.

Tab. 1. Tribological Theses of Students of the Faculty of Mechanical Engineering

No.	Year of Defence	Graduate's Name and Surname	Subject of Thesis	Name and Surname of Thesis Supervisor
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
1.	1966	Stefan SZAFRAN	Project of the Test Stand for the Plain Bearings Lapping. Study of Influence of Certain Oil Additives on the Course of Lapping of Bushings Made of Bearing Alloy	
2.	1967	Czesław OPALIŃSKI	Project of Device for Testing and Lapping of the Rear Axles with Forced Planet Gear Operation	
3.	1968	Marek ŚLASKI	Project of the Test Stand for Testing Wear of Samples in Reciprocating Movement	
4.	1969	Aleksander ŁUKASIK	Reasons of Intensive Wear and Damage of the Basic Units of Star 66 Car	Michał HEBDA
5.	1969	Wiesław KAMIŃSKI	Study of the Influence of Oil on the Lapping Process of the Bushings of the Crankshaft	Jerzy CYPKO

1	2	3	4	5
6.	1970	Włodzimierz KOMINEK	Studies of Some Phenomena Occurring in the Process of Lapping of the Pin-Bushing Coupling	Jerzy CYPKO
7.	1971	Jerzy WALENTYNOWICZ	Modelling Studies of Electrical Phenomena Occurring During the Friction Process of the Pin-Bushing Coupling	Jerzy CYPKO
8.	1971	Andrzej BEDNARZ	Evaluation of Operating Usability of Motor Oils in the Light of the Tests Performed at the Stands: Almen-Wieland and the Four-Ball Apparatus	Andrzej WACHAL
9.	1971	Andrzej ŁUCZAK	Evaluation of Operating Usability of Motor Oils in the Light of the Tests Performed at the Stands: KEWAT-4, AMSLER, TIMKEN, the Four-Ball Apparatus	Michał HEBDA
10.	1972	Marek JUREWICZ	Study of Current Phenomena Occurring During Interaction in the Couplings in Rotary Motion	Jerzy CYPKO
11.	1972	Kazimierz BĄKOWSKI	Modelling Studies of Wear of Piston Rings and Some Phenomena Accompanying Friction	Jerzy CYPKO
12.	1972	Tadeusz KAŁDOŃSKI	Studies of Friction Current of Lubricated Areas of Contacts of Machine Metal Parts	Andrzej WACHAL
13.	1972	Andrzej FLISIUK	Measurements of Electrical Resistance of the Oil Layer in the Friction Machines	Andrzej WACHAL
14.	1972	Ryszard REGULSKI	Experimental Studies of Oil Lubricity at the Standard Test Stands	Andrzej WACHAL
15.	1972	Leszek STARZEWSKI	Study of Changes of Friction Factor Between Metal Surfaces in Dependence of the Amount and Type of Oil Additives	Andrzej WACHAL
16.	1973	Józef KOPYSZKO	Attempts to Measure Lubricity as a Physical Quantity	Andrzej WACHAL
17.	1973	Zdzisław KOPCZYK	Modelling Studies of Current Phenomena for Reciprocating Friction of Selected Metals Couplings	Jerzy CYPKO
18.	1973	Andrzej KOS	Modelling Studies of Phenomena Occurring for Sliding Friction in the Presence of Some Lubricating Media	Jerzy CYPKO
19.	1974	Krzysztof SŁOWIK	Modelling Studies of Some Phenomena Occurring in the Process of Lapping of Parts of Internal Combustion Piston Engines	Jerzy CYPKO
20.	1974	Antoni WILK	Modelling Studies of Electrical Phenomena Accompanying Friction During Reciprocating Motion	Jerzy CYPKO
21.	1974	Janusz KOLCZYŃSKI	Study of the Behaviour of Lubricating Oils with Different Additives During Boundary Lubrication	Andrzej WACHAL
22.	1975	Tadeusz KAŁDOŃSKI	Study of the Influence of Pollution on the Mechanical Wear of the Supply System of Diesel Engine	Andrzej WACHAL
23.	1975	Henryk WIATR	Influence of Water, Fuel and Model Pollution on Stability of the Oil Film	Andrzej WACHAL
24.	1976	Mirosław NIEPSUJ	Modelling Studies of the Influence of Polymeric Densifiers (Viscosators) on the Intensity of Wear of Friction Couplings	Andrzej WACHAL
25.	1976	Eugeniusz OLSZEWSKI	Modelling Studies of the Influence of Oil Type, Load and Slip on the Tribological Characteristics of the Worm Gear	Andrzej WACHAL
26.	1976	Grzegorz WIŚNIEWSKI	Studies of the Influence of Sulphur Compounds on Anti-Wear and Anti-Seizing Properties	Andrzej WACHAL
27.	1976	Zbigniew WAWRZYŃIAK	Evaluation of the Wear Intensity of Plastics in the Process of Friction in the Presence of Oil	Andrzej WACHAL
28.	1977	Krzysztof RUDNICKI	Study of the Influence of the Reworked Oil Types on the Friction Characteristics Obtained at the Stand for Modelling Tests of the Worm Gears	Marian MACHEL
29.	1977	Bogdan ŻYŁKA	Analysis and Determining of Requirements for Permissible Contents of Pollutants in Motor Oils	Andrzej WACHAL
30.	1979	Edmund TRACZYKOWSKI	Determination of the Influence of Additives of Various Substances on the Behaviour of Oil During Boundary Lubrication	Andrzej WACHAL
31.	1979	Marek DZIEWIT	Determination of the Influence of Load and Speed on the Behaviour of Oil in the Disc-Spindle Coupling	Andrzej WACHAL

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32.	1979	Wojciech BAK	Modelling Studies of the Influence of Lubrication Type on the Process of Lapping of the Pin-Bushing Coupling	Jerzy CYPKO
33.	1980	Krzysztof CHYŁA	Study of Lapping of the Parts of the Piston-Cylinder Coupling	Jerzy CYPKO
34.	1981	Tomasz LIPSKI	Studies of the Effectiveness of Thiophosphorus Additives in the Process of Boundary Friction	Andrzej WACHAL
35.	1981	Zygmunt BIAŁKA	Testing of Lubricating Oils Properties at Low Temperatures	Andrzej WACHAL
36.	1983	Wojciech HEILMAN	Testing of Flexible Lubricants for Rolling Bearings	Franciszek BIEDA
37.	1984	Bogusław ŚWIDERSKI	Influence of Lubricant on the Tribological Processes for Selected Sliding Couplings	Jerzy CYPKO
38.	1986	Jarosław CHOJNACKI	Study of the Lapping Process of Selected Coatings for Motor Vehicle Parts Regeneration	Jerzy CYPKO
39.	1987	Marek JEZIERSKI	Influence of the Base Oil Composition on the Behaviour of Oil at Low Temperatures	Andrzej WACHAL
40.	1987	Henryk CHMIELEWSKI	Influence of Quality of Flexible Lubricants on the Durability of Military Vehicle Rolling Bearings	Franciszek BIEDA
41.	1987	Wiesław ROKICKI	Studies of the Surface Layer Properties and Their Influence on the Operating Characteristics of P76 Fuel Injection Precision Pump Pairs Under Operation	Tadeusz KALDOŃSKI
42.	1988	Zbigniew GRZEŚKOWIAK	Analysis of the Structure and Tribological Properties of 36H3M and 33H3MF Ion Nitrided Construction Steels Paying Special Attention to the Assessment of Their Usability for the Production of Internal Combustion Engines	Stanisław KOSTRZEWA
43.	1989	Wojciech DZIEGIELEWSKI	Studies of the Influence of the Diesel Oil Group Composition on Its Lubricating Properties	Tadeusz KALDOŃSKI
44.	1990	Andrzej PILUCIK	Analysis of Tribological Properties of the Multilayer Bearings with the Lead-Tin Sliding Layer	Stanisław KOSTRZEWA
45.	1991	Andrzej KAMINSKI	Experimental Studies of the Abrasive Wear of LH-15 Steel	Tadeusz KALDOŃSKI
46.	1993	Jarosław BATOR	Studies of Electrolytic Layers Resistance to Wear Project of the Technological Process of Regeneration of the Selected Part	Czesław PAKOWSKI
47.	1993	Zbigniew KRÓL	Project of the Technological Regeneration Process of the Selected Part by Spraying Ceramic Layers Studies of Tribological Properties of Sprayed Ceramic Layers	Adam WOŹNIAK
48.	1993	Aleksander MAJKA	Studies of the Abrasive Wear of Multiphase Structures	Tadeusz KALDOŃSKI
49.	1993	Jacek WENSLAWOWSKI	Studies of Lubricity of the Petroleum Products in the Magnetic Field	Tadeusz KALDOŃSKI
50.	1994	Waldemar BARGŁOWSKI	Analysis of Usability of the Layers Formed by Surfacing Powders by Welding on the Co and Ni Matrix Base for Regeneration of Motor Vehicle Parts	Edward CYPKO
51.	1994	Janusz PILZAK	Studies of Resistance to Wear of Regenerative Layers Formed by Surfacing by Welding on the Nickel and Cobalt Matrix Base for Selected Parts of Motor Vehicles	Henryk ZIENCIK
52.	1995	Piotr MACHCIŃSKI	Studies of Lubricity of Multifunctional Oils	Tadeusz KALDOŃSKI
53.	1995	Zbigniew MALINOWSKI	Evaluation of Self-Lubricating Bearings Properties	Czesław PAKOWSKI
54.	1995	Jacek WODZIŃSKI	Studies of the Tribological Wear of the Metal in the Magnetic Field	Tadeusz KALDOŃSKI
55.	1996	Andrzej BANACH	Comparative Studies of Oils Containing New Improvers Designed for Motor Vehicles	Tadeusz KALDOŃSKI
56.	1996	Jarosław CHACHNOWSKI	Studies of the Influence of Selected Additives on the Operating Properties of Lubricants Used in the Military Technology	Tadeusz KALDOŃSKI

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57.	1996	Sylwester SZADURA	Study of the Influence of Temperature on the Tribological Properties of Self-Lubricating Bearings	Stanisław KOWALCZYK
58.	1997	Konrad KŁOS	Studies of the Bearing Materials Containing Boron Nitride	Tadeusz KAŁDOŃSKI
59.	1997	Tomasz SMUSZKIEWICZ	Experimental Studies of the Tribological Properties of Boron Nitride	Tadeusz KAŁDOŃSKI
60.	1998	Ryszard KIDYBIŃSKI	Preliminary Project of the Stand for Tests of the Porous Plain Bearings	Tadeusz KAŁDOŃSKI
61.	1998	Adam WIAK	Analysis of the Possibility of Using Boron Nitride in the Lubrication Technology of Armed Forces	Tadeusz KAŁDOŃSKI
62.	1998	Sławomir WIŚNIEWSKI	Preliminary Project of the System for Measurements of the Friction Torque at KRWAT-1 Tribological Stand	Edward CYPKO
63.	1998	Jarosław BODZIONY	Preliminary Project of AMSLER Stand for Tribological Tests at Decreased Ambient Temperature	Czesław PAKOWSKI
64.	1999	Bolesław GIEMZA	Analysis of The Parameters of Porous Bearings in Dependence of Used Lubricant	Tadeusz KAŁDOŃSKI
65.	1999	Maciej ŁUCZAK	Preliminary Project of the System for Continuous Recording of Selected Tribological Parameters of Materials Used in the Military Vehicle Sliding Nodes	Czesław PAKOWSKI
66.	2001	Mariusz GINIEWICZ	Comparative Studies of the Porous Bearings Impregnated with Synthetic and Mineral Oils	Tadeusz KAŁDOŃSKI
67.	2001	Wiesław KRUKOWSKI	Analysis of The Methods of Tests of Operating Properties of Porous Plain Bearings	Tadeusz KAŁDOŃSKI
68.	2001	Emil NOWIŃSKI	Analysis of Factors Determining the Durability of Porous Plain Bearings	Tadeusz KAŁDOŃSKI
69.	2002	Marcin DELA	Studies of the Multi-Layer Bearing with the Sprayed Sliding Layer in Terms of Its Application in Heavily Loaded Engines	Edward CYPKO
70.	2002	Arkadiusz DOBEK	Study of the Influence of Lubricants on the Durability of Porous Plain Bearings	Tadeusz KAŁDOŃSKI
71.	2002	Piotr IWANIEC	Study of the Influence of Oil Viscosity on Selected Operating Parameters of Porous Bearings	Tadeusz KAŁDOŃSKI
72.	2002	Norbert KOWALCZYK	Analysis of The Applicability of Composite Materials with Polymer Matrix Used for Sliding Nodes	Edward CYPKO
73.	2002	Piotr SZALBIERZ	Study of the Influence of Ageing on the Permeability of Porous Plain Bearings	Tadeusz KAŁDOŃSKI
74.	2004	Marek KUMOREK	Study of the Influence of the Oil Lubricity on the Operating Characteristics of Porous Bearings	Tadeusz KAŁDOŃSKI
75.	2004	Grzegorz PAŁASZ	Studies of the Influence of Flexible Lubricants Properties and Operating Conditions on the Operating Characteristics of Self-Lubricating Porous Plain Bearings	Tadeusz KAŁDOŃSKI
76.	2004	Łukasz WŁODARSKI	Studies of Influence of Flexible Lubricants Properties and Saturation Parameters on the Degree of Saturation of Porous Sleeves	Tadeusz KAŁDOŃSKI
77.	2005	Agnieszka GDULA	Studies of the Aged Oils Lubricity	Tadeusz KAŁDOŃSKI
78.	2005	Paweł GIEROWSKI	Studies of the Lubricity and Sorption of Selected Gear Oils	Tadeusz KAŁDOŃSKI
79.	2005	Jarosław JUDA	Studies of the Lubricity and Sorption of Selected Engine Oils	Tadeusz KAŁDOŃSKI
80.	2006	Krzysztof GOCMAN	Modelling of the Wear During the Friction Sliding of the Quasi-Point Contact with the Use of the Artificial Neural Networks	Tadeusz KAŁDOŃSKI
81.	2006	Wojciech MIKŁOSZ	Studies of the Porous Plain Bearings Load Capacity	Tadeusz KAŁDOŃSKI
82.	2007	Michał KRASOWSKI	Comparative Tests of the Anti-Wear Properties of Lubricants at Various Tribotesters	Tadeusz KAŁDOŃSKI

1	2	3	4	5
83.	2008	Łukasz BOJARA	Analysis of the Heat Exchange Process Generated by Friction in the Pin-Disc Tribological Node	Tadeusz KAŁDOŃSKI
84.	2009	Jarosław JASIECZEK	Initiate Studies of the Superficial and Tribological Properties of Selected Ionic Liquids	Tadeusz KAŁDOŃSKI
85.	2009	Tomasz BANIAK	Studies of the Temperature Influence on Egeing Process of Oils in Durability Tests of Porous Sliding Bearings	Artur KRÓL
86.	2009	Tomasz BLACHA	Studies of the Course of Egeing Process of Oils into Porous Sliding Bearings Depending on the Kind of Base Oil	Artur KRÓL
87.	2009	Dawid BOREK	Initiate Test of Fe-Al Base Porous Materials on Self-lubrication of Sliding Bearings	Bolesław GIEMZA
88.	2010	Paweł ŻOCHOWSKI	Influence of Friction Generated Thermal Processes on the Work of the Lubricated Frictional Nodes	Czesław PAKOWSKI
89.	2010	Mariusz STAŃCZYK	Studies of the Superficial and Lubricity Properties of Selected Ionic Liquids	Tadeusz KAŁDOŃSKI
90.	2010	Łukasz GRYGLEWICZ	Studies of the Superficial and Lubricity Properties of Selected Synthetic Oils	Tadeusz KAŁDOŃSKI
91.	2010	Paweł WOJDYNA	The Lubricants for Space Technology	Tadeusz KAŁDOŃSKI
92.	2010	Emil GARWACKI	Initiate Studies of the Tribological Properties of Boron Nitride Nanolayers on the Metal Base	Tadeusz KAŁDOŃSKI

4. Department of Tribology, Surface Engineering and Service Fluids Logistics

In 2008 the integration of tribologists at the Faculty of Mechanical Engineering took place. As it was mentioned before, two Departments were mainly interested in the tribological issues: Department of Engine Fuels and Lubricants and Department of Production Technology and Repairs of Motor Vehicles. At the moment, at the Institute of Motor Vehicle and Transportation exist Department of Tribology, Surface Engineering and Service Fluids Logistics employing the staff from the two Departments mentioned above. The personnel composition of the Department is as follows:

- Prof. Tadeusz Kałdoński, Ph.D.,D.Sc.,Eng.
- Kazimierz Baczewski, Ph.D.,D.Sc.Eng.
- Edward Cypko, Ph.D.,Eng.
- Major Bolesław Giemza, Ph.D.,Eng.
- Stanisław Kowalczyk, Ph.D.,Eng.
- Lt Col. Artur Król, Ph.D.,Eng.
- Wojciech Napadłek, Ph.D.,Eng.
- Czesław Pakowski, Ph.D.Chem.
- Adam Woźniak, Ph.D.,Eng.
- Piotr Szczawiński, Ph.D.,Eng.
- Wiesława Zielnik, Ph.D.Chem.
- Tomasz Kałdoński, M.Sc.,Eng.
- Lieut. Krzysztof Gocman, M.Sc.,Eng.
- Milena Kamińska, M.Sc.,Eng.
- Czesław Laskowski, Eng.
- Krzysztof Jancik, Eng.
- Krzysztof Gieryń, Technician.
- Jacek Perski, Technician.
- Ireneusz Wilamowski, Technician.

Over the past ten years the test and teaching equipment at the Department was mostly replaced by the modern one, corresponding to the world standards and allowing to implement more and more ambitious research programmes. At the moment, the following research projects, funded by the Ministry of Science and Higher Education, are, among other things, under realization:

- PBG 393/WAT/2006 titled “Development of applied technologies of production and regeneration of the military motor vehicles with the use of the laser padding and alloying, and

testing the operating properties of padded and alloy layers” — Project Manager: Stanisław Kowalczyk, Ph.D.,Eng.;

- PBG 411/WAT/2006 titled “Development of applied technologies to modify the surface layer of the monoblock cylinders and the cylinder sleeves of the internal combustion engines with the use of laser micro-machining”, — Project Manager: Adam Woźniak, Ph.D.,Eng.;

- PBG 120/WAT/2007 titled “Studies of the possibilities to use the ablation laser micro-machining for the processes of forming the practical abilities, exposed to the thermal shocks and tribological wear” — Project Manager: Professor Tadeusz Burakowski. It must be emphasized that Prof. Burakowski has been cooperating with the Faculty of Mechanical Engineering for years. Professor Burakowski is the creator of an important surface engineering branch that was named areology. He is also the Chairman of the Surface Engineering Intersectional Group of the Committee of Mechanical Engineering of the Polish Academy of Sciences.

- PBG 245/WAT/2007 titled “Modern materials based on the matrix of intermetallic phases of Fe-Al to be used for the self-lubricating plain bearings”, Project Manager: Bolesław Giemza, Ph.D.,Eng.;

- PBG 234/WAT/2007 titled “Evaluation of the interaction of the elements forming the frictional coupling with the use of the triboelectric phenomena” — Project Manager, Edward Cypko, Ph.D.,Eng.;

- PBG 441/WAT/2008 titled “Study of the ageing processes and determination of the limiting values of lubricating oils in the selection process for porous plain bearings” — Project Manager, Artur Król, Ph.D.,Eng.;

- PBR 15-249/WAT/2007 titled “Development, testing and preparation for implementation of porous plain bearings of new generation with increased capacity and sustainability, impregnated with eco-friendly oils containing selected surfactants, including ionic liquids, in the military technology” — Project Manager: Professor Tadeusz Kałdoński, Ph.D.,D.Sc.,Eng.;

- PBZ 257/2008 titled “Development of new technologies for preparation of surfaces of selected metal alloys for heat-resistant coating layers (CVD, TBC and others) used for structural components” — Project Manager: Wojciech Napadłek, Ph.D.,Eng.

The equipment investment realization is nearing completion. The project titled “Modernization of laboratories for testing fluids and tribological systems” is also financed by the Ministry of Science and Higher Education. As part of this investment the following equipment was purchased:

- E801 Nikon Eclipse research microscope with accessories;
- IROX Diesel portable fuel analyser;
- FTIR spectrophotometer with a microscope and a portable computer;
- DEWAR KL20 nitrogen tank;
- Portable device for evaluation of the state and degree of the wear of lubricating oils.

Within the framework of the research projects, own and developmental, mentioned above a line of modern research facilities was purchased. Some of them are shown in Figures 1 ÷ 15.



Fig. 1. Atomic absorption spectrophotometer



Fig. 2. FTIR spectrophotometer with IR microscope



Fig. 3. Apparatus for acid value testing



Fig. 4. Automatic set for normal distillation



Fig. 5. Stand for PLS-01 bearings testing



Fig. 6. T-11 tribotester (pin-on-disc)



Fig.7. NIKON research microscope with a set for image analysis



Fig. 8. Automatic set for testing low temperature properties



Fig. 9. KSV701 tensiometer for evaluation of the surface-energy properties of liquid lubricants

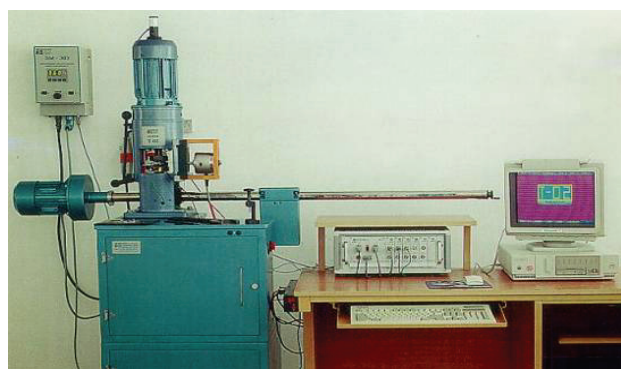


Fig. 10. T-02 four-ball apparatus for evaluation of liquids lubricity

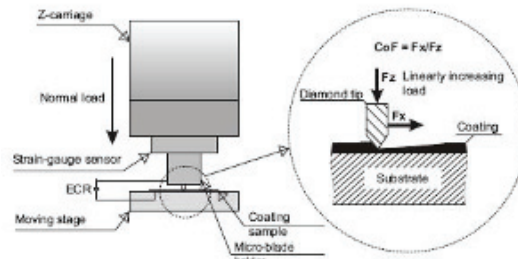
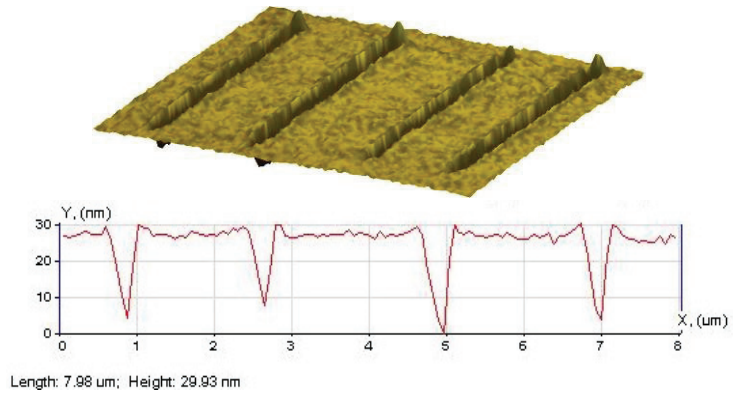


Fig. 11. UNMT research set (Universal Nano & Micro Tester), made by CETR (USA), for characterizing mechanical and tribological properties of surfaces



Fig. 12. General view of the stand for the laser spreading of oil microcontainers



Fig. 13. Laser machining of the cylinder sleeves



Fig. 14. Laboratory observation and archiving set for microscopic images consisting of: Discovery stereoscopic microscope, Canon camera, workstation PC



Fig. 15. "Surface Engineering Laboratory": optical microscope sets with specialized software for image archiving

In 2006, the Polish Centre for Accreditation accredited the Institute of Motor Vehicles and Transportation, FME (Certificate No. AB 733 of 28 June 2006). The Testing Station for Service Fluids is one of the three research stations of this Laboratory.

Education of students within the scope of tribology and related fields is being realized at the Division of Tribology, Surface Engineering and Operating Fluids Logistics on the basis of monographs, textbooks, and course books written by academics from the Department, for example (in Polish):

- Tribology, T1 and T2, MUT, Warsaw, 1979 (A. Łuczak, M. Machel, A. Wachal),
- Tribology, WNT, Warsaw, 1980 (M. Hebda, A. Wachal),
- Tribology and Service Fluids, P.I – Selected Problems of Tribology, MUT, Warsaw, 1995 (T. Kałdoński),
- Tribology and Service Fluids P.II – Service Fluids, MUT, Warsaw, 1994 (K. Baczewski),
- Tribology and Service Fluids – Subjects for laboratory work, MUT, Warsaw, 1995 (T. Kałdoński, T. Kowal, M. Licau, P. Szczawiński, W. Zielnik),
- Fuels for Diesel Engines, WKiŁ, Warsaw, 2004 (K. Baczewski, T. Kałdoński),
- Fuels for Petrol Engines, WKiŁ, Warsaw, 2005 (K. Baczewski, T. Kałdoński),
- Tribological Application of Boron Nitride, MUT, Warsaw, 2006, (T. Kałdoński),
- Study and Modelling of Abrasive Wear Processes of Hydraulic Precise Pairs, MUT, Warsaw, 2008 (T. Kałdoński).

5. Summary

Some good and bad things happened at Military University of Technology in the last decade. The latter ones were generally the result of external influences, although there were also centrifugal tendencies. As part of this trend, the Department of Mechanical Engineering, the foundation and mainstay of Military University of Technology since its beginning, was sometimes endangered — we hope this is the past. Regardless of the organizational and educational turbulence, most research teams at MUT always did their job, i.e. conducted scientific research, realized education tasks, often implemented in 200% and more, tried to get funds for the purchases of modern equipment. The Team of Division of Tribology, Surface Engineering and Fuels and Lubricants Logistics was such a group. The growth rate of publications and ongoing research indicate that it will be so in the coming years.

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- [3] Kałdoński, T., *Tribology for construction and maintenance of machines and technical devices*, Journal of KONES – Powertrain and Transport, Vol. 14 No 2, pp. 223-233, 2007.
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