Ministry of Education and Science of Ukraine
Sumy National Agrarian University
Faculty of Engineering and Technology
Department of Technical Service

Work program (syllabus) of the educational component

CC 5 – Tribotechnics

(mandatory)

Implemented within the educational program Industrial Machinery Engineering

(name)

in specialty 133 "Industrial machinery engineering"

(code, name)

third (educational and scientific level) level of higher education

Sumy – 2022

Developers: _____, Radionov O.V., Doctor of Technical Sciences, Professor, Professor of the Department of Technical Sciences

(signature) (surname, initials) (academic degree and title, position)

Reviewed, approved and ratified at a meeting of the Technical Service Department (name of the department)	protocol of August 30, 2022 No. 1
	Head departments _____ (signature) Tarelnyk V.B. (last name, initials)

Agreed:

Guarantor of the educational program _____ V.B. Tarelnyk

(signature) (full name)

Dean of the Faculty _____ V.M. Zubko

(signature) (full name)

Review of the work program (attached) provided by: V.M. Zubko _____

(Full name)

_____ M.Yu.Dumanchuk

(Full name)

Methodologist of the Department of Educational Quality, licensing and accreditation 03.09 N.M. Baranik

(signature)

Registered in the electronic database: date: _____ 2022.

Information on reviewing the work program (syllabus):

Academic year in which changes are made	Number of the appendix to the work program with a description of the changes	Changes reviewed and approved		
		Date and number of the department meeting minutes	Head of the Department	Educational program guarantor

1. GENERAL INFORMATION ABOUT THE EDUCATIONAL COMPONENT

1.	Name CC	Tribotechnology			
2.	Faculty/department	Faculty of Engineering and Technology / Department of Technical Service			
3.	Status CC	Mandatory			
4.	Program/Specialty (programs) of which the CC is a component (to be filled in for mandatory CCs)	Educational and scientific program "Industrial machinery engineering" in specialty 133 "Industrial machinery engineering"			
5.	NQF level	Level 8			
6.	Semester and duration of study	Daily 1semester, 8 weeks			
7.	Number of ECTS credits	3			
8.	Total hours and their distribution 1 semester – 90 hours	Contact work (classes)			Independent work
		Lectures	Practical / seminar	Laboratory	
		24	16	-	50
9.	Language of instruction	Ukrainian, English			
10.	Teacher/Educational Component Coordinator	Radionov O.V., Doctor of Technical Sciences, Professor, Professor of the Department of Technical Service Consultation hours– every Monday from 9:00 to 11:00, office 316m			
10.1	Contact information	alexander.radionov@ukr.net			
11.	General description of the educational component	The main focus of the educational component is on methodologies achieving operational properties of friction surfaces, assemblies and parts by due to strengthening effects of various physical nature and application of functional coatings.			
12.	Purpose of the educational component	Acquisition by applicants of the necessary amount of knowledge for studying tribotechnical laws that operate during the life cycle of machines. Mastering design and technological methods for increasing the wear resistance of working surfaces of machine parts, in order to ensure the operability of machines at optimal cost of work.			
13.	Prerequisites for studying CC, connection with other educational components of ESP	The educational component is based on knowledge and skills in solving applied scientific problems in the field of mechanical engineering using methods of modern science based on a systems approach, taking into account the complexity and uncertainty of the operating conditions of technological systems. The educational component is the basis for CC14 "Innovative technological solutions in industrial machinery engineering."			
14.	Academic Integrity Policy	If a candidate submits another candidate's work as their own, such work is canceled and retaken. In case of cheating, retake the corresponding assignment. In case of using text borrowings without proper citation (academic plagiarism), the work will be canceled.			
15	Link to the course in Moodle	https://cdn.snau.edu.ua/moodle/course/view.php?id=3717			

2. LEARNING OUTCOMES BY EDUCATIONAL COMPONENT AND THEIR RELATIONSHIP WITH PROGRAM LEARNING OUTCOMES

Learning outcomes for CC: After studying the educational component, the applicant is expected to be able to...	Program learning outcomes that the CC aims to achieve (indicate the number according to the numbering given in the ESP)						How is the LOA assessed?
	PLO1	PLO3	PLO4	PLO9	PLO11	PLO12	
LOA1. Formulate the main technical and economic requirements for the objects under study and apply existing scientific and technical means for their implementation.	X		X	X	X		Research work with presentation, peer evaluation
LOA2. To master the tribotechnical aspects of shaping parts, in order to achieve the necessary properties of friction surfaces, assemblies and parts through strengthening effects and application of special coatings.					X	X	Preparation of theses with justification of rational research methods in accordance with the selected object and task, mutual evaluation
LOA 3. Perform a critical analysis of structural materials and protective coatings used in tribocoupling of machine parts.		X		X	X		Research work on sample preparation for tribological studies
LOA 4. Formulate task of increase wear resistance and management friction due to the use of new designs of components, materials and operating conditions receptions.	X	X			X		Research paper with presentation
LOA 5. Make a scientifically based choice of technological methods for controlling the tribological characteristics of friction surfaces.	X		X	X		X	Research paper with presentation, Written exam (solving a complex problem and short theoretical answers)

PLO 1. Have conceptual and methodological knowledge in mechanical engineering and at the border of subject areas, as well as research skills sufficient to conduct scientific and applied research at the level of the latest world achievements in the relevant field, obtain new knowledge and/or implement innovations.
PLO 3. Formulate and test hypotheses; use appropriate evidence to substantiate conclusions, in particular, the results of theoretical analysis, experimental studies and mathematical and/or computer modeling, and available literature data.
PLO 4. Develop and research conceptual, mathematical and computer models of processes and systems, effectively use them to obtain new knowledge and/or create innovative products in mechanical engineering and related interdisciplinary areas.

PLO 9. Deeply understand the general principles and methods of mechanical engineering, as well as the methodology of scientific research, apply them in their own research in the field of industrial mechanical engineering and in teaching practice.
PLO 11. Carry out reengineering to improve the operational characteristics of machines, equipment, complexes, and production lines using safe technological and energy-efficient methods.
PLO 12. Increase the efficiency of systems engineering aimed at the creation, operation and utilization of industrial mechanical engineering products.

3. CONTENT OF THE EDUCATIONAL COMPONENT (COURSE PROGRAM)

Topic. List of issues to be addressed within the topic	Distribution within the overall time budget				Recommended reading
	Classroom work			Independent work	
	Lec	PC	Lab		
Topic 1. Methodological aspects of tribotechnical materials science. General information. Basic terms and concepts. Influence of the main parameters of surface geometry on the wear resistance of machine parts. General requirements for materials of friction pairs. Main problems of tribotechnical materials science and ways to solve them. Plastic deformation, recrystallization and mechanical properties. Criteria for ensuring the operability of materials in friction pairs. Distribution of materials in friction pairs. Methodology and criteria for selecting materials of friction pairs.	2	4		4	[1-8], [13], [14]
Topic 2. Analysis of types of wear of working surfaces. Analysis of the main reasons for the decrease in reliability and durability of parts. Wear of metal surfaces. Abrasive wear. Types and characteristics of wear. Cavitation wear. Wear during fretting corrosion and other types of wear. Properties of the surfaces of parts. Residual stresses, structural and phase transformations. Physicochemical properties of surfaces. Adsorption effect of strength reduction (Rebinder effect). Contacting of parts.	2	2		6	[1-10], [12], [28], [30]
Topic 3. No wear and tear effect. Classification of parts of rotary machines for which surface layer quality control is relevant. General information about wear of rotor parts. Mechanical seals. Sliding bearings. Impellers. Effect of non-wear. Energy criteria of friction and wear. Analysis of existing criteria for wear of metal surfaces. Development of a mathematical model of wear of coatings on metal surfaces of parts.	4	-		6	[1-5], [9-12], [14], [15], [17], [26-28]

Topic 4. Design methods for increasing the wear resistance of parts. Wear of working parts of machines. Friction in a sliding bearing. Rolling friction. Basic concepts of the wear mechanism of friction pairs. The wear mechanism of metal surfaces. The wear mechanism of polymers and rubber. Stages of wear of friction pairs.	4	-		6	[1-11], [14], [28]
Topic 5. Lubrication of machine parts. Materials for friction pairs. About the arrangement of friction pairs by hardness. Lubrication of connecting parts. Physico-chemical characteristics of lubricants. Deposits on parts in the lubrication system Selection of lubricants. Control and safety devices. Lubrication of units during operation.	2	-		8	[1], [2], [6-8], [14], [28]
Topic 6. Technological methods for increasing the wear resistance of parts. Surface hardening. Cementation. Nitriding. Ion nitriding. Boriding. Other methods of increasing the wear resistance of parts.	4	-		8	[1-8], [13], [14], [26], [28]
Topic 7. Combined technologies for strengthening and repairing parts surfaces. Combined technologies for strengthening the surfaces of parts. Multilayer electric spark coatings. Electric spark alloying (ESD) followed by PPD. ESD followed by ion nitriding. ESD followed by epilaminating.	4	10		2	[1-5], [9-14], [16-30]
Topic 8. Wear resistance of friction units under operating conditions. Increasing the reliability and durability of parts under operating conditions. Changing the quality of lubricants. Machine running-in. Machine testing. The influence of operating conditions on the intensity of wear.	2	-		10	[1], [2], [6-8]
Total	24	16		50	

4. TEACHING AND LEARNING METHODS

LOA	**Teaching methods**(work that will be carried out by the teacher during classroom lessons, consultations)	**Number of hours**	**Teaching methods**(what types of educational activities should a postgraduate student perform independently)	**Number of hours**
LOA 1	Problem lecture, thematic discussion, discussion of current issues	8	Independent work with textbook, studying theoretical material.	10
LOA 2	Showing examples of solving production problems	8	Independent work with textbook, studying	10

	using an interactive method in lectures and practical classes		theoretical material.	
LOA 3	Multimedia lecture, "brainstorming", discussion of current issues.	8	Independent work with the textbook, completion of individual tasks.	10
LOA 4	Showing examples of solving production problems using an interactive method in lectures and practical classes	8	Personalized learning,independent work with the textbook, completion of individual tasks.	10
LOA 5	Problem lecture, thematic discussion, "Round table", discussion of current issues.	8	Independent work with the textbook, learning through research.	10

5. EVALUATION BY EDUCATIONAL COMPONENT

5.1. Diagnostic assessment (indicated as needed)

5.2. Summative assessment

5.2.1. To assess the expected learning outcomes, there are

No.	Summative assessment methods	Points / Weight in the overall score	Date of compilation
1.	Completing an individual task	*25 points / 25%*	*For 2 weeks*
2.	Completing an individual task	*25 points / 25%*	*For 4 weeks*
3.	Analytical review with presentation	*20 points / 20%*	*At 6 weeks*
4.	Written exam (solving a complex problem and short theoretical answers)	30 points /30%	Week 8 (as scheduled)

5.2.2. Evaluation criteria

Component	**Unsatisfactorily**	**Satisfactorily**	**Good**	**Perfectly**
Completion of an individual task	*<11 points*	*11-15 points*	*16-21 points*	*22-25 points*
	Little awareness of the problem, a brief description is provided. Does not demonstrate independent thinking on the chosen topic.	The problem is mostly described (without analysis), the main points are not sufficiently substantiated, the argumentation is not sufficiently consistent, the presentation is absent or superficial. Only literature recommended by the teacher is reviewed.	Demonstrated understanding, depth and/or detail of the problem; main problem aspects are well-founded, arguments are consistent; different points of view are explored, presentation is meaningful, consistent. Literature reviewed is only recommended by the teacher.	The problem is sufficiently deeply and/or in detail disclosed, different views on the problem are analyzed; all main points are stated, the arguments are consistent and weighty; different points of view are analyzed, and one's own suggestions are given.
Analytical review with presentation	*<10 points*	*10-14 points*	*15-17 points*	*18-20 points*
	Task requirements not	Most requirements are met, but individual	All task requirements met	All task requirements have

	met	components are missing or insufficiently disclosed, there is no analysis of other approaches to the issue		been met, creativity and thoughtfulness have been demonstrated, and an original solution to the problem has been proposed.
Written exam	*<18 points*	*18-22 points*	*23-26 points*	*27-30 points*
	<60% correct answers, problem tasks not completed	60-74% correct answers, problem tasks partially completed	75-89% correct answers, problem tasks completed with minor inaccuracies.	90-100% correct answers, problem tasks completed with full, reasoned answers.

5.3. Formative assessment:

To assess current progress in learning and understand areas for further improvement,

No.	Elements of formative assessment	Date
1	Verbal feedback from the teacher and students regarding individual task iconography	Within 2 weeks
2	Verbal feedback from the teacher and students regarding individual task iconography	Within 4 weeks
3	Verbal feedback from the teacher and students regarding analytical review with presentation	Within 6 weeks
4	Written test with elements of problem tasks	During the 8th week

6. LEARNING RESOURCES (LITERATURE)

6.1. Main sources:

1. Tarelnyk V.B. Tribotechnology of machine parts: a textbook / [Tarelnyk V.B., Konoplyanchenko E.V., Martsynkovsky V.S., Antoshevsky Bohdan]; edited by Prof. V.B. Tarelnyk.- Sumy: Publishing house "MakDen", 2010.- 264 p.
2. Fundamentals of Tribology: Textbook / Antipenko A.M., Belas O.M., Voitov V.A. and others / Edited by Voitov V.A. – Kharkiv: KhNTUSG, 2008.- 342 p.
3. Increasing the stability of cutting tools by technological methods: a textbook / [Tarelnyk V.B., Konoplyanchenko E.V., Martsynkovsky V.S. and others]; edited by Prof. V.B. Tarelnyk.- Sumy: University Book, 2011.- 189 p.
4. Tarelnyk V.B. Tribotechnical materials science and tribotechnology in problems / V.B. Tarelnyk //.- Sumy: University Book, 2014.- 192 p.
5. Tarelnyk V.B. Modern methods of shaping friction surfaces of machine parts: Monograph / Tarelnyk V.B., Martsynkovsky V.S., Antoshevsky B..- Sumy: Publishing house "MakDen", 2012.-280 p.
6. Bhushan B. Modern Tribology Handbook Vol. 1 - Principles of Tribology (2001). 1760 p.

7. Introduction to tribology / Bharat Bhushan. - Second edition. John Wiley & Sons (2013). 738 p.
8. The tribology handbook [electronic resource] / edited by MJ Neale. - 2nd ed. Butterworth-Heinemann, (1995), 640p.
9. Antoszewski B., Tarelnik W., Konopliaczenko J.Improvement of resistance to fretting wear in sprzęgłach with elastic metal elements. W: Wybrana Problematyka w Technologiach Inżynierii Mechanicznej: Monografie, Studia, Rozprawy, M 135. redakcija Radek N., Sęk P. Kielce, Wydawnictwo Politechniki Świętokrzyskiej, 2020, pp. 67-76.
10. Selected problems of surface engineering and tribology: Monografie, Studia, Rozprawy, M 85/ V. Martsynkovskyy, V. Tarelnyk, B. Antoszewski, Ie. Konoplianchenko, A. Zhukov and etc.; edited by B. Antoszewski, V. Tarelnyk - Kielce: Wydawnictwo Politechniki Świętokrzyskiej, 2016. – 111p.
11. V. Tarelnyk, V. Martsynkovskiy, Ie. Konoplianchenko. Electroerosive alloying modes optimization at formation of a special microrelief on bronze sliding bearings friction surfaces Selected problems of mechanical engineering and maintenance. Monograph, edited by Norbert Radek. - Wydawnictwo Politechniki Świętokrzyskiej. - Kielce, 2012. – 188 p. (P.98-103).http://bc.tu.kielce.pl/127/1/Radek_Selected.pdf
12. Tarelnyk V., Konoplianchenko Ie., Martsynkovskyy V., Zhukov A., Kurp P. Comparative Tribological Tests for Face Impulse Seals Sliding Surfaces Formed by Various Methods, In: Ivanov V. et al. (eds) Advances in Design, Simulation and Manufacturing. DSMIE 2018. Lecture Notes in Mechanical Engineering. Springer, Cham, (2019), 382,https://doi.org/10.1007/978-3-319-93587-4_40

Additional sources:

13. Tarelnyk V.B. Control of the quality of the surface layers of parts by combined electroerosion alloying. - Sumy.: MakDen, 2002.-323p.
14. V.B. Tarelnyk, V.S. Marcinkovsky, B. Antoshevsky Improving the quality of sliding bearings: Monograph. - Sumy: "MakDen" Publishing House, 2006.-160 p.
15. V. Tarelnyk, D. Hlushkova, V. Martsynkovskyy, M. Dumanchuk, B. Antoszewski, Cz. Kundera, Ie. Konoplianchenko, N. Tarelnyk, S. Hudkov, A. Zahorulko. Increasing fretting resistance of flexible element pack for rotary machine flexible coupling Part 1. Analysis of the reasons affecting fretting resistance of flexible elements for expansion couplings. Journal of Physics: Conference Series. 1741 (2021) pp. 012048-1 - 012048-11.https://doi.org/10.1088/1742-6596/1741/1/012048
16. Antoszewski B, Gaponova OP, Tarelnyk VB, Myslyvchenko OM, Kurp P, Zhylenko TI, Konoplianchenko I. Assessment of Technological Capabilities for Forming Al-CB System Coatings on Steel Surfaces by Electrospark Alloying Method. Materials. 2021; 14(4):739. https://doi.org/10.3390/ma14040739
17. Tarelnyk V., Konoplianchenko Ie, Gaponova O., Antoszewski B., Kundera Cz., Martsynkovskyy V., Dovzhyk M., Dumanchuk M., Vasilenko O. (2020) Application of multicomponent wear-resistant nanostructures formed by

electrospark allowing for protecting surfaces of compression joint parts. In: Pogrebnjak A., Bondar O. (eds) Microstructure and Properties of Micro- and Nanoscale Materials, Films, and Coatings (NAP 2019). Springer Proceedings in Physics, Chapter 18, vol 240. Springer, Singapore, pp 195-209.https://doi.org/10.1007/978-981-15-1742-6_18

18. Pliszka I., Radek N., Corrosion Resistance of WC-Cu Coatings Produced by Electrospark Deposition, Procedia Engineering, Vol. 192, 2017, pp. 707-712,https://doi.org/10.1016/j.proeng.2017.06.122
19. Pablo D. Enrique, Zhen Jiao, Norman Y. Zhou, Ehsan Toyserkani, Dendritic coarsening model for rapid solidification of Ni-superalloy via electrospark deposition, Journal of Materials Processing Technology, Vol. 258, (2018), pp. 138-143.https://doi.org/10.1016/j.jmatprotec.2018.03.023
20. Burkov, AA Wear resistance of electrospark WC–Co coatings with different iron contents, Journal of Friction and Wear (2016) Volume 37, Issue 4, pp 385–388.https://doi.org/10.3103/S1068366616040048
21. Anisimov E., Khan AK, Ojo OA Analysis of microstructure in electro-spark deposited IN718 superalloy// Materials Characterization, Vol. 119, 2016, pp. 233-240.https://doi.org/10.1016/j.matchar.2016.07.025
22. Padgurskas J., Kreivaitis R., Rukuiža R, Mihailov V., Agafii V., Kriūkienė R., Baltušnikas A. Tribological properties of coatings obtained by electro-spark alloying C45 steel surfaces//Surface and Coatings Technology, Vol. 311, 2017, pp. 90-97,https://doi.org/10.1016/j.surfcoat.2016.12.098
23. Xiang Hong, Ke Feng, Ye-fa Tan, Xiao-long Wang, Hua Tan, Effects of process parameters on microstructure and wear resistance of TiN coatings deposited on TC11 titanium alloy by electrospark deposition, Transactions of Nonferrous Metals Society of China, Vol. 27, Issue 8, (2017), pp. 1767-1776.https://doi.org/10.1016/S1003-6326(17)60199-7
24. T. Penyashki, G. Kostadinov, I. Mortev, E. Dimitrova, Investigation of properties and wear of WC, TiC and TiN based multilayer coatings applied onto steels C45, 210CR12 AND HS6-5-2 deposited by non-contact electrospark process, Journal of the Balkan Tribological Association, Vol. 23, No. 2, 325–342 (2017).https://www.researchgate.net/publication/322199533
25. Ph.V. Kiryukhantsev-Korneev, AN Sheveyko, NV Shvindina, EA Levashov, DV Shtansky, Comparative study of Ti-C-Ni-Al, Ti-C-Ni-Fe, and Ti-C-Ni-Al/Ti-C-Ni- Fe coatings produced by magnetron sputtering, electro-spark deposition, and a combined two-step process, Ceramics International, Vol. 44, Issue 7, (2018), pp. 7637-7646.https://doi.org/10.1016/j.ceramint.2018.01.187
26. Tarel'nik, VB, Paustovskii, AV, Tkachenko, YG et al. Electric-spark coatings on a steel base and contact surface for optimizing the working characteristics of babbitt friction bearings. Surf. Eng. Appl. Electrochem. 53, 285–294 (2017). https://doi.org/10.3103/S1068375517030140
27. Tarel'nik, VB, Paustovskii, AV, Tkachenko, YG et al. Electrospark Graphite Alloying of Steel Surfaces: Technology, Properties, and Application. Surf. Eng.

Appl. Electrochem. 54, 147–156 (2018). https://doi.org/10.3103/S106837551802014X

28. Tarel'nik, VB, Konoplyanchenko, EV, Kosenko, PV et al. Problems and Solutions in Renovation of the Rotors of Screw Compressors by Combined Technologies. Chem Petrol Eng 53, 540–546 (2017). https://doi.org/10.1007/s10556-017-0378-7
29. Tarelnyk, VB, Paustovskii, AV, Tkachenko, YG et al. Electrode Materials for Composite and Multilayer Electrospark-Deposited Coatings from Ni–Cr and WC–Co Alloys and Metals. Powder Metal Met Ceram 55, 585–595 (2017). https://doi.org/10.1007/s11106-017-9843-2
30. V. Tarelnyk et al., "New Method of Friction Assemblies Reliability and Endurance Improvement", Applied Mechanics and Materials, Vol. 630, pp. 388-396, 2014https://doi.org/10.4028/www.scientific.net/AMM.630.388