



Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»



Department of machines
and
chemical devices and
oil refineries
productions

QUALITY ASSURANCE MODELS FOR DESIGN, MANUFACTURING, INSTALLATION, OPERATION AND REPAIR OF CHEMICAL ENGINEERING EQUIPMENT

Working program of the academic discipline (Syllabus)

Level of higher education	<i>Second (master's)</i>
Branch of knowledge	<i>13 Mechanical engineering</i>
Specialty	<i>133 Industrial engineering</i>
Educational program	Engineering and computer-integrated design technologies of innovative industry equipment
Discipline status	Selective
Form of education	Daytime
Year of training, semester	1st year, fall semester
Scope of the discipline	7.5 ECTS credits 225 hours
Semester control/ control measures	exam, MKR, current control
Lessons schedule	http://rozklad.kpi.ua/Schedules/ScheduleGroupSelection.aspx
Language of teaching	<i>Ukrainian</i>
Information about the course leader / teachers	Lecturer: candidate of technical sciences, associate professor Zubrii O.H. dataolegz1940@gmail.com Practical: Ph.D., associate professor O.G. Zubriy, contact detailsolegz1940@gmail.com
Placement of the course	Campus, http://ci.kpi.ua

Program of educational discipline

1 Description of the educational discipline, its purpose, subject of study and learning outcomes

The purpose of the educational discipline.

The purpose of the educational discipline is to form students' competence:

- ability to project activities in the field of engineering and technology*
- ability to present technical documentation in accordance with the requirements of current systems and design documentation standards*
- ability to the analysis of scientific and technical information, domestic and foreign experience in the technique and technology of chemical engineering*
- ability to perform design calculations of technological equipment of chemical industries*
- ability to the design of technological equipment of chemical industries*

the ability to work independently, individually, and make decisions within the framework of one's professional tasks.

1.2. The main tasks of the academic discipline.

According to the requirements of the educational and professional program, after mastering the academic discipline, students must demonstrate the following learning outcomes:

KNOWLEDGE:

- *modern approaches, methods and techniques, solving problems in equipment design*
- *modern approaches, methods and techniques, solving problems during maintenance, modernization and operation throughout the entire life cycle of technological equipment.*

SKILL:

- *using scientific and technical information, regulatory documents, professional knowledge, perform calculation and design, modernization and operation along the entire life cycle of technological equipment.*
- *apply methods of computer engineering using special software, perform computer design of equipment.*

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

- *The list of disciplines that the student needs to master (requirements for the level of training)*
- *mechanics of materials and structures-1. Basics of resistance of materials;*
- *mechanics of materials and structures-2. Resistance of materials under complex loading;*
- *structural materials and basics of metallurgy;*
- *processes and equipment of chemical technologies;*
- *calculation and design of typical equipment;*

The list of disciplines provided by this educational discipline:

- *Computer-integrated technologies of technological equipment design*
- *Modeling of synthesis and separation processes*
- *Innovative technologies for cleaning and processing materials*
- *construction design*

3. Content of the academic discipline

Chapter 1. CENTRIFUGES AND SEPARATORS

Topic 1.1. Centrifuges and separators. Purpose Basic terms and definitions. Classification, main structures, materials, allowable stresses. The shape of the liquid surface in the centrifuge rotor.

Chapter 1. CENTRIFUGES AND SEPARATORS

Topic 1.1. Centrifuges and separators. Purpose Basic terms and definitions. Classification, main structures, materials, allowable stresses. The shape of the liquid surface in the centrifuge rotor.

Basic terms and definitions of non-homogeneous liquid mixtures, methods of their separation and classification of relevant processes are given; the definition of the separation factor and the performance index is given. The main designs of centrifuges and separators and areas of their use are considered. The geometric characteristics of the space in which the

separation process takes place and the shape of the internal surface of the liquid in the centrifuge rotor are determined.

Topic 1.2. Load on drum parts. Calculation of normals in the momentless zone Calculation of normals in the boundary zone. Calculation of assemblies and parts of centrifuges for strength, stiffness and stability

Concepts of strength, rigidity and stability of parts and assemblies of centrifuges and separators are given. Active loads distributed over the surface and volume of the load on the drum body are considered. equations are given for determining the internal forces and stresses in the moment-free and shear zone of cylindrical, conical solid and perforated casings of the centrifuge drum and separator. The calculation of cylindrical and conical casings is given. momentless zone. Normative dependencies are given.

The loads on the edges of the drum of the centrifuge are considered. Differential equations of equilibrium, deformations and their solutions are presented. Edge stresses and strength conditions are determined.

Topic 1.3 Calculation of the bottom and sides of centrifuge drums

Designs of bottoms, covers and sides of centrifuges and separators are given. The simplest geometric models of them are given.

Stresses in a disk of constant thickness, which rotates rapidly, are considered; internal forces and stresses in an axisymmetric plate loaded with moment and transverse force uniformly distributed along the edge. Stresses in the plate under the combined action of centrifugal and edge loads, strength conditions are determined.

Topic 1.4. Critical speed of rotors of centrifuges and separators.

The concept of frequency of natural oscillations of an elastic system is explained. The phenomenon of resonance. Concept of critical speed. Active loads.

Derivation of the deflection equation. Determination of the critical speed of the rotor.

Analysis of the received decision.

Chapter 2. DRUM ROTATING APPARATUS

Topic 2.1. Drum rotating devices. Purpose Terms and definitions. Classification. Constructions

Appointments are being considered. rotary drum machines; basic terms and definitions; classification, basic designs of devices and individual components and parts.

Topic 2.2. Loads on nodes and parts. Calculation of strength, stiffness and stability.

The concepts of strength, stiffness and stability of parts and assemblies are given.

The calculation of loads on the hull is presented and analyzed. Inspection of the case for strength and rigidity is indicated. The forces acting on the brace are determined. Calculation of the bending moment in the section of the bandage. The calculation of the bandage for durability is given

Topic 2.3. Contact strength of rims and rollers.

The concepts of contact strength and examples of contact strength of parts in engineering are given; features of the destruction of parts in case of violation of contact strength. The contact stresses in the tire and rollers are determined, stress plots are shown; the stress state is analyzed, and the strength conditions are stated.

Section 3. STIRRING EQUIPMENT

Topic 3.1. Purpose Terms and definitions. Classification. Constructions

Appointments are being considered. mixing devices; basic terms and definitions; classification, basic designs of mechanical mixing devices and their individual units and parts.

Topic 3.2. Calculation of mixing devices. Calculation of shafts for vibration resistance, strength and stiffness

The concept of the resistance force when moving a body in a liquid medium, the calculation of the power spent on mixing is presented. The calculation of the equivalent resistance force and the coordinate of the point of its application to the blade of a paddle mixer, inclined blade, elliptical blade, the relationship between force and power are explained. Bending and torque moments are determined. The algorithm for calculating the strength of the blade is given.

Calculation of shafts for vibration resistance, strength and stiffness. The concept of frequency of natural oscillations of an elastic system is explained. The phenomenon of resonance. Concept of critical shaft speed. Calculation schemes of shafts and determination of critical speed are given. The method of calculating shafts for strength and stiffness is taught.

4. Educational materials and resources

Basic

1. Zubrii O.G. Synopsis of lectures
2. Calculation of centrifuges: Methodological instructions for conducting practical classes in the disciplines "Constructive design of equipment of chemical productions" and "Computer design of equipment of central processing plants" for students of the specialties "Equipment of chemical productions and enterprises of building materials and "Equipment of the forest complex" / Incl.: O. G. Zubrii, O.O. Seminsky - K.: NUTU "KPI", 2010. - 62 p
3. DNAOP 0.00-1.07-94* Rules for the construction and safe operation of vessels operating under pressure, -K.: Derzhnadrachhoranova prati, 1998 273p.
4. GOST 225777-77 Stirring devices for liquid inhomogeneous media. terms and definitions.
5. GOST34233.1-2017 Vessels and devices. STANDARDS AND METHODS OF STRENGTH CALCULATION. General requirements.
6. GOST 34233.2—2017 Vessels and apparatus STANDARDS AND METHODS OF STRENGTH CALCULATION Calculation of cylindrical and conical shells, convex and flat bottoms and lids.
7. GOST34233.3—2017 Vessels and apparatus STANDARDS AND METHODS OF STRENGTH CALCULATION Strengthening of holes in shells and bottoms under internal and external pressure. Calculation of the strength of shells and bottoms with external.
8. GOST 34233.6-2017 Vessels and apparatus STANDARDS AND METHODS FOR STRENGTH CALCULATION Strength calculation for low-cycle loads
9. GOST 34233.8—2017 Vessels and devices. STANDARDS AND CALCULATION METHODS FOR STRENGTH. Vessels and devices with jackets
10. OST 26-01-1271-81. Centrifuge rotors. Norms and methods of strength calculation.
11. RD 26-01-158-86. Drum sets. Norms and methods of strength calculation
12. Methodical instructions for the implementation of a course project for students of the specialty "Equipment of chemical production and building materials enterprises" from the discipline "Calculation and design of rotating equipment elements" Electronic resource of NTUU "KPI" comp. O.H. Zubrii, S.V. Gulienko. - Kyiv. NTUU "KPI", 26 p.
13. Dobronogov V.G., Zubriy O.G., Voronin L.G. Algorithm for calculation of vibration resistance of shafts of mechanical mixing devices.
14. Dobronogov V.G., Zubriy O.G., Voronin L.G. Algorithm for calculating the strength of shafts of mechanical mixing devices.
15. Andreev I.A., Zubrii O.G., Mikulenok I.O. Application of materials in chemical engineering. Steel and cast iron. Education manual., - K.: 1999.-148 p. – 168 copies. (26 copies).

Electronic versions of the mentioned materials are available on the website of the MAHNV department, personal websites of teachers who conduct classes.

When mastering a discipline, performing practical classes, individual tasks and a course project, the materials of the standards are mandatory.

On the recommendation of teachers and personal initiative, you should familiarize yourself with the materials posted on the Internet.

The specified resources are related to specific topics of the discipline

Educational content

5. Methods of mastering an educational discipline (educational component)

Lecture classes

Lectures are aimed at:

- provision of modern, comprehensive in-depth knowledge of the discipline, the level of which is determined by the target attitude to each specific topic;
- provision of critical creative work together with the teacher in the process of work;
- education of students' professional qualities and development of their independent creative thinking;
 - awareness of world trends in the development of science in the area of calculation and construction of property;
 - awareness of the methods of processing information resources and determining the main directions for solving specific scientific and technical problems;
 - teaching development materials in a clear and high-quality language in compliance with structural and logical connections, explaining all the given terms and concepts available for perception by the audience.

No. z/p	The name of the topic of the lecture and a list of the main questions (a list of didactic tools, references to the literature and tasks on SRS)	Number hours
	Chapter 1. Centrifuges and separators	
	Topic 1.1 Centrifuges and separators. Purpose Basic terms and definitions. Classification, main structures, materials, allowable stresses. The shape of the liquid surface in the centrifuge rotor.	
1	Lecture 1. Centrifuges and separators. Purpose Basic terms and definitions. Classification, main designs. The shape of the liquid surface in the centrifuge rotor. Basic terms and definitions of non-homogeneous liquid mixtures, methods of their separation and classification of relevant processes are given; the definition of the separation factor and the performance index is given. The main designs of centrifuges and separators and areas of their use are considered. The shape of the liquid surface in the centrifuge rotor. literature [1,2,3,4,5,6,7,8,9,11,14] Tasks on SRS. Classification, main designs of centrifuges and separators Literature [1,5]	2
	Topic 1.2. Load on drum parts. Calculation of normals in the momentless zone.	
2	Lecture 2. Active loads on the drum core. Calculation Values of active loads - pressure, equivalent pressure...inertial load component are derived. Calculation of the normal in the momentless zone. The main provisions of the momentless theory are explained. Internal forces and stresses are determined, stress state analysis is performed. Calculated and	2

	operational wall thickness, permissible rotation frequency are determined. Thin-walled condition literature [1,2,,9,11,14] Tasks on SRS. Determination of active loads. Literature [1,2,11]	
3	Lecture 3. Calculation of a cylindrical joint in the momentless zone. Internal forces and stresses are determined, stress state analysis is performed. Calculated and operational wall thickness, permissible rotation frequency are determined. literature [1,2,5,6,7,9,11,14] Tasks on SRS. Determination of stresses in the wall of conical and perforated tubes. Literature [1,2,7,9,11,14]	2
4	Lecture 4. Calculation of conical and perforated drum cores of centrifuges. The internal forces and stresses in the perforated cylindrical shell are determined, the analysis of the stress state is performed. Calculated and operational wall thickness, permissible rotation frequency are determined. A comparison is made with a continuous custom. literature [1,2,5,6,7,9,11,14] Tasks on SRS. Determination of stresses in the wall of conical and perforated tubes. Literature [1,2,7,9,11,14]	2
	Topic 1.3 Calculation of customs in the marginal zone	
5	Lecture 5. Calculation of the custom in the marginal zone. The reasons for the occurrence of edge loads are explained. The sequence of calculating the cylindrical shape of the centrifuge drum in the edge zone is explained. The main equation of the compatibility of deformations is given and the rule of signs is explained. The method of calculating unit movements is given. literature [1,2,6,7,8,9] Tasks on SRS. Designs of drum parts connection nodes. Definition of movements. Literature [1,2,5,7]	2
6	Lecture 6. Calculation of the custom in the marginal zone. Boundary loads on the cylindrical hub of the centrifuge drum are determined. A method of calculating the forces, moments, and stresses acting on the element of the cylindrical shell is carried out literature [1,2,6,7,8] Tasks on SRS. Designs of drum parts connection nodes. Definition of movements. Literature [1,2,9,5,7]	2
		2
	Topic 1.4 Calculation of the bottoms of centrifuge drums, separators	
7	Lecture 7. Calculation of the bottom of the centrifuge drum. Calculation of the bottom according to the model of a rapidly rotating disk. Designs of the bottoms of centrifuge drums and separators The calculation models of the bottom or side of the centrifuge drum are explained. The model of a rapidly rotating thin-walled disk is substantiated. General dependences for stresses in a thin-walled disk are derived. Constant integrations are determined from the boundary conditions. Dependencies for stresses in solid and annular disks are recorded. Radial dimensions and permissible rotation frequency are determined from strength conditions literature [1,	2

	<p>Tasks on SRS. Designs of bottoms of centrifuge drums and separators. Calculation of a solid disk. Calculation of the ring disk. Refer to the literature [8] to familiarize yourself with the method of calculating the stepped disk. Literature [1,2,7,8,11]</p>	
8	<p>Lecture 8.Calculation of the bottom loaded with distributed load, ultimate moment and ultimate force according to the plate model . Their calculation by the initial effort method is explained. Determination of stresses due to internal forces. Strength condition. literature[1,2,7,9] Tasks on SRS.Familiarize yourself with the method of initial efforts. Literature [1,2,7]</p>	2
	<p>Topic 1.5Critical speed of rotors of centrifuges and separators</p>	
9	<p>Lecture 9.Critical speed of rotors of centrifuges and separators The concept of the frequency of natural oscillations of an elastic system. The phenomenon of resonance. Concept of critical speed. Use of resonance in technology. Critical speed of rotors of centrifuges and separators. Active loads. Deflection equation Determination of the critical speed of the rotor. Analysis of the received decision literature[1,2,8]. Tasks on SRS. Critical speed of rotors. Literature [1,2,8].</p>	2
	<p>Chapter 2. Design and calculation of rotary drum machines</p>	
	<p>Topic 2.1. Drum rotating devices. Purpose Terms and definitions. Classification. Constructions. .</p>	
10	<p>Lecture 10.Drum rotating devices. Purpose Terms and definitions. Classification. Designs of drum rotary devices. The definition of "Rotary drum apparatus" is given. The signs of classification are given, the classification is given. The choice of the apparatus, the material of the parts is explained. The determination of the physical properties of the material and the allowable stresses of the material of the parts. The requirements for the design of the casing of the rotary drum apparatus are substantiated literature[1,9,]. Tasks on SRS. Designs of drum rotary devices. Literature [1].</p>	2
	<p>Topic 2.2.Loads on nodes and parts. Calculation of strength, stiffness and stability</p>	2
11	<p>Lecture 11.The calculation of the bending moment on the body of the rotating drum apparatus is explained. .Calculation of the hull under the action of bending and torques, transverse force literature[1,]. Tasks on SRS. Designs of drum rotary devices. Literature [1,].</p>	2
12	<p>Lecture 12Determination of the forces acting on the bandage fixed on the shoes. Calculation of forces in a key section, Castigliano's theorem. Determination of the bending moment in the section of the bandage. Calculation of the bandage for strength literature[1,,]. Constructions of bandages and methods of connection with the body of the apparatus.</p>	2

thirteen	<p>Lecture 13. Contact pressure and contact stresses in the material of the tire and roller. Calculation of the tire and rollers from the conditions of contact strength.</p> <p>The geometric dimensions of the contact strip, the contact pressure and its distribution over the width of the contact strip are calculated. The stresses in the contact zone are determined. The analysis of the stress state is performed and a conclusion is made regarding strength.</p> <p>literature[1,8,9]</p> <p>Tasks on SRS. Designs of support and support-support stations. Prepare the topic contact strength.. Literature [1,8,]</p>	2
14	<p>Lecture 14 Inspection of the bandage, support and thrust rollers for contact strength</p> <p>literature[1,8]</p> <p>Tasks on SRS. Designs of support and support-support stations. Prepare the topic contact strength.. Literature [1,8,]</p>	2
	Chapter 3. Stirring devices	
	Topic 3.1. Appointment. Terms and definitions. Classification. Constructions	
15	<p>Lecture 15 Purpose Terms and definitions. Classification. Constructions.</p> <p>The definition of the term mixing, methods of mixing, classification of mixing devices is given. Designs of the main types of mixers are given. The power calculation for the adopted type of mixer is explained. Resistance of the body when moving in a liquid. Power consumption, calculation of torque and bending moments</p> <p>literature[1, 10]</p> <p>Tasks on SRS. Classification and designs of mixing devices</p> <p>Literature [1,10]</p>	2
	Topic 3.2. Calculation of mixing devices. Calculation of shafts for vibration resistance, strength and stiffness.	2
16	<p>Lecture 16. Determination of the frequency of natural oscillations of the shafts and the critical frequency</p> <p>The frequency of natural oscillations of the shafts and the critical frequency are defined. Rigid and flexible shafts. Vibration resistance condition. Determination of the frequency of natural oscillations of shafts with one concentrated mass, Determination of the frequency of natural oscillations of shafts with several concentrated masses. Determination of the natural oscillation frequency of shafts with distributed mass.</p> <p>literature[1, 10,]</p> <p>Tasks on SRS. Study the material on the topic of natural shaft frequency and forced oscillations. Resonance phenomenon and critical frequency. Literature [1,9,10,]</p>	2
17	<p>Lecture 17 Calculation of shafts for stiffness and strength</p> <p>The rules and dependencies for determining the active and reactive forces acting on the shaft are given. Calculation of moments and stresses in dangerous sections. Strength conditions are given. According to the accepted geometric dimensions, and</p> <p>the movement of the shaft is determined by known efforts. Rigidity condition.</p> <p>literature[1,9,10,]</p>	2

	Tasks on SRS. Study the material on the topic "Calculation of shafts for stiffness". Literature [1,9,10,]	
	Topic 3.2. Calculation of mixing devices. Calculation of shafts for vibration resistance, strength and stiffness.	2
18	Lecture 18. Determination of the frequency of natural oscillations of the shafts and the critical frequency The frequency of natural oscillations of the shafts and the critical frequency are defined. Rigid and flexible shafts. Vibration resistance condition. Determination of the frequency of natural oscillations of shafts with one concentrated mass, Determination of the frequency of natural oscillations of shafts with several concentrated masses. Determination of the natural oscillation frequency of shafts with distributed mass. literature [1,9,10,] Tasks on SRS. Study the material on the topic of natural shaft frequency and forced oscillations. Resonance phenomenon and critical frequency. Literature [1,9,10,]	2

Practical training

The main goals of practical classes are to systematize and consolidate the knowledge gained at lectures and during independent work with theoretical material; acquired skills and experience in using calculation models for calculations of parts for strength, rigidity, stability, skills and experience in using reference literature, regulatory documents: skills and experience in creating sketches of parts and nodes.

	Name of the subject of the lesson and list of main questions (list of didactic support, references to the literature and tasks on the SRS)	Number of hours
	Chapter 1. Centrifuges and separators	
	Topic 1.1. Centrifuges and separators. Purpose Basic terms and definitions. Classification, main designs. The shape of the liquid surface in the centrifuge rotor. .	
1	Practical lesson 1. Centrifuges. Selection of a centrifuge. Selection of material. Determination of physical properties of the material and allowable stresses in momentless and momentary zones. The shape of the liquid surface in the rotor.	2
	Topic 1.2. Load on drum parts. Calculation of normals in the momentless zone	
2	Practical lesson 2.. The thin-wall condition of the centrifuge rotor core is checked. Calculation of active loads. for a cylindrical drum sleeve. Determination of internal forces and stress, stress state analysis. Determination of the calculated and executive wall thickness, permissible rotation frequency from strength conditions.	2
3	Practical lesson 3. Determining the thin-walled core of the centrifuge rotor. Calculation of active loads. for a conical drum head. Determination of internal forces and stress, analysis of the stress state is performed. Determination of the calculated and executive wall thickness, permissible rotation frequency.	2
4	Practical lesson 4. The thin-wall condition of the centrifuge rotor core is checked. Calculation of active loads. for a perforated drum liner.	2

	<i>Calculation of internal forces and stress is performed, analysis of the stress state is performed. Determination of the calculated and executive wall thickness, permissible rotation frequency</i>	
	<i>Topic 1.3. Calculation of customs in the marginal zone</i>	
5	Practical lesson 5. <i>Calculation of customs in the marginal zone Unit movements are calculated. The results are summarized in a table. End force and moment are determined. Movements are calculated. The results are summarized in a comparative table. Analysis is in progress.</i>	2
6	Practical lesson 6. <i>Calculation of customs in the marginal zone The forces and moments acting on the element of the cylindrical shell are calculated. Stresses are calculated. The results are summarized in a comparative table. The results are summarized in a comparative table. A stress graph is constructed. An analysis is performed and a conclusion is drawn regarding strength</i>	2
	<i>Topic 1.4 Calculation of the bottom and side of drums of centrifuges and separators</i>	
7	Practical lesson 7 <i>Calculation of the bottom (or side) as a rapidly rotating disk. Stresses are calculated depending on the current radius. The results are summarized in a comparative table.</i>	2
8	Practice session 8 <i>Calculation of the bottom as a plate loaded with pressure, end force and moment. Stresses are calculated depending on the current radius. The results are summarized in a comparative table and on a graph. Analysis of results. . The total stresses are calculated depending on the current radius. The results are summarized in a comparative table. A stress graph is constructed. An analysis is performed and a conclusion is drawn regarding strength</i>	2
	<i>Topic 1.5. Critical speed of rotors of centrifuges and separators</i>	
9	Practical lesson 9 <i>Critical speed of the centrifuge rotor. The values on which the critical speed depends are calculated. The value of the critical speed is determined. An analysis is performed and a conclusion is made regarding stability.</i> Control work for chapter 1	2
	Chapter 2. Drum rotating devices.	
	<i>Topic 2.1. Drum rotating devices. Purpose Terms and definitions. Classification. Constructions</i>	
10	Practical lesson 10 <i>Drum rotating devices. Purpose Terms and definitions. Classification. Constructions The device, the materials of the parts are selected. Determination of the physical properties of the material and the allowable stresses of the material of the parts. construction of the casing of the drum rotary apparatus. Determination of the mass of the device. Active loads on the body of the drum rotating apparatus.</i>	2
	<i>Topic 2.2. Loads on nodes and parts. Calculation of strength, stiffness and stability.</i>	
11	Practical lesson 11. <i>The resistance reactions are calculated. The reactions in the supports are determined separately from the distributed</i>	2

	<i>load and concentrated forces, the moment and the transverse force in the cross-sections of the hull. Checking the hull for strength, stiffness and stability</i>	
12	<p>Practical lesson 12Structural calculation of the bandage and the roller. Calculation of active loads on the truss with continuous contact with the body and contact at individual points</p> <p>The structural calculation of the bandage and the roller is performed. Active loads on the truss are determined during continuous contact with the body and contact at individual points. Calculation of forces in the key section of the truss. Calculation of the moment and force in the key section of the truss is performed.</p>	2
thirteen	<p>Practical lesson 13.. Determination of the moment in the sections of the truss. An analysis is performed and a conclusion is made regarding the dangerous section. The bandage is tested for strength</p>	2
14	<p>Practical lesson 14.Determination of temperature stresses. Checking the bandage for strength and durability under the simultaneous action of loads.</p> <p>Based on the given temperatures, the temperature stresses are calculated. The bandage is checked for strength and durability under the simultaneous action of loads.</p>	2
	Topic 2.3. Contact strength	
15	<p>Practical lesson 15Contact strength.</p> <p>The geometric dimensions of the contact strip, the contact pressure in the middle of the contact strip and its distribution along the width of the maximum stress are calculated. An analysis is performed and a conclusion is made regarding strength.</p> <p>Control work for chapter 2</p>	2
	Chapter 3. Stirring devices	
	Topic 3.1. Purpose Terms and definitions. Classification. Constructions	
16	<p>Practical lesson 16Choice of agitator. Determination of power, torque and bending moments.</p> <p>According to normative materials, the type of mixer is adopted and its dimensions are determined. Calculation of power for the adopted type of mixer, calculation of torque and bending moments is carried out. The strength of the burgher's blade is being tested. An analysis is performed and a conclusion is made regarding strength.</p>	2
	Topic 3.2. Calculation of mixing devices. Calculation of shafts for vibration resistance, strength and stiffness	
17	<p>Practical lesson 17.Calculation of the shaft from the conditions of vibration resistance.</p> <p>According to normative materials, coefficients and values necessary for determining the frequency of natural oscillations are calculated.</p>	2
18	<p>Practical lesson 18.Calculation of defects on strength and. rigidity.</p> <p>Active and reactive forces acting on the shaft are determined by the accepted geometric dimensions. Moments and stresses in dangerous cross-sections. The condition of strength is checked. According to the</p>	2

	<i>accepted geometric dimensions, the movements of the shaft are determined by known forces. The analysis is performed, the displacements are compared with the permissible ones, and a conclusion is made regarding stiffness</i>	
--	--	--

6 . Independent work of student

The student's independent work is 105 hours, of which 30 hours are for exam preparation.

The main task of students' independent work is mastering the knowledge of the material of the discipline, mastering the methods of calculations and design developments. development of problem formulation skills and ways to solve them.

mastering knowledge about constructions and calculations, through personal search for information, formation of active interest and creative approach in educational work.

Independent work includes determining the properties of materials and calculated values according to standards; development of schemes, tables, graphs that explain the performance of individual tasks; drawings nodes and parts according to an individual task. Work is performed using computer equipment.

No. z/p	The name of the topic submitted for independent processing	Number of hours
Chapter 1. Centrifuges and separators		
1	<i>Topic 1.1 Centrifuges and separators. Purpose Basic terms and definitions. Classification, main designs. The shape of the liquid surface in the centrifuge rotor[1,2,11,14].</i>	4
	<i>Graph of the shape of the surface. calculation of the volume of liquid in the rotor</i>	
	<i>Topic 1.2. Load on drum parts. Calculation of normals in the momentless zone. Load schedule. Drawing of cylindrical, conical, and perforated mandrels [1,2,11,14]</i>	10
	<i>Topic 1.3. Calculation of customs in the marginal zone. Schemes of loads. Graphs of changes in effort along the length of the rod. Drawing of a cylindrical border on the edge. [1,2,5,7]</i>	6 8 6
	<i>Topic 1.4 Calculation of the bottoms of centrifuge drums, separators. Sketches for calculation schemes. Stress graphs depending on the current radius. [1,2,7,8,11]</i>	
Chapter 2. Drum rotating devices		
2	<i>Topic 2.1. Drum rotating devices. Purpose Terms and definitions. Classification. Designs of devices. and their components, namely, the construction of the drum (body), nozzles, seals, bandages and methods of their fastening, support and support-support stations, loading and unloading chambers, mechanisms for entering the fluid medium. [1,9,16,25].</i>	4
		14
		4

	<i>Loads on nodes and parts. graph of the plot of internal forces and stresses Calculation of strength, stiffness and stability [1,8,16] Contact strength [1,8,10,] Schemes of loads, graphs of loads and stresses</i>	
Chapter 3. Stirring devices		
3	<i>Topic 3.1 Purpose. Terms and definitions. Classification. Constructions of mechanical mixing devices [1,] Calculation of mixing devices [1,]. Designs of mechanical mixing devices. graphic illustrations for calculation schemes. Graphs of load and stress diagrams</i>	5 14
4	<i>Preparation for the exam</i>	30

Policy and control

7. Policy of educational discipline

The system of requirements that the teacher sets before the student

Rules for attending lectures and practical classes

- *Attending classes is mandatory.*
- *do not be late for classes and do not miss them without valid reasons;*

Rules of behavior in classes:

- *Students are obliged to actively participate in the educational process;*
- *do not interfere with the teacher conducting classes*
- *not to be distracted by actions not related to the educational process*
- *turn off phones during class;*
- *use means of communication only to search for information on the teacher's Google Drive or on the Internet, etc.);*

Rules for the protection of individual practical tasks.

In the practical lesson, the necessary calculations are performed, the teacher checks their validity, the student completes the work. Works designed in accordance with the requirements for textual and design documents are submitted for protection. Requirements are announced by the teacher at the first practical session

The work must be protected and credited no later than the next practical session.

Rules for assigning incentive and penalty points

incentive points can be awarded by the teacher for active and honest performance of work and for creative works and working hypotheses

the sum of incentive points cannot exceed 25% of the rating scale.

Penalty points within the academic discipline are usually not provided

Policy of deadlines and rescheduling

In the event of academic debts arising from the academic discipline or any force majeure circumstances, students should contact the teacher to coordinate actions related to solving the existing problems.

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism refers to the absence of references when using printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes, tests, exams.

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details: <https://kpi.ua/code>

Policy of academic behavior and ethics

Students should be tolerant, respect the opinions of others, formulate objections in the correct form, adequately support feedback during classes.

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details: <https://kpi.ua/code>

8. Types of control and rating system for evaluating learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working schedule curriculum:

Semester	Training time		Distribution of study hours					Control measures
	Credits	Acad. hours	audio hours	Lectures	Practical	SRS	MKR	Semester control
1	7.5	225	72	32	36	153	1	examination

The student's rating in the discipline is 100 points (maximum value) and has two components:

1. starting 60 points;
2. exam answer 40 points.

The starting rating (during the semester) consists of points that the student receives for: work in practical classes (18 classes); and execution of modular control work

System of rating points

1. Practical training.
 - "excellent", creative disclosure of the question, fluency in the material - 2.5 points
 - "good", deep disclosure of the question - 2 points.
 - "enough", disclosure of the main provisions of the question - 1.5 points
 - "unsatisfactory", unsolved question - 0 points.
2. modular control work
 - "excellent", creative disclosure of the question, fluency in the material - 15 points
 - "good", deep disclosure of the question - 12 points.
 - "enough", disclosure of the main provisions of the question - 9 points
 - "unsatisfactory", unsolved question - 0 points.

A necessary condition for admission to the exam is the completion of the control work and the absence of arrears for practical classes. The starting rating is at least 36 points.

The maximum value of the rating semester scale:

$$R = 2.5 \cdot 18 + 15 \cdot 1 + 40 = 45 + 15 + 40 = 100 \text{ points}$$

At the exam, students perform written work. Each paper contains four tasks (questions). The first two theoretical questions, the third theoretical or task, the fourth question is a

description of the structure, and the first two questions are more complex and voluminous. The maximum score for questions is 12 points for the first two questions, 8 points for the third and fourth

Evaluation system of the first two questions:

- "excellent", complete answer (at least 90% of the required information) - 11-12 points
- "good", sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 7-10 points;
- "enough", incomplete answer (at least 60% of the required information and some errors) - 7-9 points;
- "unsatisfactory", unsatisfactory answer - 0 points.

Evaluation system for the third and fourth questions:

- "excellent", complete answer (at least 90% of the required information) - 7-8 points
- "good", sufficiently complete answer (at least 75% of the required information or minor inaccuracies) – 6-7 points;
- "enough", incomplete answer (at least 60% of the required information and some errors) - 4-5 points;
- "unsatisfactory", unsatisfactory answer - 0 points.

The sum of the starting points and the points for the examination work is transferred to the examination grade according to the table:

$R=rC+rE$	Rating
100...95	Perfectly
94...85	Very good
84...75	Fine
74...65	Satisfactorily
64...60	Enough
Less than 60	Unsatisfactorily
There are not included practical works or starting rating is less than 36 points	Not allowed

9. Additional information on the discipline (educational component)

a list of questions submitted for semester control (as an appendix to the syllabus);

Main questions of examination tickets

Centrifuges. separators

Analyze designs of centrifuges.

To analyze the designs of centrifuges with knife discharge of sediment

To analyze the designs of centrifuges with auger sediment discharge

Analyze the design of centrifuges with pulsating sediment discharge 3.

The shape of the inner surface of the liquid in the centrifuge rotor

Justify the calculation of the pressure in the liquid layer of the cylindrical sleeve of the centrifuge drum.

To substantiate the calculation of the load P_i from the action of the inertial force in the cylindrical shaft of the centrifuge rotor

Justify the calculation of the net pressure on the bottom of the centrifuge drum

Internal forces and stresses in the moment-free zone of the cylindrical sleeve of the centrifuge drum

To substantiate the determination of internal forces and stresses in the moment-free zone of the cylindrical shaft of the centrifuge rotor.

Perform an analysis of the stress state in the moment-free zone of the cylindrical shaft of the centrifuge rotor

Calculation of the wall thickness of the cylindrical solid liner of the centrifuge drum.

Justify the calculation of the permissible speed for the cylindrical hub of the centrifuge drum.

Checking the condition of the thin-walled cylindrical continuous sleeve of the centrifuge drum

Internal forces and stresses in the perforated cylindrical casing of the centrifuge drum

To substantiate the calculation of the wall thickness of the perforated cylindrical sleeve of the centrifuge rotor

Explain the sequence of calculation of the cylindrical shell of the centrifuge drum in the edge zone.

Determination of limit loads on the cylindrical hub of the centrifuge drum.

The differential equation of the deflection of the cylindrical shaft of the centrifuge drum

The equation of the deflection of the cylindrical sleeve of the centrifuge drum.

Checking the strength of the cylindrical sleeve of the centrifuge drum on the edge

Justify the calculation of the cylindrical barrel of the supercentrifuge drum

Structures of bottoms of centrifuges.

To substantiate the determination of stresses in a rapidly rotating disk.

Calculation of the strength of a rapidly rotating annular disk.

Calculation of the strength of a solid, rapidly rotating disk.

Calculation of the bottom (side) of the centrifuge drum loaded with extreme moment.

Analyze the calculation of the critical speed of the supercentrifuge rotor

To substantiate the determination of the critical speed of the centrifuge rotor.

Drum machines

Fields of application of drum rotary devices

Designs of drum rotary devices.

Analyze the structure of the body of the drum rotary apparatus

To analyze the methods of fastening bandages on the body of the drum rotary apparatus

To analyze the designs of the crown gear of the rotating drum apparatus

Analyze the structure of the support station of the drum rotary apparatus

Analyze the calculation of the loads on the body of the drum rotating apparatus.

Calculation of the bending moment in the cross-sections of the housing of the drum rotating apparatus

Calculation of the torque on the body of the drum rotating apparatus

Calculation of the body of the drum rotary apparatus for strength.

To substantiate the calculation of the body of the drum rotary apparatus for stiffness.

Calculation of the body of the rotating drum apparatus for stability.

Calculation of the forces acting on the bandage of the drum rotating apparatus.

To substantiate the calculation of the bending moment in an arbitrary section of the bandage of the drum rotating apparatus.

Determination of forces in the key section of the truss.

To substantiate the inspection of the bandage for strength from the action of the bending moment.

Calculation of the geometric dimensions of the support rollers of the drum rotating apparatus

Explain the contact pressure in the bandage-support roller pair

Contact stresses in the materials of the bandage (roller)

Justify the calculation of the bandage (roller) on the contact strength.

mixing devices

Classification of mixing devices.

Designs of paddle mixers.

To evaluate the constructions of anchor stirrers.

To evaluate the designs of turbine mixers.

To evaluate the designs of screw mixers.

Analyze designs of planetary mixers

The force of resistance of a body moving in a liquid.

To substantiate the calculation of the net resistance force of the blade of the paddle mixer.

To justify the calculation of the coordinate of the point of application of the net resistance force to the blade of the paddle mixer.

Justify the strength calculation of the blade of the paddle mixer

Explain the strength calculation of the blade of the anchor stirrer

To substantiate the calculation of the net resistance force of the blade of the anchor (elliptical) stirrer

Coordinates of the point of application of the net resistance force to the blade of the elliptical mixer.

To substantiate the calculation of the critical speed of a cantilever shaft with one concentrated mass. Rigid and flexible shaft.

To justify the determination of the natural oscillation frequency of a single-span shaft with one concentrated mass.

To substantiate the determination of the frequency of natural oscillations of a cantilever shaft with one concentrated mass

Working program of the academic discipline (syllabus):

Compiled by an associate professor of the Department of the National Academy of Sciences of the Russian Academy of Sciences, candidate. technical Sciences, associate professor Oleg Zubriy

Approved by the Department of the Academy of Medical Sciences (protocol No. 20 dated June 20, 2022)

Agreed by the Methodical Commission of the faculty (protocol No. 10 dated 24.06.2022)