



# NAME OF THE COURSE

## Calculation and design of typical equipment-3. Calculation and design of elements of special equipment

### Working program of the academic discipline (Syllabus)

#### Details of the academic discipline

Level of higher education	First (bachelor's)
Field of knowledge	13 Mechanical engineering
Specialty	133 Industrial mechanical engineering
Educational program	Industrial Mechanical Engineering
Discipline status	Normative
Form of study	full-time
Year of training, semester	4 course, spring semester
Scope of discipline	4.5 (135)
Semester control/ control measures	Exam
Lessons schedule	<a href="https://rozklad.kpi.ua/">https://rozklad.kpi.ua/</a> <a href="https://ecampus.kpi.ua/">https://ecampus.kpi.ua/</a> 6 hours per week (2 hours of lectures and 4 hours of practical classes)
Language of teaching	Ukrainian
Information about head of the course / teachers	Lecturer: Ph.D., Assoc. Andreiev I. A. Practical/Seminar: Ph.D., Assoc. Andreiev I. A. che@kpi.ua
Placement of the course	<a href="https://ecampus.kpi.ua/">https://ecampus.kpi.ua/</a> , <a href="http://ci.kpi.ua">http://ci.kpi.ua</a>

#### Program of educational discipline

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

#### *Description of the educational discipline*

The course covers the basics of designing thick-walled vessels, their application, theoretical information on the basics of engineering calculations, modern standard calculation formulas, normative methods of strength calculation.

Discipline "Calculation and design of typical equipment-3. Calculation and design of elements of special equipment" considers the requirements for the design and calculation of equipment and individual elements, their application.

#### *The subject of the academic discipline*

The discipline "Calculation and design of typical equipment-3. Calculation and design of elements of special equipment" is taught as the main component of training qualified specialists in the field of mechanical engineering, resource conservation, ecology and computer-integrated technologies.

Mastering the methods of construction and calculation involves not just mastering certain rules, but rather the development of a unique style of thinking, focused on the creation of modern technology in the field of chemical and oil refining engineering.

#### **The purpose of the educational discipline**

The purpose of studying this discipline is the formation of students of a complex of knowledge, skills, and abilities necessary for qualified design and calculation of typical equipment of the chemical

industry. In accordance with the goal, the training of bachelors requires the formation of the following abilities:

- use and application in professional activity of normative methods of calculation of vessels and devices of chemical industries,
- using knowledge of design and construction of typical equipment,
- mastering the method of determining loads that occur during installation, testing and in working conditions,
- receiving information about the current state of equipment elements during operation,
- improvement of chemical production equipment,
- use of the method of calculating stresses and deformations that occur during the operation of typical equipment.

### **The main tasks of the credit module**

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

#### **knowledge:**

- basic designs of machines and devices, typical units and parts and requirements for them;
- materials used in chemical engineering and their properties;
- calculation parameters and rules for their determination;
- conditions of strength, stiffness, stability, vibration resistance, tightness;
- calculation models of shells, plates, rods;
- determination of stresses, analysis of the stress state, permissible and limit loads;
- regulatory methods of calculating vessels and devices;
- development of a structurally perfected product.

#### **skill:**

- based on the features of the technological process, determine the initial and limiting conditions and load scheme for the structure,
- on the basis of working conditions, determine the stress-strain state of the structure under static and dynamic thermoforce loads,
  - based on the knowledge of theoretical training, using reference books and standards, choose structural materials and seal materials,
  - using reference materials, perform calculations regarding the strength of typical equipment,
  - perform parametric calculations of typical equipment using known analytical dependencies and reference information,
- take into account the need for assembly, disassembly, transportation and installation of the product,
  - on the basis of the acquired knowledge, perform calculations on stiffness, stability, strength and develop design documentation,
  - create constructions that are safe in operation.

#### **experience:**

- design development of a vessel or apparatus;
- ensuring strength, stability, rigidity, tightness, corrosion resistance, structural integrity and other requirements for elements of chemical 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)**

Mastering the discipline "Calculation and design of typical equipment-3. Calculation and design of elements of special equipment" is based on the principles of integration of the complex of knowledge acquired by students during the course of bachelor's education while studying natural and engineering disciplines in the field of "Mechanical Engineering". To successfully master this discipline, it is necessary to have basic knowledge in the field of higher mathematics, physics, resistance of materials, hydraulics, processes and equipment of chemical industries, to be able to use a computer to provide the necessary

calculations, to have skills in the field of applied programming, mathematical modeling of processes and systems.

As a result of mastering the discipline, the student will be ready to use fundamental and natural scientific knowledge and methods to solve complex scientific and technical problems in the field of professional and research and innovation activities.

### 3 Content of the academic discipline

**Topic 1.** Thick-walled vessels and devices. fields of use. Constructions of thick-walled vessels.

**Topic 2.** Stress in a cylindrical monolithic wall during elastic deformation of the material. Stress state analysis. Calculation of the wall by the allowable stress method and its shortcomings.

**Topic 3.** Calculating the thickness of a thick-walled custom.

**Topic 4.** Calculation of shutters of high-pressure devices.

**Topic 5.** Calculation of flanges of high-pressure devices.

**Topic 6.** Calculation of bottoms and covers of high-pressure devices.

**Topic 7.** Reinforcement of holes in thick-walled vessels. Навчальні матеріали та ресурси

### 4 Educational materials and resources

#### Basic literature

1. Андреев І.А. Конструювання і розрахунок типового устаткування хімічних виробництв. Основні положення. Елементи тонкостінних посудин, навантажених внутрішнім тиском. Навч. посібник. – К.: «Видавництво «Політехніка», 2011. – 272 с.
2. Андреев І.А., Мікульонок І.О. Розрахунок, конструювання та надійність обладнання хімічних виробництв: Термінологічний словник. – К.: ІВЦ “Видавництво «Політехніка» , 2002. – 216 с.
3. Андреев І.А., Зубрій О.Г., Мікуленок І.О. Застосування матеріалів у хімічному машинобудуванні. Сталі і чавуни,- К.: ІЗМН, 1999. – 148 с.
4. Андреев І.А., Зубрій О.Г. Конструювання та розрахунок апаратів високого тиску, - К.: ІЗМН, 1999. – 144 с.
5. Правила будови та безпечної експлуатації посудин, що працюють під тиском, –К.: Держнаглядохорона праці, 1998. – 273с.
6. ГОСТ 34233.1–12–2017 (міждержавні стандарти).
7. І. А. Андреев. Методичні вказівки до практичних занять для студентів спеціальності “Галузеве машинобудування” з дисципліни “Розрахунок і конструювання типового обладнання-2. Розрахунок і конструювання товстостінних посудин, теплообмінних та колонних апаратів”: [Електронний ресурс] / КПІ ім. Ігоря Сікорського ; уклад. І. А. Андреев. – Електронні текстові данні (1 файл: 9,989 Кбайт). – Київ : КПІ ім. Ігоря Сікорського, 2017. – 99 с. – Назва з екрана. – Доступ: <http://ela.kpi.ua/handle/123456789/19342>.

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

#### Lecture classes

Lecture classes are aimed at providing modern, holistic knowledge in the discipline "Calculation and design of typical equipment-3. Calculation and design of elements of special equipment", definition at the current level of scientific development in the field of calculation and design of machines and devices; ensuring fruitful work of students during the lecture; application of effective methods of teaching, presentation of material and its assimilation; education of students' professional qualities and development of creative thinking; formation of their scientific and practical interest in mastering the course material, the desire for independent work.

<b>№№</b>	<b>The name of the topic of the lecture, a list of main questions, references to the literature and tasks for students' independent work</b>	<b>Hours</b>
<b>1</b>	<b>Thick-walled vessels and devices.</b> Thick-walled vessels and devices, fields of their use. Constructions of thick-walled vessels. Literature: [2–4]	<b>4</b>
<b>2</b>	<b>Stresses that arise in the wall of the high-pressure apparatus.</b> Stress in a cylindrical monolithic wall during elastic deformation of the	<b>8</b>

	material. Stress state analysis. Calculation of the wall by the allowable stress method and its shortcomings. Literature: [2–4]	
<b>3</b>	<b>Custom high pressure device.</b> Calculation of the thickness of a thick-walled custom. Literature: [2–4]	<b>4</b>
<b>4</b>	<b>Shutters and flanges of high pressure devices.</b> Calculation of shutters and flanges of high-pressure devices. Literature: [2–4]	<b>12</b>
<b>5</b>	<b>Bottoms, covers and openings in high-pressure devices.</b> Calculation of bottoms and covers of high-pressure devices. Strengthening holes in thick-walled vessels. Literature: [2–4]	<b>8</b>
<b>Total hours (including individual lessons)</b>		<b>36</b>

### **Practical training**

When studying a credit module, 2/3 of the classroom load is allocated to practical classes. A practical lesson on a separate topic of this discipline is aimed at consolidating the material presented in the lecture by considering specific examples, exercises and problems on this topic. This enables students to systematize and deepen their theoretical knowledge. The practical session is conducted in a dialogue mode with educational discussions. At the beginning of the class, a control survey of the students is conducted based on the materials of the previous lectures, their familiarization with literary sources on the subject of the discipline.

<b>№№</b>	<b>Name of the subject of the practical session, list of main questions, references to the literature</b>	<b>Hours</b>
<b>1</b>	Determination of normative parameters and permissible stresses in high-pressure devices. Calculation of stresses in the wall during plastic deformation and elastic-plastic deformation of the material. Literature [1-7].	<b>4</b>
<b>2</b>	Розрахунок товщини стінки апарата високого тиску Література [1 – 5, 12].	<b>2</b>
<b>3</b>	Shutters of thick-walled vessels. Calculation of forces that arise in shutters. Literature [4, 12].	<b>6</b>
<b>4</b>	Calculation of flanges of thick-walled vessels. Literature [4, 12].	<b>2</b>
<b>5</b>	Calculation of flat and convex lids of a thick-walled vessel. Literature [4, 12].	<b>2</b>
<b>6</b>	Calculation of the bottom of a thick-walled vessel. Literature [4, 12].	<b>2</b>
<b>Total hours (including individual lessons)</b>		<b>18</b>

### **6 Independent work of the student**

When teaching the educational discipline "Calculation and design of typical equipment-3. Calculation and design of elements of special equipment" independent work of the student takes 44% of the time of studying the credit module, taking into account the preparation for the exam. Independent work of students includes preparation for classroom classes, execution of modular control work, calculation and graphic work, and study of sections of the program and topics that are not included in the list of lecture questions or require more detailed study. The acquisition of knowledge on these topics is carried out through detailed familiarization with the relevant sections of the recommended basic and additional literature and independent scientific and informational research on one's own initiative. The student's preparation for the next classroom classes involves mastering the material of the previous lectures in the process of independent work.

<b>№№</b>	<b>Type of work and titles of topics submitted for independent study</b>	<b>Hours</b>
<b>1</b>	<b><i>Preparation for classroom classes.</i></b>	<b>18</b>
<b>2</b>	<b><i>Performance of individual practical tasks on the topic of the module.</i></b>	<b>34</b>
<b><i>Working out sections of the program and topics that are not taught in lectures</i></b>		
<b>3</b>	Basic constructions of thick-walled vessels. Basic designs of rolled thick-walled vessels. Stress state analysis. Analysis of the stress state caused by the temperature difference. Designs of lids and bottoms of thick-walled vessels. Designs of shutters of thick-walled vessels. Classification of thick-walled vessels. Suggestions for ways to reduce stresses in the hull. The influence of temperature stresses on the value of total stresses in the housing. Design the lids and bottoms of a thick-walled vessel. Designs of shutters. Design the flanges of high-pressure devices. Literature [1-7].	<b>9</b>
<b>4</b>	<b><i>Preparation for the exam</i></b>	<b>20</b>
<b><i>Total hours</i></b>		<b>81</b>

## Policy and control

### 1 Policy of academic discipline (educational component)

#### *Rules for attending lectures and practical classes*

Attending lectures and practical classes is a mandatory component of studying the material. At the lecture, the teacher uses his own presentation material. Students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without a good reason, not to be distracted by actions unrelated to the educational process.

#### *Policy of deadlines, rescheduling and incentive rules*

Missed classes must be made up. The student independently prepares a synopsis of the missed lecture or practical session, answers control questions to the teacher on the materials of the topic of the missed session. Individual practical tasks should be performed carefully and in a precisely defined time. Fulfillment of these requirements ensures an increase in the rating assessment of the results of mastering the educational discipline.

#### *Academic Integrity Policy*

The policy of the academic discipline is built taking into account the norms of Ukrainian legislation on academic integrity, the Code of Honor of the National Technical University of Kyiv "Ihor Sikorsky Kyiv Polytechnic Institute" and is determined by the system of requirements that the teacher presents to the student when studying the discipline (rules of behavior in classes, absences, retakes, etc.).

### 2 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 study plan:

Training time		Distribution of study hours				Control measures		
Credits	Hours	Lectures	Practical	Laboratory	Independent work of students	Modular control work	Calculation and graphic work	Semester control
4,5	135	36	18	–	81	1	–	Exam

Control of students' knowledge is carried out with the help of an interview during practical classes, the results of individual practical tasks, and at the exam - with the help of tickets.

During the evaluation, the following is taken into account:

Attending lectures and practical classes, fruitfulness of work during classroom classes.

Timely and accurate performance of control practical tasks for independent work.

Study of basic and auxiliary literature.

1 The rating of the student from the credit module consists of the points he receives for work in practical classes, for the performance of control module work on the topic of the module and based on the results of the semester control - exam.

2 Scoring criteria:

2.1 Work in practical classes:

- fruitful work – 5 points;
- untimely completed task – 3 points;
- passive work or absence from class – 0 points.

The maximum number of points for work during practical classes is 45.

2.2 Evaluation criteria for modular control work:

- "excellent" – 13–15 points;
- "good" – 8–12 points;
- "satisfactory" – 3–7 points;
- "unsatisfactory" – 0 points.

For 9 weeks of study, based on the results of the educational work and the performance of control modular and calculation-graphic works, the maximum number of points that a student can score is 60 points.

2.3. Compilation of examination exams.

At the exam, students receive an exam ticket. Each ticket contains four questions (two of which are more difficult).

Each difficult question is valued at 12 points, and easier – 8 points.

The system of evaluating difficult 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) – 9–10 points;
- "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 7–8 points;
- "unsatisfactory", an unsatisfactory answer – 0 points.

Evaluation system for simpler 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) – 5–6 points;
- "satisfactory", incomplete answer (at least 60% of the required information and some errors) – 3–4 points;
- "unsatisfactory", an unsatisfactory answer – 0 points.

The maximum number of points that a student can receive as a result of successfully passing the exam is 40 points.

According to the rating scale (R), the maximum number of points is 100.

A prerequisite for admission to the exam is a rating of at least 30% of the rating scale (R), i.e. 30 points.

Distribution of rating points received by graduate students after studying the credit module and passing exams.

<b>Content module</b>	<b>Total points</b>
Practical training	45
Control module work	15
<b>Semester control</b>	
Exam	40
<b>Together:</b>	<b>100</b>

The procedure for enrolling missed lectures and practical classes: the student independently prepares a synopsis of the missed lecture and/or practical class, answers the teacher's control questions.

The sum of the rating points received by the student after mastering the discipline and passing the exam is transferred to the final grade according to the table:

Scores	Rating
95...100	perfectly
85...94	very good
75...84	good
65...74	satisfactorily
60...64	enough
< 60	unsatisfactorily
Admission conditions not met	not allowed

## 7 Additional information on the discipline (educational component)

### Preliminary list of questions submitted for semester control

- 1 Analyze and give examples of the use of thick-walled vessels. Give constructions of cylindrical thick-walled vessels.
- 2 Give constructions of monolithic and multi-layered thick-walled vessels.
- 3 Give normative parameters and permissible stresses for high-pressure devices.
- 4 To analyze the stresses in a continuous thick-walled shell arising from the action of internal pressure.
- 5 Provide an algorithm for calculating the strength of cylindrical, thick-walled, single-layer tiles.
- 6 Provide an algorithm for calculating temperature stresses in a thick-walled cylindrical shell.
- 7 Provide an algorithm for calculating flat bottoms of high-pressure devices.
- 8 Provide an algorithm for calculating the convex bottoms of high-pressure devices.
- 9 Give an assessment of the shutters of high-pressure devices.
- 10 Analyze the design, conditions of use and calculation of shutters with a flat metal gasket.
- 11 Analyze the design, conditions of use and calculation of valves with a double-cone ring.
- 12 Analyze the design, conditions of use and calculation of shutters with a ring of triangular section.
- 13 Analyze the design, conditions of use and calculation of shutters with a trapezoidal gasket.
- 14 Analyze the design, conditions of use and calculation of shutters with a wedge seal.
- 15 Analyze the design, conditions of use and calculation of shutters and flanges with lens sealing.
- 16 To substantiate the strength calculation of the pins of high-pressure devices.
- 17 To substantiate the structural calculation of the flanges of high-pressure devices.
- 18 To substantiate the verification calculation of the flanges of high-pressure devices.
- 19 To justify the calculation of the reinforcement of holes in high-pressure devices.
- 20 Provide an algorithm for calculating covers of high-pressure devices.

**Working program of the academic discipline (syllabus)** was compiled by an associate professor of the Department of the Academy of Sciences of the Russian Academy of Sciences, Ph.D. Andreev Ihor Anatoliyovych

**Approved** by the Department of Machines and Apparatus of Chemical and Oil Refining Industries (Protocol No. 19 dated 05.17.2023)

**Agreed** by the Methodical Commission of the Faculty of Engineering and Chemistry (protocol No. 10 dated 05.26.2023)