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

Department of machines and devices of chemical and oil refining industries

Processes and devices of chemical production -1. Technical hydraulics. Basics of heat transfer. Heat exchange equipment.

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	*First (undergraduate)*
Branch of knowledge	*16 Chemical technology*
Specialty	*161 Chemical technologies and engineering*
Educational program	*Name*
Discipline status	Normative
Form of education	daytime
Year of training, semester	3rd year, autumn
Scope of the discipline	3.5 credits
Semester control/ control measures	*Exam, MKR, RR, current control*
Lessons schedule	
Language of teaching	*Ukrainian*
Information about head of the course / teachers	Lecturer: candidate of technical sciences, associate professor, Shved Mykola Petrovych, npchved46@gmail Practical: candidate of technical sciences, senior lecturer Oleg Anatoliyovych Novokhat, candidate of technical sciences
Placement of the course	*Campushttp://ci.kpi.ua/*

Program of educational discipline

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

Manufacturing technology of chemical, oil refining, biotechnological, food, etc. products. industries is built as a sequence of a limited number of basic processes that occur under different conditions (temperature, pressure, concentration, etc.). These processes include mechanical, hydromechanical, thermal, mass exchange, diffusion-controlled, chemical processes based on the fundamental laws of conservation of energy, mass, and momentum.

Processes and devices of chemical and oil refining industries are a branch of science and technology that investigates the main characteristics of the micro- and macro-kinetics of chemical-technological processes and establishes the parameters that are the conditions for their implementation in the appropriate equipment. A decisive role is played by physical and mathematical modeling of processes, in particular

with the use of automated modeling, calculation and design systems, which allow the transition from laboratory and theoretical research to the implementation of processes in industrial equipment (large-scale transition).
The discipline is based on the knowledge acquired by students during the study of educational disciplines of humanitarian, natural-scientific and professional-practical cycles, namely higher mathematics, physics, chemistry, physical chemistry, theoretical mechanics, resistance of materials, theoretical foundations of heat engineering, hydraulics, graphic geometry, engineering and computer graphics.

Formation of knowledge, practical skills and skills of a bachelor is carried out during lectures, practical and laboratory classes, organization of independent work.

Description of the academic discipline

<table>
<tr><th>Field of knowledge, direction of training, educational and qualification level</th><th>General indicators</th><th>Characteristics of the credit module</th></tr>
<tr><td>Branch of knowledge
16 "Chemical technology"</td><td>The name of the discipline to which the credit module belongs
Processes and devices of chemical industries</td><td>Form of education
daytime</td></tr>
<tr><td>Training direction
161 "Chemical technology and engineering"</td><td>Number of ECTS credits
3.5</td><td>Credit module status

Discipline of the university's choice</td></tr>
<tr><td></td><td>The number of sections is 4</td><td>The cycle to which the credit module belongs
Cycle of professional and practical training</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">RR</td><td>Year of training 2024/2025</td></tr>
<tr><td>Semester 5</td></tr>
<tr><td rowspan="5">Education level
bachelor</td><td rowspan="3">Total hours
105</td><td>Lectures
36 hours</td></tr>
<tr><td>Practical (seminar)
6 p.m.</td></tr>
<tr><td>Laboratory (computer workshop)
0 hours</td></tr>
<tr><td rowspan="2">Weekly hours:
classrooms - 3
SRS - 2.5</td><td>Independent work
51 hours
including for the performance of an individual task
12 hours</td></tr>
<tr><td>Type and form of semester control
Exam</td></tr>
</table>

The object of the educational discipline there are processes and apparatuses of chemical industries.

Mastering the material of the discipline will allow you to learn the basic theoretical principles of technical hydraulics, hydromechanical processes and thermal processes, to master the methods and techniques of evaluating their efficiency, and to be able to justify technical decisions to improve their efficiency. This will contribute to increasing the competitiveness of specialists when employed in prestigious engineering positions.

The purpose of the educational disciplinethere is the formation of students' abilities (competencies):

– to the study and analysis of chemical technology processes;
– to the analysis of structural features of chemical equipment;
– to the analysis of methods of calculations and design of chemical equipment;
– to the selection of elements of chemical equipment;
– to the selection of energy carriers and determination of their energy parameters.

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:

– basic chemical and technological processes and their classification;
– designs of heat exchange equipment;
– methods of calculating the main dimensions and technical parameters of heat exchange equipment;
– sources of thermal energy supply;
– directions for saving thermal energy and increasing the reliability of heat exchange equipment;
– structural schemes of thermal equipment for the implementation of certain processes of the technological scheme;

skill:

– using data on the main features of heat exchange equipment
carry out their classification;
– using data on the main properties of energy carriers, calculate their main parameters;
– using data on the main needs of technological processing, choose the appropriate design of heat exchange equipment;
– using data on designs and technological characteristics of heat exchange equipment, calculate their main dimensions and technical parameters according to appropriate methods;
– using data on designs of heat exchange equipment;
and technological characteristics of the processes taking place in them, to evaluate the technical and economic feasibility of sources of thermal energy supply;
– using data on technical and economic indicators of heat exchange equipment
determine the main areas of thermal energy savings;
– based on the analysis of options, make a rational choice of structural schemes of thermal equipment for the implementation of certain processes of the technological scheme;
– during the development of a technical proposal, sketch and technical projects and working design documentation, using the methods and methods of engineering and computer graphics, the principles of interchangeability and the system of tolerances and landings, to perform assembly drawings of heat exchange equipment;
– using methods, computer technology, perform material and heat balances of equipment, calculate kinetic characteristics of processes and basic geometric dimensions of devices;
– knowing the basic designs of equipment, be able to develop design documentation for heat exchange equipment;

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experience:

- design or verification calculation of heat exchange equipment;
– constructive calculation of heat exchange equipment;
– determination of the characteristics of heat carriers;

Program learning outcomes, control measures and deadlines are announced to bachelors in the first lesson.

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

Prerequisites of the discipline. For successful mastery of competencies, knowledge of the following disciplines is required:

- Math
- Physics
- Chemistry
- Physical chemistry

Postrequisites of the discipline. The list of disciplines provided by this educational discipline:

- Calculation and design of typical equipment.
- Educational disciplines in computerized engineering.
- Educational disciplines on means of delivery and movement.
- Educational disciplines on the processes of thermal preparation and processing.
- Educational disciplines in the management of technological processes.

3. Content of the academic discipline

Chapter 1 Basics of transference theory.
Chapter 2 Technical hydraulics
Chapter 3. Basics of heat transfer
Chapter 4. Heat exchange equipment

Educational materials and resources

Basic literature, which must be used to master the discipline, is worked out independently for preparation for practical classes and in the conditions of distance learning. It is suggested to use additional literature and Internet resources to perform modular tests, prepare reports, presentations, and write essays based on the results of independent work.

Basic literature:

1. Kornienko Y.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev - K.: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Kornienko Y.M. Processes and equipment of chemical technology 2: textbook /Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev - K.: NTUU "KPI", 2011 - Part 2 - 416 p.
3. Yu.Yu. Lukach Thermal processes and devices of chemical and oil refining industries// Yu.Yu. Lukach, I.O. Mikulonok, G.L. Ryabtsev, M.V. Sezonov.– K.: NMCSO, 2000 Part 1..-172 p.
4. Yu.Yu. Lukach Thermal processes and devices of chemical and oil refining industries// Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev.– K.: NMCSO, 2004. Part 2.- 161 p.
5. Processes and equipment of chemical technology-1. Thermal processes: instructions for performing calculation work [Electronic resource]: training. manual for students specialty 133 Industrial mechanical engineering, educational professional bachelor's program "Computer-integrated technologies of chemical engineering equipment design" / KPI named after Igor Sikorskyi; comp.: Shved M.P., Stepaniuk A.R., Shved D.M. – Electronic text data (1 file: 3.71 MB). – Kyiv: KPI named after Igor Sikorskyi, 2022. – 271 p.

6. Processes and equipment of chemical technology-2. Thermal processes: laboratory practice, study guide [Electronic resource]: training. manual for students specialty 133 "Industrial mechanical engineering", specialization "Computer-integrated technologies of chemical engineering equipment design" / KPI named after Igor Sikorskyi; comp.: A. M. Lubek, M.P. Shved, Y.M. Kornienko, G.S. Podyman - Electronic text data (1 file: 1.5 MB). – Kyiv: KPI named after Igor Sikorskyi, 2022. – 65 p.

Additional

1. Basic dependencies and examples of calculations of heat exchangers. [Electronic resource]: study guide for students studying "Mechanical engineering" specialty "Equipment of chemical production and building materials enterprises"/ NTUU "KPI"; structure. L.G. Voronin, A.R. Stepaniuk, L.I. Ruzhynska, - Kyiv: NTUU "KPI", 2011. - 68 p
2. Processes and equipment of chemical technologies-1. Basic principles of the theory of heat and mass transfer: practicum on the credit module [Electronic resource]: education. manual for students specialty 133 "Industry of mechanical engineering", specialization "Engineering, computer modeling and equipment design of chemical and oil refining industries" / KPI named after Igor Sikorskyi; comp.: S.V. Gulienko, Ya.V. Hrobovenko. – Electronic text data (1 file: 2.93 MB). – Kyiv: KPI named after Igor Sikorskyi, 2019. – 120 p
3. Processes and devices of chemical production: Workshop [Electronic resource]: training. manual for students specialty 161 "Chemical technologies of processing of wood and vegetable raw materials", educational program "Chemical technologies of processing of wood and vegetable raw materials" / KPI named after Igor Sikorskyi; comp.: B.I. Duda, A.R. Stepaniuk, S.V. Gulienko, R.V. Kychak, Y.H. Gotsky - Electronic text data (1 file: 2.62 MB). – Kyiv: KPI named after Igor Sikorskyi, 2020. – 116 Hydrogas dynamics (examples and problems): study guide / S. Y. Tkachenko, N. D. Stepanova. – Vinnytsia: VNTU, 2012. – 180 p.
4. Heat and mass transfer (fundamentals of theory and calculation): teaching. manual /A.I. Pogorelov - 2nd edition. Ex. – Lviv: Novy svit -2000, 2004. – 144 p.
5. Labai V.Y. Heat and mass exchange - Lviv: Triada plus, 1998. - 260 p.
6. 2. Varlamov G.B. Thermal power plants and ecological aspects of energy production: textbook / G.B. Varlamov, H.M. Lyubchyk – K.: IVC "Polytechnic Publishing House", 2003. – 232 p.
7. 3. Yegorov Ya.O. Theoretical foundations of heat engineering (in mechanical engineering systems): / Ya.O. Yegorov, S.B. Belikov, O.M. Ulitenko: Education. manual. – Zaporizhzhia: Dyke Pole, 2004. – 286 p.
8. 4. Slinko G.I. Heat engineering processes and heat treatment of materials and products: Education. manual. / G.I. Slynko, S.B. Belikov, O.M. Ulitenko - Melitopol, 2011 - 360

Regulatory documentation

1. DSTU EN 247-2003 Heat exchangers. Terminology.
2. DSTU EN 305-2001 Heat exchangers. Determination of operational characteristics of heat exchangers and general test methodology for establishing operational characteristics of all heat exchangers.
3. DSTU EN 1118:2008. Heat exchangers. Liquid coolers cooled by a refrigerant. Test methods for establishing performance characteristics (EN 1118:1998, IDT

Educational content

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

Information (by sections, topics) about all educational classes (lectures, practical, seminars, MKR, SRS)

Names of sections and topics	Number of hours				
	In total	including			
		Lectures	Laboratory	Practical	SRS
1	2	3	4	5	6
Chapter 1. Basics of transference theory					

Topic 1.1. Introduction to the course of processes and devices. Classification of chemical and technological processes	2	2	-	2	2
Transfer phenomena in chemical technology. Equation of conservation of mass, energy and momentum. The principles of their solution.	4	4			
Together by chapter 1	**10**	**6**	**-**	**2**	**2**
Chapter 2. Technical hydraulics					
Topic 2.1. Fluid statics. Characteristics and their properties. Euler's equation. Basic equation of hydrostatics. Classification and principle of operation of hydraulic machines.	4	2	-	-	2
Topic 2.2. Hydrodynamics of liquids. Euler, Navier-Stokes, Bernoulli equations. Friction resistance and local resistance, their calculation. The optimal diameter of the pipeline.	12	4		4	4
Together by chapter 2	**16**	**6**	**–**	**4**	**6**
Chapter 3. Basics of heat transfer					
Topic 3.1. Diffusion transfer of thermal energy	11	3	-	4	4
Topic 3.2. Convective heat exchange. Partial cases of convective heat transfer	11	3	-	4	4
Topic 3.3. Heat exchange during change of aggregate state and radiation	6	2	-	-	4
Together by section 3	**28**	**8**	**-**	**8**	**12**
Chapter 4. Heat exchange equipment					
Topic 4.1. Heating, cooling and heat exchange devices	12	4	–	4	4
Topic 4.2. Evaporation and evaporation installations	8	4	-	–	4
Topic 4.3. Drying and drying installations	12	4	-	4	4
Topic 4.4. Moderate and deep cold	12	3	–	4	4
Together under section 4_	**44**	**15**		**12**	**16**
MKR according to sections 1–4	**7**	**1**	**–**	**-**	**6**
Exam			–	–	9
Hours in general	**105**	**36**	**–**	**18**	**51**

5.1. Lecture classes

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 the SRS)	Number of hours
	Chapter 1. Basics of transference theory	
1	**Topic 1.1.** Introduction to the course of processes and devices.	**6**

	Scheduled: The classification of chemical-technological processes is given, and transfer phenomena in chemical technology are considered. The equations of conservation of mass, energy, equilibrium and driving force are analyzed. The principles of their solution are considered. *SRS topic:* The equations of conservation of mass, energy, equilibrium and driving force are analyzed. The principles of their solution are considered. *Recommended:* 1-7.	
	Chapter 2. Technical hydraulics	
2	**Topic 2.1.** Fluid statics. Characteristics and their properties. Euler's equation. Basic equation of hydrostatics. Classification and principle of operation of hydraulic machines.	**2**
	Scheduled: The characteristics of liquids are given, their classification is explained. Euler's equations, the basic equation of hydrostatics, as well as the classification and principle of operation of hydraulic machines are given and analyzed. *SRS topic:* Compile an album of constructions of hydraulic machines and devices for measuring pressure, level, speed and flow of liquid *Recommended:* 1-7.	
3,4	**Topic 2.2.** Hydrodynamics of liquids. Euler, Navier-Stokes, Bernoulli equations. Friction resistance and local resistance, their calculation. The optimal diameter of the pipeline.	**4**
	Scheduled: Properties and concepts of liquid viscosity are considered. Ideal and real fluids are characterized. The Euler, Navier-Stokes, and Bernoulli equations are derived and analyzed. Head losses along the length of the channel and local losses are considered. Dependencies are analyzed to determine the optimal pipeline diameter. *SRS topic:* To classify and compile an album of constructions of hydraulic machines for moving liquids and gases. *Recommended:* 1-7.	
	Chapter 3. Basics of heat transfer	
5,6	**Topic 3.1.** Diffusion transfer of thermal energy	**3**
	Scheduled: Types of heat transfer and concepts of temperature gradient, temperature field, heat flow and heat flow density are considered. The basic equation of heat conduction is derived and analyzed. Unambiguity conditions and cases of stationary thermal conductivity are considered. Kinetic coefficients of thermal conductivity, thermal conductivity and heat transfer are considered. *The subject of SRS*: Prepare the topic 3.1. Diffusion transfer of thermal energy. *Recommended*1-7.	
6,7	**Topic 3.2.** Convective heat exchange. Partial cases of convective heat transfer	**3**
	Scheduled: The physical essence of convective heat exchange is considered. The Newton-Richmann heat transfer equation is considered. The concept of heat transfer coefficient is introduced. The system of convective heat transfer equations is derived and the ways of its solution are considered. The method of similarity theory, theorems and criteria of thermal similarity are considered. Criterion equations for determining the heat transfer coefficient and ways of its	

	intensification are given. Literature 1-7. SRS topic: Prepare topic 3.2. Convective heat exchange. Partial cases of convective heat exchange and ways of its intensification. Literature 1-7.	
8,9	**Topic 3.3.**Heat exchange during change of aggregate state and radiation.	**2**
	*Scheduled:*Types and physical essence of boiling and condensation processes are considered. Calculated dependences for determining heat transfer coefficients during boiling and condensation and ways of intensifying these processes are given. The mechanism of radiant heat transfer is considered. The basic laws of radiation are given. Dependencies are analyzed to determine radiation heat exchange between bodies and complex heat exchange. Literature 1-5 *SRS topic:*: To classify and compile an album of designs of condensers and boilers. Highlight use cases, advantages and disadvantages. Recommended: 1-7.	
	Chapter 4. Heat exchange equipment	
10-12	**Topic 4.1.**Heating, cooling and heat exchange devices.	**4**
	*Scheduled:*Requirements for coolants and heating schemes with water, steam, mineral oils and other high-temperature coolants, electric current and furnace gases are given. Types of movement of heat carriers and methods of determining the driving force of heat transfer are considered. The material and heat balances of heat transfer, as well as the design and verification calculation algorithm of heat exchangers, are presented. *The subject of SRS*: To classify and compile an album of designs of heat exchange devices. Highlight cases of application of their advantages and disadvantages. *Recommended:*1-7.	
13,14	**Topic 4.2.**Evaporation and evaporation installations	**4**
	*Scheduled:*The mechanism and features of concentration of solutions by evaporation are considered. Material and heat balances of a single-body evaporation plant. Temperature losses and the algorithm for determining the heat transfer surface are analyzed. Multi-body evaporation plants. The principle of action. Material and heat balances. Use cases. Literature 1-7. *The subject of SRS*: To provide a classification and make an album of the structures of evaporation plants. To highlight the cases of use of advantages and disadvantages. *Recommended:*1-7.	
15,16	**Topic 4.3.**Drying and drying installations	**4**
	*Scheduled:*The mechanism, stages and types of drying units are given. The characteristics of moist air as a drying agent and their display on the I-X diagram are given. The material and heat balances of a convective dryer are considered and the concept of an ideal dryer is defined. Variants of drying processes and an algorithm for determining heat and air costs for drying are given. Periods and kinetics of drying are considered. Dependencies are given for determining the duration of drying periods and overall dimensions of dryers. Literature 1-7. *The subject of SRS*: To classify and compile an album of designs of drying plants.	

	Highlight the use cases of advantages and disadvantages. *Recommended:* 1-7.	
17-18	**Topic 4.4.** Refrigeration units	**3**
	Scheduled: The concept of moderate and deep cold is introduced. The methods of obtaining artificial cold, the inverse thermodynamic Carnot cycle, refrigerating efficiency and refrigerating coefficient are studied. The cycles of a vapor compression refrigerating machine are considered and analyzed. The thermodynamic foundations of deep cooling are studied. The cycles of Linde, Claude, Kapitsa are analyzed. *The subject of SRS*: The processes that take place in a vapor compression refrigerating machine are studied and analyzed with the help of a T-S diagram. *Recommended:* 13.	
18	MKR	1

5.2. Practical training

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

No. z/p	The name of the topic presented at the practical session	Number of hours
	Chapter 2. Technical hydraulics	
	Topic 2.2. Fluid hydrodynamics	
1	Study of the designs of machines for the movement of liquids and gases and calculations based on the equations of hydrostatics and Bernoulli. Literature 1,2,3,9	2
	Chapter 3. Basics of heat transfer	
	Topic 3.1. Diffusion transfer of energy	
2	Calculation of the heat conduction process. Literature 1,2,3,9	2
	Chapter 4. Heat exchange equipment	
	Topic 4.1. Heat exchange devices	
3-4-5	Study of designs of heat exchangers and calculation of a shell-and-tube heat exchanger. Literature 1,2,3,9	6
	Topic 4.2. Evaporation and evaporation installations.	
6-7	Study of structures of evaporation apparatuses and calculation of evaporation plant.	4
	Topic 4.1. Drying and drying installations	

8-9	Study of designs of dryers and calculation of a convective drying unit. Literature 1,2,3,9	4

5.3. Laboratory classes.

Laboratory classes are not included in the plan

1. Independent work of student

The discipline "Processes and devices of chemical production - 1 provides the following types of student work: lectures and practical classes, one modular control work, calculation work, as well as independent work of the student. The study of the discipline ends with the passing of an exam, to which students who have fully completed the program of the credit module are admitted. The main form of studying the discipline by students is independent work with recommended educational and educational and methodological literature. The purpose of this work is the acquisition of theoretical knowledge of the discipline, the formation of skills and experience in the design of industrial equipment.

The purpose of the lectures is to generalize and systematize the knowledge acquired by students during independent work.

Practical classes are designed to familiarize students with individual topics in more detail and to better assimilate the material taught in lectures.

The purpose of the calculation work is to develop the ability to apply the acquired knowledge to solve practical and theoretical tasks of modern production, to gain experience in the execution of reporting documentation.

6.1. Individual tasks

When studying the course, students perform one calculation work (RR), the purpose of which is to study equipment designs and the basics of its calculation. Individual assignments are issued according to the topics listed in Appendix A.

The result of the work is drawn up in the form of a report, which includes the formulation of the purpose of the work, a description of the design features of the device, parametric design calculations and a sketch diagram of the device. The volume of the report is 10-15 A4 pages.

6.2. Control works

One modular control work is planned. (ICR)

The main purpose of the control work is to check the level of learning of the taught material, which will make it easier for students to learn the material and provide more complete control by the teacher over the students' implementation of the curriculum.

Approximate questions are listed in Appendix B.

Policy and control

Policy of academic discipline (educational component)

The student must be present at all lectures, practical and laboratory classes, except for confirmed valid reasons.

Defense of practical, laboratory works, as well as individual tasks is carried out personally according to established deadlines, taking into account incentive and penalty points

Students have the right to challenge the points for the assignment, but must be reasoned, explaining which criterion they disagree with according to the evaluation letter and/or comments.
The detailed criteria for evaluating students' learning outcomes are defined in the regulation on RSO of the discipline

University policy

Academic integrity

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.

Norms of ethical behavior

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

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

The student's rating in the discipline consists of the points he receives for:

1) execution and defense (at the teacher's choice) of 4 tasks and 4 sections of the synopsis of structures;
2) writing ICR;
3) implementation and protection of RR;
4) the answer to the exam.

System of rating (weighted) points and evaluation criteria

1. **Work in practical classes**

The weighted point is 8. The maximum number of points in all practical classes is equal to:
8 points x 4 = 32 points.
Evaluation criteria:

score 8 is awarded under the condition of an excellent answer.
a score of 3-7 is given if the answer is sufficient.
a score of 0-2 is given if the answer is unsatisfactory.

2. Modular control

Weight score – 12.
a score of 12 is given if at least 95% of the questions are answered;
a score of 7-11 is awarded on the condition that 85 to 95% of the questions are answered;
a score of 4-6 is awarded on the condition that 75 to 85% of the questions are answered;
2-3 points are given on the condition that 60 to 75% of the questions are answered;
a score of 0-1 is given if less than 60% of the questions are answered.

3. Calculation work.

Weight score – 16.
RR evaluation criteria:
a score of 14-16 is given if all sections of the work are covered in full, or individual inaccuracies are admitted;

a score of 10-13 is given if certain inaccuracies are allowed in the work;
a score of 9-4 is given if the topic of the work is not clearly covered, mistakes are made in wording, terms and definitions;
a score of 0-3 is assigned if the work is performed unsatisfactory: the presence of significant errors or the absence of separate sections, the RR is not counted.

4. Penalty and incentive points for:

- untimely (later than at the control session) submission of the task or section of the synopsis of structures - 2 points.
- untimely (later than in the control session) handing in the calculation of the apparatus in the practical session - 2 points;
- untimely (later than a week) submission of calculation work - 5 points;
- incentive points: performance of tasks to improve didactic materials from the credit module - up to 10 points.

The size of the rating scale RD = Rпр+Рмкр+РРП=32+12+16 = 60 points
The size of the examination scale Re= 40 points.

Conditions of positive intermediate attestation

To receive "passed" from the first intermediate certification (week 8), a student must have at least 8 points (provided that at the beginning of week 8, according to the calendar plan of control measures, the "ideal" student must receive 17 points).

In order to receive "credited" from the second intermediate certification (week 14), a student must have at least 22 points (provided that at the beginning of week 14, according to the calendar of control activities, the "ideal" student must receive 45 points).

Conditions for admission to the exam:enrollment of all practical classes, calculation work, a positive result of the modular control work, as well as a starting rating of Rs > 24 points (at least 40% of Rs).

Examination assessment criteria:the examination ticket contains 4 questions, the maximum number of points for each question is distributed equally.

Table of criteria for evaluating answers to ticket questions

Response rate	Number of points for answering the question			
	Question 1	Question 2	Question 3	Question 4
Distinctive	9-10	9-10	9-10	9-10
Very good	7-8	9-10	9-10	9-10
Good	5-6	6-8	6-8	6-8
Satisfactory	3-4	3-5	3-5	3-5
Sufficient	1-2	1-2	1-2	1-2
Unsatisfactory	0	0	0	0

Table of correspondence of rating points to grades on the university scale
:

Scores	Rating
100-95	Perfectly
94-85	Very good

84-75	Fine
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

Additional information on the discipline (educational component)

During their studies, students acquire new knowledge, skills and abilities, mainly during specific lectures, practical and laboratory classes under the leadership of the department's leading NPPs. Quite often during their studies, students, in order to receive incentive points, are involved in providing assistance in the development of educational and methodological documentation (publication of manuals, licensing, development of methodological documentation, etc.). At the same time, the nature of such assistance must strictly correspond to the profile of the discipline and in terms of duration should not interfere with the implementation of the student's study plan.

Working program of the academic discipline (syllabus):

Compiled by:Associate Professor of the Department of Machines and Apparatus of Chemical and Oil Refinery Industries, Candidate of Technical Sciences, Associate Professor, Shved Mykola Petrovych

Adopted:by the department by the department of machines and devices of chemical and oil refining industries (protocol No. 20 dated 20.06.2024)

Agreed:methodological commissioncommission of the Faculty of Engineering and Chemistry(protocol No. 11 dated 28.06.2024)

Appendix A

Tasks for calculation work

Task No. 1 to RR

Calculate the heat exchanger for heating / cooling / condensation of substance "P". The initial temperature of the substance is tr1, the final temperature is tr2; . The heating (cooling) agent is T. Heat losses through the outer surface of the heat exchanger should be taken as ___% of usefully spent heat. The working pressure of the substance pp. of the agent is pa.

Version	Substance "P"	Version	Mass fraction of the dissolved substance in the	Version	G×10m, kg/s	Version	p1	Version	p2
1.	solution of ethanol in water	1	5	1	0.50	1	10	1	90
2.	solution of methanol in water	2	10	2	0.60	2	20	2	80
3.	a solution of benzene in toluene	3	20	3	0.70	3	30	3	70
4.	a solution of toluene in benzene	4	30	4	0.80	4	40	4	60
5.	a solution of formic acid in acetic acid	5	40	5	0.90	5	50	5	50
6.	water	6	100	6	0.95	6	60	6	40
7.	acetic acid	7	60	7	1.20	7	70	7	30
8.	ethanol	8	70	8	1.30	8	80	8	20
9.	methanol	9	80	9	1.40	9	90	9	tboil
0	benzene	0	100	0	1.50	0		0	tcond.
and		and		and		and	tcond.	and	

Type of heat exchanger:□ - pipe in a pipe; □ - spiral; □ - lamellar; □ - shell and tube

Agent "T":□ - - water; □ - - 25% aqueous $CaCl_2$ solution; □ saturated water vapor (relative mass fraction of air in the vapor Y = _____ % (mass);

Pressure: pp = ____ MPa;The coefficient of power m= -1

The structure of the explanatory note

Content

Task

Introduction

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2. Description and justification of the selected design
3. Parametric calculation of the apparatus
4. Schematic drawing of the device
5. Conclusion
6. References

Recommended Books

1. Kornienko Y.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev - K.: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Yu.Yu. Lukach Thermal processes and devices of chemical and oil refining industries// Yu.Yu. Lukach, I.O. Mikulonok, G.L. Ryabtsev, M.V. Sezonov.– K.: NMCSO, 2000 Part 1..-172 p.
3. Processes and equipment of chemical technology-1. Thermal processes: instructions for performing calculation work [Electronic resource]: training. manual for students specialty 133 Industrial mechanical engineering, educational professional bachelor's program "Computer-integrated technologies of chemical engineering equipment design" / KPI named after Igor Sikorskyi; comp.: Shved M.P., Stepaniuk A.R., Shved D.M. – Electronic text data (1 file: 3.71 MB). – Kyiv: KPI named after Igor Sikorskyi, 2022. – 271 p.

Task No. 2 to RR

Calculate a drum dryer with a lifting-blade nozzle for drying material "M" within the city "N". Mass productivity of the dryer G. Relative humidity of the material: initial ω1, final ω2,:. Drying agent - "A". Heat losses to the environment should be ___% of usefully spent heat.

Version	Substance "M"	Version	ω1.%	Version	ω2,%	Version	G, kg/s	Version	City "N"
	potassium chloride	1	6	1	0.4	1.	0.3	1.	Dnipropetrovsk
	ammonium sulfate	2	3.6	2	0.4	2.	0.4	2.	Kyiv
	ammonium nitrate	3	4	3	0.3	3.	0.6	3.	Kirovohrad
	sodium chloride	4	5	4	0.2	4.	0.8	4.	Mykolaiv
	superphosphate	5	18	5	3.5	5.	1.0	5.	Odesa
	sand	6	4	6	0.1	6.	1,2	6.	Kharkiv
	coal	7	9	7	0.6	7.	1.4	7.	Lviv
	clay	8	23	8	4.5	8.	1.6	8.	Sumy
	barium chloride	9	5.5	9	1,2	9.	1.8	9.	Vinnitsa
	sodium bicarbonate	0	6	0	0.1	0	2.0	0	Kherson
						and		and	

Productivity of the dryer: □:G= G1; □:G= G2;
Drying agent "A": □ - air; □ - flue gases.
Scheme of movement of the drying agent and the material to be dried: □ - II-current: □ - counter-current.
Make the calculation: □ - for summer conditions; □ - for winter conditions; □ - for average annual conditions; □ - for summer and winter conditions.
Plot the change in parameters of moist air in the dryer on the x-th diagram.

The structure of the explanatory note

Content
Task
Introduction

1. Technical characteristics of the material and drying agent
2. Description and justification of the selected design
3. Parametric calculation of the apparatus
4. Schematic drawing of the device
5. Conclusion

References

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Task No. 3 to RR

Calculate a vacuum-evaporating unit of continuous action and select the design of the evaporating apparatus (type and design) for concentrating the aqueous solution of substance "P". The mass productivity of the installation based on the initial solution G1. The initial mass fraction of substance "P" in the evaporated solution is x1. final — x2. The temperature of the initial solution t1, the absolute pressure in the condenser p0, the relative humidity of the heating water vapor φ.

Version	Substance P"	*X2.* %mass	Version	*p0*,MPa	Version	t1, °C	Version	G1, kg/h	*X1* % (mass)	Version	φ, % wt.
1	NaOH	40	1	0.010	1	20	1	10000	10	1	0
2	Na2CO3	35	2	0.012	2	25	2	13000	1 1	2	0.5
3	NH4Cl	25	3	0.015	3	30	3	15000	12	3	1.0
4	KOH	40	4	0.016	4	35	4	18000	13	4	1.5
5	K2CO3	37	5	0.018	5	40	5	20000	14	5	2.0
6	MgSO4	40	6	0.020	6	45	6	25000	1 5	6	2.5
7	KCl	30	7	0.022	7	50	7	30000	16	7	3.0
8	CaCl2	40	8	0.023	8	55	8	35000	17	8	3.1
9	MgCl2	30	9	0.024	9	23	9	37000	18	9	3.3
0	NaCl	50	0	0.025	0	28	0	40000	19	0	3.5
and	KNO3	50	and	0.026	and	30	and	43000	20	and	4.0
b	NH4NO3	50	b	0.028	b	37	b	45000	23	b	4.5
in	NaNO3	45	in	0.030	in	43	in	50000	25	in	5.0
Mr			Mr		Mr		Mr			Mr	

Mass fraction of air in heating water vapor. % (mass): 0.5 1.0 1.5

Heat losses to the environment, % of usefully spent heat: 2, 5, 8.

The structure of the explanatory note:

Content

Task

Introduction

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Appendix B

Questions to the MKR

1. Define liquid. What is the difference between a real liquid and an ideal one?
2. What is Newton's law of viscous friction?
3. How do Newtonian fluids differ from non-Newtonian fluids?
4. Formulate the basic law of hydrostatics. Give examples of its application.
5. Define the main types of fluid movement: steady, uniform and unsteady, pressure and non-pressure.
6. What is the form of the flow continuity equation?
7. What is the physical essence of the quantities included in the Navier-Stokes differential equations?
8. Explain the geometric and energy content of all terms of the Bernoulli equation.
9. Under what conditions can the Bernoulli equation be applied?
10. What is the difference between laminar and turbulent motion?
11. What criterion of similarity characterizes the mode of fluid movement?
12. How are pressure losses determined in the case of fluid movement in a pipeline?
13. What hydraulic supports are called local?
14. What is the technical and economic calculation of the pipeline?
15. Under the influence of what forces does the liquid move in the suction and discharge pipelines?
16. Thanks to what forces is the pressure created in the impeller of centrifugal pumps?
17. Why do piston pumps usually work with air caps?
18. Does the fluid flow depend on the pressure created by the piston pump?
19. What are the total pressures created by the fan?
20. By what features are gas blowers divided into fans, gas blowers (superchargers) and compressors?
21. What types of heat transfer are involved in heat exchange?
22. What are temperature gradient, isothermal surface and temperature field and what are their properties?
23. Write down and analyze the heat conduction equation for different types of temperature field.
24. Unambiguity conditions and their types.
25. Derive the equation for temperature distribution in a flat wall.
26. Derive the equation for the temperature field in the cylindrical wall.
27. Derive the equation for the temperature distribution in a multi-layered wall under boundary conditions of the 1st kind.
28. Derive and analyze the basic heat transfer equation.
29. On what factors does the radiative capacity of the body depend?
30. State the basic laws of thermal radiation.
31. How to determine the amount of heat transferred from a more heated body to a less heated one.
32. Give the mechanism of convective heat transfer.
33. Give a system of equations that describes convective heat transfer.
34. The essence and main theorems of the similarity theory method.
35. How do you convert differential equations that describe one or another process into criterion equations? Give the generalized criterion equation.
36. Name the main criteria of hydrodynamic and thermal similarity. Specify their main physical content. Describe the modified criteria of similarity. Name the main advantages and disadvantages of the theory of similarity.
37. What is the difference between the equation for determining the heat transfer coefficient during forced and free convection.
38. The intensity of heat transfer and ways of its intensification depend on what.
39. Give the algorithm for calculating the heat transfer coefficient.
40. Give the mechanism of condensation and the features of determining the heat transfer coefficient. Name the condensation factors. How does the gas content affect heat transfer?
41. Give the types of boiling and explain the concept of critical temperature difference during boiling.
42. Derive and analyze the equation for the average temperature difference between heat carriers in direct and counterflow.
43. What processes of chemical production belong to heat exchangers?
44. What are the requirements for coolants?
45. What process is called heat transfer?
46. What equation determines the relationship between the amount of transferred heat and the dimensions of the heat exchange equipment?
47. What is the physical meaning of the heat transfer coefficient?
48. What process is called heat transfer?
49. What parameters characterize heat transfer during natural and forced convection?
50. Why are criterial equations of convective heat exchange used in calculation practice?
51. What criteria of thermal and hydrodynamic similarity are included in the criterion equations of convective heat transfer? What is their physical significance?
52. What are the features of heat transfer in the event of a change in aggregate state? By what criteria are these features taken into account? What is the physical essence of this criterion?
53. What is the relationship between heat transfer coefficient and heat transfer coefficients?
54. What are the total thermal resistances of heat transfer?
55. What is the driving force of heat exchange processes?
56. Why is the average driving force used in the calculations of heat exchange processes

57. strength? How is it defined?
58. How can the heat transfer process be intensified?
59. What methods of heating are used in chemical industries?
60. From which equation is the flow rate determined? What are the methods of heat carrier for heating?
61. In what cases can "hot" steam be used for heating?
62. In what cases is heating with combustion gases used? What are the disadvantages of heating with combustion gases?
63. What methods of electric heating are used in chemical industries?
64. What positive qualities and disadvantages do water and air have when cooling hot coolants?
65. How to determine the flow of cooling water in the heat exchanger?
66. How are heat exchangers classified?
67. What is the structure and principle of operation of a single-pass shell-and-tube heat exchanger?
68. Why is heat exchange intensified in multi-pass shell-and-tube heat exchangers?
69. In what cases are temperature compensators used in shell and tube heat exchangers?
70. When are heat exchangers of the "pipe-in-pipe" type used? What are their advantages and disadvantages compared to shell and tube heat exchangers?
71. How is a spiral heat exchanger built? What are its disadvantages?
72. In which chemical industries are plate heat exchangers used? What are their positive qualities and disadvantages?
73. When are heat exchangers with ribbed heat exchange surfaces used? Give a comparative description of heat exchangers of different types.
74. Give the diagram of the design calculation of heat exchangers. What values should be known during design calculations of heat exchangers?
75. Why perform a hydraulic calculation of heat exchangers?
76. What is the optimal calculation of heat exchangers?
77. What is the difference between the verification calculation of heat exchangers and the design one?
78. What is called condensation?
79. What is the purpose of the condensation process in chemical industries?
80. By what features are capacitors classified?
81. What is the peculiarity of the calculation of surface capacitors?
82. What does the efficiency of mixing capacitors depend on?
83. What is the mechanism of rarefaction in vacuum installations using the condensation process?
84. What is the purpose of the barometric tube?
85. What is the purpose of using a two-stage barometric condenser?
86. Why is the amount of non-condensable gases calculated?
87. How is the height of the barometric tube calculated?
88. Explain the essence of the evaporation process.
89. What solutions are concentrated by evaporation?
90. What methods are used in the chemical industry to carry out the evaporation process?
91. What is the difference between the useful temperature difference and the total difference?
92. What are the temperature losses in the evaporation plant?
93. What does the amount of evaporated water depend on?
94. How is the consumption of heating steam determined during evaporation?
95. List the methods of saving heating steam during evaporation.
96. For what purpose do evaporation apparatuses create conditions for the circulation of the evaporated solution?
97. What is the procedure for calculating evaporation plants?
98. Why is the extra pair selected?
99. What causes self-evaporation?
100. How is the total useful temperature difference of a multi-body evaporation plant distributed across the bodies?
101. How to determine the optimal number of cases of a multi-case evaporation plant?
102. What designs of vaporizers are most common in industry?
103. What process is called drying?
104. What is the driving force behind the drying process?
105. Explain the concepts: relative humidity, moisture content and enthalpy of moist air.
106. Clarity of the principles of constructing a diagram of the I-th state of moist air.
107. List and characterize the types of moisture connection with the material.
108. How is air consumption (total and specific) determined for drying?
109. From which balance are specific heat consumption and heating steam consumption for drying determined?
110. How is the process of theoretical and real drying constructed on the I-x diagram?
111. What are the options for the drying process?
112. Clarity of the principles of construction of drying curves and drying speed.
113. What factors determine the drying speed in the first and second periods?
114. By what features are dryers classified?
115. Describe the structure and principle of operation of convective dryers.
116. Describe the structure of contact dryers.
117. Which materials should be dried in convective dryers, and which in contact dryers?
118. Name the methods of intensification of drying processes.