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

Machines and devices of chemical and oil refining industries

Processes and equipment of chemical technologies -2. Thermal processes.

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of higher education	***First (undergraduate)***
Branch of knowledge	*13 Mechanical engineering*
Specialty	*133 Industrial engineering*
Educational program	*Equipment of chemical, oil refining and pulp and paper industries*
Discipline status	*Normative*
Form of education	*daytime*
Year of training, semester	*3rd year, autumn*
Scope of the discipline	*6 credits*
Semester control/ control measures	*Exam, MKR, RR, current control*
Lessons schedule	*Scientific and pedagogical worker*
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, assistant, Andriy Mykolayovych Lyubeka* *Laboratory: candidate of technical sciences, assistant, Lyubeka Andriy Mykolayovych, candidate of technical sciences, senior lecturer, Serhii Serhiyovych Haydai*
Placement of the course	*Campushttp://ci.kpi.ua/*

Program of educational discipline

1. 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, which are 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, using systems of automated modeling, calculation and design, 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

Higher education level, specialty, educational program, form of education	General indicators	Characteristics of the credit module
VO level first (undergraduate)	Name of the discipline, Processes and equipment of chemical technologies - 2. Thermal processes	Lectures 54 hours
specialty 133 Industrial engineering	Cycle of professional training	Practical 36 hours
Educational program Equipment of chemical, oil refining and pulp and paper industries	The status of the credit module is mandatory	Laboratory work 6 p.m.
Form of education daytime	Semester 5	Individual work 232 hours, including for the performance of an individual task 3 p.m.
		Individual task RR
	Number of credits (hours) 8(240)	Type and form of semester control examination

The object of the educational discipline there are chemical technology processes and equipment.

Mastering the material of the discipline will allow you to master the basic theoretical principles of hydromechanical processes and thermal processes, to master the methods and techniques of evaluating their efficiency, and to be able to justify technical solutions to increase 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 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;

.

experience:

- design or verification calculation of heat exchange equipment;
– constructive calculation of heat exchange equipment;

– determination of the characteristics of heat carriers;
Program study results, control measures and deadlines are announced to bachelors in the first session.

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:

- Labor protection and civil protection.
- Construction materials technology.
- Materials science.
- Theoretical mechanics.
- Mechanics of materials and structures.
- Theory of mechanisms and machines.
- Metrology and standardization.
- Machine details.
- Theoretical foundations of heat engineering.

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

- Calculation and design of typical equipment.
- Educational disciplines in calculation and modeling with the help of a PC.
- Educational disciplines in computerized engineering.
- Educational disciplines in three-dimensional modeling.
- 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.
  Educational disciplines on equipment preparation and operation.

3. Content of the academic discipline

Chapter 1 Transfer phenomena in chemical production processes and devices.
Chapter 2. Basics of heat transfer
Chapter 3. Heat exchange equipment

The structure of the discipline

<table>
<tr><td rowspan="3">Names of sections and topics</td><td colspan="5">Number of hours</td></tr>
<tr><td rowspan="2">In total</td><td colspan="4">including</td></tr>
<tr><td>Lectures</td><td>Practical (seminar)</td><td>Laboratory (computer workshop)</td><td>SRS</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td colspan="6">Chapter 1 Transfer phenomena in chemical production processes and devices.</td></tr>
</table>

Topic 1.1 Introduction to the course of processes and devices. Topic 1.2. Transfer phenomena in chemical technology. Topic 1.3. Basics of the theory of similarity.	2 8 6	2 6 4	-	- -	- 2 2
Together by chapter 1	16	12			4
Chapter 2. Basics of heat transfer					
Topic 2.1. Thermal conductivity.	18	4	4	4	6
Topic 2.2. Convective heat exchange.. Topic 2.3. Heat exchange when the aggregate state changes.	20 12	8 4	4 4	4	4 4
Topic 2.4. Heat exchange during radiation.	5	2			3
Topic 2.5. Complex heat exchange	11	4	4	-	3
Topic 2.6. Unsteady thermal conductivity	11	4		4	3
Together by chapter 2	77	26	16	12	23
Chapter 3. Heat exchange equipment					
Topic 3.1. Heating and cooling in chemical technology.	26	6	8-	8	4
Topic 3.2 Evaporation and evaporation plants in chemical technology.	22	4	6	8	4
Topic 3.3 Drying and drying installations in chemical technology.	22	4	6	8	4
MKR on sections 1, 2, 3.	2	2		-	
Calculation work	15	-	-	-	15
Preparation for the exam	30	-	-	-	30
Together by section 3	117	16	20-	24	57
Together according to section 1,2,3	210	54	36	36	84

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 recommended 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. Kasatkin A.G. Basic processes and apparatuses of chemical technology. - M.: Khimiya, 1973. - 752 p.

4. Yu. I. Dytnersky Processes and apparatuses of chemical technology: Textbook for universities. Part 1. Theoretical foundations of chemical technology processes. Hydromechanical and thermal processes and devices / Yu. I. Dytnerskyi. — M.: Khimiya, 1992. — 416 p.
5. Pavlov K.F., Romankov P.G., Noskov V.N. Examples and tasks for the course of processes and apparatus of chemical technology. - L.: Khimiya, 1987. - 576 p.

Additional

1. Ioffe I.L. Designing processes and apparatuses of chemical technology. - L.: Khimiya, 1991. - 352 p.
2. Basic processes and apparatuses of chemical technology: design guide / Ed. Yu. I. Dytnerskyi. — M.: Khimiya, 1991. — 494 p.
3. Planovsky A.N., Nikolaev P.I. Processes and devices of chemical and petrochemical technology. - M.: Khimiya, 1987. - 490 p.
4. Gelperin N.I. Basic processes and apparatuses of chemical technology. Part 1, 2 - M.: Khimiya, 1981. - 811 p.
5. Kogan V.B. Theoretical foundations of typical processes of chemical technology. - L.: Khimiya, 1977. - 591 p.
6. Kryvorot A.S. Construction and basics of designing machines and apparatus of the chemical industry. - M.: Mashinostroenie, 1976. - 376 p.
7. Calculations of the main processes and apparatus of oil refining: Reference book / H.G. Rabinovych, P.M. Ryabykh, P.A. Khokhryakov et al. - M.: Khimiya, 1979. - 568 p.
8. Isachenko V.P., Osypova V.A., Sukomel A.S. Heat transfer. - M: Energy, 1981. - 417 p.
9. Mykheev M.A., Mykheeva N.M. Basics of heat transfer. - M: Energy, 1977. - 342 p.
10. Thermal processes and devices of chemical and oil refining industries// Part 1. Yu.Yu. Lukach, I.O. Mikulonok, G.L. Ryabtsev, M.V. Sezonov - K.: NMCSO, 2000.-172 p. Part 2. Yu.Yu. Lukach, I.O. Mikulonok, V.L. Rakytskyi, G.L. Ryabtsev. - K.: NMCSO, 2004. - 161 p.
11. Machines and apparatuses of chemical production / Ed. I.I. Chernobyl. - M.: Mashinostroenie, 1974. - 456 p.
12. I. I. Chernobylsky Evaporation plants. - K.: Higher School, 1970. - 240 p.
13. Chernobylsky I.I., Tananayko Yu.M. Drying installations of the chemical industry. - K.: Tehnika, 1969. - 280 p.
14. Study of stationary heat conduction through a cylindrical wall / Incl.: O.H. Zubrii, L.B. Radchenko. - 1994.
15. Research of the processes of non-stationary thermal conductivity / Comp.: V.G. Dobronogov, L.B. Radchenko. - 1994.
16. Study of heat transfer during thermal convection / Incl. L.B. Radchenko. - 1994.
17. Study of heat transfer during boiling and condensation / Incl.: S.V. Sydorenko, I.A. Andreev. - 1993.
18. Study of the heat transfer process in a heat exchanger with U-shaped tubes / Incl.

Educational content

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

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

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 hours
	Chapter 1 Transfer phenomena in chemical production processes and devices.	

1-	Topic 1.1. Introduction to the course of processes and devices.	2
	*Scheduled:*The structure, classification and types of chemical and technological processes are given. *SRS topic:*Structure, classification and types of chemical and technological processes. *Recommended:*Literature 1-5, 7, 8.	
2–4	Topic 1.2. Transfer phenomena in chemical technology.	4
	*Scheduled:*The equations of conservation of mass, energy, equilibrium, driving force and the principles of their solution are analyzed. *The subject of SRS*: Equations of conservation of mass, energy, equilibrium, driving force and the principles of their solution. *Recommended:*Literature 1-7.	
5,6	Topic 1.3. Basics of the theory of similarity.	4
	*Scheduled:*Physical and mathematical models of thermal processes and their solutions are considered. Similarity conditions and theorems are presented. Criteria, criterion equations and principles of their derivation are analyzed. Topic of SRS: Physical and mathematical models of thermal processes and their solutions are considered. Similarity conditions and theorems are presented. Criteria, criterion equations and principles of their derivation are analyzed. *Recommended:*Literature 1-7.	
	Chapter 2. Basics of heat transfer	
7,8	Topic 2.1. Thermal conductivity.	4
	*Scheduled:*Concepts of thermal energy and types of its transfer, temperature field and temperature gradient are considered. The basic equation of heat conduction is derived and analyzed. The coefficient of thermal conductivity, conditions of uniqueness and cases of heat transfer under boundary conditions of the first and third kind through flat and cylindrical walls are considered. *SRS topic:*Coefficients of thermal conductivity, conditions of uniqueness and cases of heat transfer under boundary conditions of the first and third kind through flat and cylindrical walls. *Recommended:*Literature 1-7.	
9–12	Topic 2.2. Convective heat exchange.	4
	*Scheduled:*The heat transfer equation and the physical content of the heat transfer coefficient are analyzed. Physical and mathematical models and ways of solving them are considered. Criteria and criterion equations of thermal similarity and partial cases of convective heat exchange are given. *SRS topic:*Physical and mathematical models and ways of their solution. Criteria and criterion equations of thermal similarity and partial cases of convective heat exchange are given. *Recommended:*Literature 1-7.	
13,14	Topic 2.3. Heat exchange when the aggregate state changes.	4
	*Scheduled:*Types and physical models of condensation and boiling processes are considered, calculated dependencies are analyzed to determine heat transfer coefficients and ways of their intensification. *SRS topic:*Physical models of condensation and boiling processes, analysis of calculated dependencies to determine heat transfer coefficients and ways of their intensification. *Recommended:*Literature 1, 2, 3.	

15,16	Topic 2.4. Heat exchange during radiation.	4
	*Scheduled:*The essence of radiant radiation, basic laws and heat exchange between two bodies and in gases are considered. *SRS topic:*The essence of radiation, basic laws and heat exchange between two bodies and in gases. Literature 1-7.	
17	Topic 2.5. Complex heat exchange	2
	*Scheduled:*Types and physical models of complex heat exchange are considered, dependencies are analyzed to determine heat transfer coefficients and ways of their intensification. *The subject of SRS*: Physical models of complex heat exchange, dependencies are analyzed to determine heat transfer coefficients and ways of their intensification. *Recommended:*Literature 1-7.	
18,19	Topic 2.6. Unsteady thermal conductivity	4
	*Scheduled:*The basics and individual cases of solving non-stationary thermal conductivity problems are considered *SRS topic:*individual cases of solving problems of non-stationary thermal conductivity *Recommended:*Literature 1-7.	
20-22	Topic 2.7. Heating and cooling in chemical technology.	4
	*Scheduled:*Requirements for coolants, their characteristics, basic heating schemes are considered. and the bases of their calculation. Typical designs of heat exchangers, methods of design and verification calculations and ways of intensifying the heat transfer process are given. The mutual movement of heat carriers and the procedure for determining the driving force of heat transfer are analyzed. The basics of calculating heat exchange devices are given. *SRS topic:*To classify and compile an album of designs of heat exchange devices of devices. Highlight cases of their use, advantages and disadvantages. *Recommended:*Literature 1-7	
23-24	Topic 2.8. Evaporation and evaporation plants in chemical technology.	4
	*Scheduled:*The physical essence of the evaporation process is considered using the example of a single-body evaporation plant with a central circulation pipe. The material and heat balances are compiled, the features of determining the useful temperature difference are analyzed, and the calculation algorithm is given. Multi-body evaporation plants and their features in direct flow, counterflow and parallel feeding are considered. The distribution of the useful temperature difference for various cases and typical designs of devices are studied. The basics of calculating evaporation apparatuses are given. *SRS topic:*To classify and compile an album of structures of evaporating apparatuses. Highlight the use cases of advantages and disadvantages. *Recommended:*Literature 1-7.	
25,26	Topic 2.9. Drying and drying installations in chemical technology.	4
	*Scheduled:*The physical essence of the drying process and its types are considered. Convective drying and parameters of moist air, analytical and grapho-analytical methods of their determination are studied. The material and heat balances of drying are compiled. The concept of a theoretical dryer is introduced and options for drying are given. Calculated dependences are given for determining air and heat consumption for drying. Drying curves, drying periods and an algorithm for	

	determining the drying speed are considered. Dependencies are given for determining the duration of drying in the first and second periods and overall dimensions of dryers. Topic of SRS: To classify and compile an album of designs of dryers. Highlight use cases, advantages and disadvantages *Recommended:*Literature 1-7.	
27	Control module work	2

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 1. Transfer phenomena in chemical production processes and devices.	
	Topic 1.3. Basics of the theory of similarity.	
1	Physical and mathematical models of transfer processes, decision methods and criteria of similarity, their properties and physical content are considered. *Recommended:*Literature 1-7.	2
	Chapter 2. Basics of heat transfer	
	Topic 2.1. Thermal conductivity.	
2,3	Calculations of the process of thermal conductivity and thermal resistance for single-layer, multi-layer and cylindrical walls. *Recommended:*Literature 1-7.	4
	Topic 2.2. Convective heat exchange.	
4.5	Partial cases of convective heat exchange and the algorithm for calculating heat transfer and heat transfer coefficients are considered. *Recommended:*Literature 1-7.	4
	Topic 2.3. Heat exchange when the aggregate state changes.	
6	Peculiarities and examples of calculation of coefficients of heat transfer and heat transfer during boiling and condensation are considered. *Recommended:*Literature 1-7.	2
	Topic 2.5. Complex heat exchange	
7,8	Examples of complex heat transfer calculations are considered. Recommended: Literature 1-7.	4
	Topic 2.7. Heating and cooling in chemical technology.	
8–12	Heating and cooling schemes, apparatus designs and examples of their calculation are considered. *Recommended:*Literature 1-7.	8
	Topic 2.8. Evaporation and evaporation plants in chemical technology.	
13–15	Schemes, constructions and calculation examples of evaporation plants are considered. *Recommended:*Literature 1-7.	6
	Topic 2.9. Drying and drying installations in chemical technology.	
16–18	Schemes, designs and calculation examples of dryers are considered. *Recommended:*Literature 1-7.	6

5.3. Laboratory classes.

The main tasks of the laboratory cycle are the acquisition of experience in drawing up the balance equations of heat exchange processes, as well as the analysis of experimental data and the generalization of the obtained results. Systematization and consolidation of knowledge of fundamental equations of transfer of mass, energy, quantity of motion and general principles of their solution for specific processes of chemical technology.

No. z/p	Name of laboratory work (computer workshop)	Number of hours
1	Introductory lesson. Acquaintance with the requirements of safety equipment. Formation of groups, subgroups. Acquaintance with laboratory installations. Formulation of requirements for performance, preparation of reports and protection of laboratory work.	2
2,3	Study of heat transfer during thermal convection. *Recommended:*Literature 1-7, 17.	4
4.5	Study of heat conduction through a cylindrical wall *Recommended:*Literature 1-7, 14.	4
6,7	Study of designs of heat exchangers and the process of heat transfer in a heat exchanger with U-shaped tubes. *Recommended:*Literature 1-7, 18.	4
8,9	Study of non-stationary thermal conductivity *Recommended:*Literature 1-7, 15.	4
10,11	Study of structures of evaporating apparatuses and the process of heat transfer during boiling and condensation. *Recommended:*Literature 1-7, 17.	4
12,13	Study of designs of dryers and dryers with partial recirculation of the drying agent. *Recommended:*Literature 1-7, 21.	4
14,15	Study of a heat exchanger with a ribbed surface *Recommended:*Literature 1-7,19	4
16,17	Protection of abstracts of constructions	4
18	Protection and submission of reports on laboratory work	2

6. Independent work of student

The discipline "Processes and equipment of chemical technologies - 2. Thermal processes" provides the following types of student work: lectures, practical and laboratory classes, one modular control work, calculation work and independent student work. 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, namely, defended all the tasks assigned to lectures, practical and laboratory classes, 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.

Lectures are aimed at summarizing and systematizing 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.

Laboratory classes allow students to consolidate the theoretical provisions of the credit module and acquire skills and experience in their practical application by performing certain appropriately formulated tasks.

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, the purpose of which is to study equipment structures 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.

The main purpose of the control work is to check the level of mastery 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 credit module rating consists of the points he receives for:

1) execution and defense of 10 (by the teacher's choice) tasks.
2) performance and defense of 4 laboratory works and 3 sections of the synopsis of structures;

3) writing ICR;
4) writing and protecting the calculation work;
5) the answer to the exam.

System of rating (weighted) points and evaluation criteria

1.**Work in practical classes**

Weighted point - 2. The maximum number of points in all practical classes is equal to:

2 points x 10 = 20 points.

Evaluation criteria:

2 points are given if the answer is excellent.

1 point is given if the answer is sufficient.

a score of 0 is given if the answer is unsatisfactory.

2. Laboratory works

The weighted point is 4. The maximum number of points for all laboratory work and the synopsis of structures is equal to:

4 points x 4 = 16 points.

Evaluation criteria:

- preparation and performance of laboratory work:

point 1 is awarded under the condition of excellent work;

a score of 0 is awarded for unsatisfactory work.

- quality (protection) of work:

a score of 2 is awarded under the condition of an excellent answer;

1 point is given if the answer is sufficient;

a score of 0 is given if the answer is unsatisfactory.

- preparation and defense of one section of the synopsis of structures:

a score of 2 is awarded under the condition of an excellent answer;

1 point is given if the answer is sufficient;

a score of 0 is given if the answer is unsatisfactory.

3. Modular control

Weight score – 12

a score of 14-12 is given if at least 95% of the questions are answered;

a score of 11-9 is awarded on the condition that 85 to 95% of the questions are answered;

a score of 8-6 is awarded on the condition that 75 to 85% of the questions are answered;

a score of 5-2 is awarded on the condition that 60 to 75% of the questions are answered;

a score of 1-0 is given if less than 60% of the questions are answered.

4. Calculation work.

Weight score – 12.

RR evaluation criteria:

a score of 10-12 is awarded if all sections of the work are covered in full;

a score of 7-9 is awarded if certain inaccuracies are admitted in the work;

points 4-6 are assigned if individual sections are not fully covered or mistakes are made;

2-3 points are given if the topic of the work is not clearly covered: errors in wording, terms and definitions are made;

a score of 0-1 is assigned if the work is performed unsatisfactory: the presence of significant errors or the absence of separate sections, the RR is not counted.

5. Penalty and incentive points for:

- non-admission to laboratory work due to unsatisfactory input control -1 point;
- absence from a laboratory session without a valid reason - 2 points;
- untimely (later than during the control session) submission of laboratory work or section of the

synopsis of structures - 1 point.

- untimely (later than in the control session) handing in the calculation of the device in the practical session - 2 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= 100 points.

The size of the starting scale Rc= Rпр+Rlab+RMKP +Рпр =20+16+12 +12=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).

To receive "passed" 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 measures, the "ideal" student must receive 45 points).

Conditions for admission to the exam:enrollment of all practical classes, laboratory work, 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			
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 Refining Industries, Candidate of Technical Sciences, Associate Professor, Shved Mykola Petrovych

Adopted: by the Department of the Academy of Sciences of the Russian Academy of Sciences (protocol No. 20 dated 20.06.2022)

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

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 ___% of the useful 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 solvent, %	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 CaCl2 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

1. Technical characteristics of coolants
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. Basic processes and apparatuses of chemical technology: Handbook on design / Ed. Yu.I. Ditnersky - M.: Khimiya, 1982. - 772 p.
3. Pavlov K.F., Romankov P.G., Noskov V.N. Examples and tasks for the course of processes and apparatus of chemical technology. - L.: Khimiya, 1987. - 576 p.
4. Machines and apparatuses of chemical production / Ed. I.I. Chernobyl. - M.: Mashinostroenie, 1974. - 456 p.
5. Methodical instructions for performing calculation work for students of the training direction 6.0502 "Computer-integrated technological processes and production" from the discipline "Technological objects and processes of the industry - 1" [Electronic resource] / NTUU "KPI"; structure. M. P. Shved, D. M. Shved, A. R. Stepaniuk. – Access:http://library.kpi.ua:8080/handle/123456789/2434

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"	ω1.%	ω2,%	Version	G, kg/s	Version	City "N"
10.	potassium chloride	6	0.4	1.	0.3	1.	Dnipropetrovsk
11.	ammonium sulfate	3.6	0.4	2.	0.4	2.	Kyiv
12.	ammonium nitrate	4	0.3	3.	0.6	3.	Kirovohrad
13.	sodium chloride	5	0.2	4.	0.8	4.	Mykolayiv
14.	superphosphate	18	3.5	5.	1.0	5.	Odesa
15.	sand	4	0.1	6.	1,2	6.	Kharkiv
16.	coal	9	0.6	7.	1.4	7.	Lviv
17.	clay	23	4.5	8.	1.6	8.	Sumy
18.	barium chloride	5.5	1,2	9.	1.8	9.	Vinnytsia
0	sodium bicarbonate	6	0.1	0	2.0	0	Kherson
and				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
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. Kasatkin A.G. Basic processes and apparatuses of chemical technology. - M.: Khimiya, 1973. - 752 p.
3. Basic processes and apparatuses of chemical technology: Handbook on design / Ed. Yu.I. Ditnersky - M.: Khimiya, 1982. - 772 p.
4. Pavlov K.F., Romankov P.G., Noskov V.N. Examples and tasks for the course of processes and apparatus of chemical technology. - L.: Khimiya, 1987. - 576 p.
5. Machines and apparatuses of chemical production / Ed. I.I. Chernobyl. - M.: Mashinostroenie, 1974. - 456 p
6. Chernobylsky I.I., Tananayko Yu.M. Drying installations of the chemical industry. - K.: Tehnika, 1969. - 280 p.
7. Methodical instructions for performing calculation work for students of the training direction 6.0502 "Computer-integrated technological processes and production" from the discipline "Technological objects and processes of the industry - 1" [Electronic resource] / NTUU "KPI"; structure. M. P. Shved, D. M. Shved, A. R. Stepaniuk. – Access:http://library.kpi.ua:8080/handle/123456789/2434

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	thirtee	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

1. Technical characteristics of coolants
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. Kasatkin A.G. Basic processes and apparatuses of chemical technology. - M.: Khimiya, 1973. - 752 p.
3. Basic processes and apparatuses of chemical technology: Handbook on design / Ed. Yu.I. Ditnersky - M.: Khimiya, 1982. - 772 p.
4. Pavlov K.F., Romankov P.G., Noskov V.N. Examples and tasks for the course of processes and apparatus of chemical technology. - L.: Khimiya, 1987. - 576 p.
5. Machines and apparatuses of chemical production / Ed. I.I. Chernobyl. - M.: Mashinostroenie, 1974. - 456 p.
6. I. I. Chernobylsky Evaporation plants. - K.: Higher School, 1970. - 240 p.

7. Methodical instructions for performing calculation work for students of the training direction 6.0502 "Computer-integrated technological processes and production" from the discipline "Technological objects and processes of the industry - 1" [Electronic resource] / NTUU "KPI"; structure. M. P. Shved, D. M. Shved, A. R. Stepaniuk. – Access:http://library.kpi.ua:8080/handle/123456789/2434

Appendix B

Questions to the MKR

1. Unambiguity conditions and their types.
2. Derive the equation for temperature distribution in a flat wall.
3. Derive the equation for the temperature field in the cylindrical wall.
4. Derive the equation for the temperature distribution in a multi-layer wall under boundary conditions of the 1st kind.
5. Derive and analyze the basic heat transfer equation.
6. On what factors does the radiative capacity of the body depend?
7. What are temperature gradient, isothermal surface and temperature field and what are their properties? State the basic laws of thermal radiation.
8. How to determine the amount of heat transferred from a hotter body to a less heated one.
9. Give the mechanism of convective heat transfer.
10. Give a system of equations that describes convective heat transfer.
11. The essence and main theorems of the similarity theory method.
12. How do you convert differential equations that describe one or another process into criterion equations? Give the generalized criterion equation.
13. Name the main criteria of hydrodynamic and thermal similarity. Specify their main physical meaning. Describe the modified similarity criteria.
14. Name the main advantages and disadvantages of similarity theory.
15. What are the differences between the equations for determining the heat transfer coefficient during forced and free convection.
16. The intensity of heat transfer and ways of its intensification depend on what.
17. Give the algorithm for calculating the heat transfer coefficient.
18. 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?
19. Give the types of boiling and explain the concept of critical temperature difference during boiling.
20. Derive and analyze the equation for the average temperature difference between heat carriers in direct and countercurrent flow.
21. What are the requirements for coolants?
22. What process is called heat transfer?
23. What equation determines the relationship between the amount of transferred heat and the dimensions of the heat exchange equipment?
24. What is the physical meaning of the heat transfer coefficient?
25. What process is called heat transfer?
26. What parameters characterize heat transfer during natural and forced convection?
27. Why are criterial equations of convective heat exchange used in calculation practice?
28. What criteria of thermal and hydrodynamic similarity are included in the criterion equations of convective heat transfer? What is their physical significance?
29. 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?
30. What is the relationship between heat transfer coefficient and heat transfer coefficients?
31. What are the total thermal resistances of heat transfer?
32. What is the driving force of heat exchange processes?
33. Why is the average driving force used in the calculations of heat exchange processes
34. strength? How is it defined?
35. In what ways can the heat transfer process be intensified?
36. What methods of heating are used in chemical industries?
37. From which equation is the flow rate of the coolant for heating determined?
38. In what cases can "hot" steam be used for heating?
39. In what cases is heating with combustion gases used? What are the disadvantages of heating with combustion gases?
40. What methods of electric heating are used in chemical industries?
41. What positive qualities and disadvantages do water and air have when cooling hot coolants? How to determine the flow of cooling water in the heat exchanger?
42. How are heat exchangers classified?
43. What is the structure and principle of operation of a single-pass shell-and-tube heat exchanger?
44. Why is heat exchange intensified in multi-pass shell-and-tube heat exchangers?
45. In what cases are temperature compensators used in shell and tube heat exchangers?

46. When are heat exchangers of the "pipe-in-pipe" type used? What are their advantages and disadvantages compared to shell and tube heat exchangers?
47. How is a spiral heat exchanger built? What are its disadvantages?
48. In which chemical industries are plate heat exchangers used? What are their positive qualities and disadvantages?
49. When are heat exchangers with ribbed heat exchange surfaces used? Give a comparative description of heat exchangers of different types.
50. Give the diagram of the design calculation of heat exchangers. What values should be known during design calculations of heat exchangers?
51. Why perform a hydraulic calculation of heat exchangers?
52. What is the optimal calculation of heat exchangers?
53. What is the difference between the verification calculation of heat exchangers and the design one?
54. What is called condensation?
55. What is the purpose of the condensation process in chemical industries?
56. By what features are capacitors classified?
57. What is the peculiarity of the calculation of surface capacitors?
58. What does the efficiency of mixing capacitors depend on?
59. List the main requirements for coolants
60. What methods of heating are used in chemical industries?
61. From which equation is the flow rate of the coolant for heating determined?
62. In what cases can "hot" steam be used for heating?
63. In what cases is heating with combustion gases used? What are the disadvantages of heating with combustion gases?
64. What methods of electric heating are used in chemical industries?
65. What positive qualities and disadvantages do water and air have when cooling hot coolants? 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 ones should be dried in contact dryers?
118.Describe special types of drying: sublimation, infrared rays and in the field of high-frequency currents.
119.Name the methods of intensification of drying processes.
120.Write down and analyze the heat conduction equation for different types of temperature field.