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

and Apparatus for Chemical and Oil Refining

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

Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	*First (bachelor's)*
Branch of knowledge	*16 Chemical technology*
Specialty	*161 Chemical technology and engineering*
Educational program	*Name*
Discipline status	Normative
Form of study	eye (day)
Year of preparation, semester	3rd year, autumn
The scope of discipline	3.5 credits
Semester control / control measures	*Exam, MCR, RR, current control*
Lessons schedule	
Language of instruction	*Ukrainian*
Information about course leader / teachers	Lecturer: Candidate of Technical Sciences, Associate Professor, Mykola Petrovich Shved, npchved46 @ gmail Practical: candidate of technical sciences, senior lecturer Novohat Oleg Anatoliyovych, candidate of technical sciences, senior lecturer Sachok Roman
Course placement	*Campushttp://ci.kpi.ua/*

Curriculum

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

Technology of manufacturing chemical, oil refining, biotechnological, food, and other products. industries are constructed 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 transfer, diffusion-controlled, chemical processes, which are based on the fundamental laws of conservation of energy, mass, momentum.

Processes and devices of chemical and oil refining industries are a branch of science and technology that investigates the main characteristics of micro- and macrokinetics of chemical-technological processes and

sets the parameters that are the conditions for their implementation in the relevant equipment. Physical and mathematical modeling of processes plays a crucial role in this, 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 course is based on the knowledge gained by students in the study of disciplines of humanities, natural sciences and professional and practical cycles, namely higher mathematics, physics, chemistry, physical chemistry, theoretical mechanics, resistance of materials, theoretical foundations of heat engineering, hydraulics, descriptive geometry, engineering and computer graphics.

The formation of knowledge, practical skills and abilities of the bachelor is carried out during lectures, practical and laboratory classes, the organization of independent work.

Description of the 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 apparatus of chemical production</td><td>Form of study
daily</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 choice of university</td></tr>
<tr><td></td><td>Number of sections 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 preparation 2022/2023</td></tr>
<tr><td>Semester 5</td></tr>
<tr><td rowspan="4">Education level
bachelor</td><td rowspan="3">Total number of hours
105</td><td>Lectures
36 years</td></tr>
<tr><td>Practical (seminar)
18 years</td></tr>
<tr><td>Laboratory (computer workshop)
0 years</td></tr>
<tr><td rowspan="2">Weekly hours:
classroom - 3
CPC - 2.5</td><td>Individual work
51 years
including the performance of an individual task
12 years</td></tr>
<tr><td>Type and form of semester control
Exam</td></tr>
</table>

The object of the discipline there are processes and devices of chemical production.

Mastering the material of the discipline will allow to master the basic theoretical principles of technical hydraulics, hydromechanical processes and thermal processes, to master the methods and techniques of assessing their effectiveness, and be able to justify technical solutions to improve their efficiency. This will help increase the competitiveness of professionals in employment in prestigious engineering positions.

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

– to study and analyze the processes of chemical technologies;
– to the analysis of design features of the chemical equipment;
– to the analysis of methods of calculations and design of chemical equipment;
– to the selection of elements of chemical equipment;
– to the choice of energy sources and determination of their energy parameters.

The main tasks of the discipline.

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

knowledge:

– basic chemical-technological processes and their classification;
– heat exchange equipment designs;
– methods of calculation of the basic sizes and technical parameters of the heat-exchange equipment;
– sources of heat supply;
– directions of saving thermal energy and increasing the reliability of heat exchange equipment;
– constructive schemes of thermal equipment for realization of certain processes of the technological scheme;

skills:

– using data on the main features of heat exchange equipment
to classify them;
– using data on the main properties of energy, calculate their basic parameters;
– using data on the basic needs of technological processing, to choose the appropriate design of heat exchange equipment;
– using data on the design and technological characteristics of heat exchange equipment, according to the appropriate methods to calculate their basic dimensions and technical parameters;
– using data on the design of heat exchange equipment;
and technological characteristics of the processes occurring in them, to assess the technical and economic feasibility of heat supply sources;
– using data on technical and economic indicators of heat exchange equipment
to determine the main directions of thermal energy saving;
– on the basis of the analysis of variants to carry out a rational choice of constructive schemes of the thermal equipment for realization of certain processes of the technological scheme;
– during the development of technical proposal, sketch and technical designs and working design documentation, using methods and techniques of engineering and computer graphics, the principles of interchangeability and the system of tolerances and landings, perform assembly drawings of heat exchange equipment;
– using methods, computer technology, perform material and thermal balances of equipment, calculate the kinetic characteristics of processes and the basic geometric dimensions of the devices;
– knowing the basic designs of equipment to be able to develop design documentation for heat exchange equipment;
.

experience:

- design or test calculation of heat exchange equipment;

– constructive calculation of heat exchange equipment;
– determination of features of heat carriers;

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

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

Prerequisites of the discipline. To successfully master the competencies you need knowledge of the following disciplines:

- Mathematics
- Physics
- Chemistry
- Physical chemistry

Post-requisites of the discipline. List of disciplines provided by this discipline:

- Calculation and design of standard equipment.
- Academic disciplines in computerized engineering.
- Courses on delivery and transportation.
- Educational disciplines on the processes of heat treatment and processing.
- Educational disciplines in process control.

3. The content of the discipline

Section 1 Fundamentals of transfer theory.
Section 2 Technical hydraulics
Section 3. Basics of heat transfer
Section 4. Heat exchange equipment

Training materials and resources

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

Basic literature:

1. Kornienko Ya.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, IO Мікульонок, B.Л. Rakytsky, GL Ryabtsev - K .: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Kornienko Ya.M. Processes and equipment of chemical technology 2: textbook /Y.M. Kornienko, Yu.Yu. Lukach, IO Мікульонок, B.Л. Rakytsky, GL Ryabtsev - K .: NTUU "KPI", 2011 - Part 2 - 416 p.
3. Kasatkin AG Basic processes and devices of chemical technology. - M .: Химия, 1973. - 752 с.
4. Dytnersky Yu. I. Processes and devices of chemical technology: A textbook for universities. Part 1. Theoretical foundations of chemical technology processes. Hydromechanical and thermal processes and devices / Yu. I. Dytnersky. - M.: Химия, 1992. - 416 с.
5. Pavlov KF, Romankov PG, Noskov VN Examples and problems on the course of processes and devices of chemical technology. - L .: Chemistry, 1987. - 576 p.

Optional

1. Ioffe IL Design of processes and devices of chemical technology. - L .: Chemistry, 1991. - 352 p.

2. Basic processes and devices of chemical technology: a guide to design / Ed. Yu. I. Dytnersky. - M.: Химия, 1991. - 494 с.
3. Planovsky AN, Nikolaev PI Processes and devices of chemical and petrochemical technology. - M .: Химия, 1987. - 490 с.
4. Gelperin NI Basic processes and devices of chemical technology. Ch. 1,2 - M .: Khimiya, 1981. - 811 s.
5. Kogan W.B. Theoretical bases of typical processes of chemical technology. - L .: Chemistry, 1977. - 591 p.
6. Krivorot AS Design and basics of design of machines and devices of the chemical industry. - M .: Mashinostroenie, 1976. - 376 s.
7. Calculations of the main processes and devices of oil refining: Handbook / G.G. Рабинович, П.М. Рябых, П.А. Khokhryakov et al. - M .: Chemistry, 1979. - 568 p.
8. Isachenko VP, Osipova VA, Sukomel AS Heat transfer. - M: Энергия, 1981. - 417 с.
9. Thermal processes and apparatus of chemical and oil refining industries // Part 1. Yu.Yu. Lukach, IO Мікульонок, Г.Л. Рябцев, M.B. Seasons. - К .: НМЦВО, 2000.-172 с. Part 2. Yu.Yu. Lukach, IO Мікульонок, В.Л. Rakytsky, GL Рябцев. - К .: НМЦВО, 2004.- 161 с.
10. Machines and apparatus of chemical production / Ed. I.I. Chernobyl. - M .: Mashinostroenie, 1974. - 456 s.
11. Chernobyl II Evaporators. - К .: Выща школа, 1970. - 240 с.
12. Chernobyl II, Tananaiko Yu.M. Drying plants of the chemical industry. - К .: Техника, 1969. - 280 с.
13. Investigation of stationary thermal conductivity through a cylindrical wall / Encl .: OG Zubriy, LB Radchenko. - 1994.
14. Research of processes of nonstationary thermal conductivity / Sost .: VG Dobronogov, LB Radchenko. - 1994.
15. Research of heat transfer at thermal convection / Incl. L.B. Radchenko. - 1994.
16. Research of heat transfer at boiling and condensation / Incl .: S.V. Сидоренко, I.A. Andreev. - 1993.
17. Investigation of the heat transfer process in a heat exchanger with U-shaped tubes / Encl.

Educational content

5. Methods of mastering the discipline (educational component)

Information (by sections, topics) about all classes (lectures, practical, seminar, MCR, VTS)

Names of sections and topics	Number of hours				
	Total	including			
		Lectures	Laboratory	Practical	CPC
1	2	3	4	5	6
Section 1. Fundamentals of transfer theory					
Topic 1.1. Introduction to the course of processes and devices. Classification of chemical-technological processes	2	2	-	2	2
Phenomena of transfer in chemical technology. Equation of conservation of mass, energy and momentum. Principles of their solution.	4	4			
Together under section 1	**10**	**6**	**-**	**2**	**2**
Section 2. Technical hydraulics					
Topic2.1. Statics of liquids. Characteristics and their properties. Euler's equation. The basic equation of hydrostatics. Classification and principle of operation of hydraulic machines.	4	2	-	-	2
Topic 2.2. Hydrodynamics of fluids. Equations of Euler, Navier-Stokes, Bernoulli. Friction resistance and local resistance, their calculation. The optimal diameter of the pipeline.	12	4		4	4
Together under section 2	**16**	**6**	**-**	**4**	**6**
Section 3. Basics of heat transfer					
Topic 3.1. Diffusion transfer of thermal energy	11	3	-	4	4
Topic 3.2. Convective heat transfer. Partial cases of convective heat transfer	11	3	-	4	4
Topic 3.3. Heat transfer when the physical state changes and radiation	6	2	-	-	4
Together under section 3	**28**	**8**	**-**	**8**	**12**
Section 4. Heat exchange equipment					
Topic4.1. Heating, cooling and heat exchangers	12	4	-	4	4
Topic 4.2. Evaporation and evaporation plants	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**
MCR in sections 1–4	**7**	**1**	**-**	**-**	**6**
Exam			-	-	9
Hours in general	**105**	**36**	**-**	**18**	**51**

5.1. Lectures

№ s / n	Title of the lecture topic and list of main questions (list of teaching aids, references to literature and tasks on VTS)	Number of hours
	Section 1. Fundamentals of transfer theory	
1	**Topic 1.1.**Introduction to the course of processes and devices.	**6**
	*Scheduled:*The classification of chemical-technological processes is given, and also the phenomena of transfer 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, 2, 3, 7.	
	Section 2. Technical hydraulics	
2	**Topic2.1.**Statics of liquids. Characteristics and their properties. Euler's equation. The basic equation of hydrostatics. Classification and principle of operation of hydraulic machines.	**2**
	*Scheduled:*The characteristics of liquids are given, their classification is stated. 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:*Make an album of constructions of hydraulic machines and devices for measuring pressure, level, speed and fluid flow *Recommended:*1, 2, 3, 7.	
3.4	**Topic 2.2.**Hydrodynamics of fluids. Equations of Euler, Navier-Stokes, Bernoulli. 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. Pressure losses along the channel length and local losses are considered. Dependencies are analyzed to determine the optimal diameter of the pipeline. *SRS topic:*Give a classification and make an album of constructions of hydraulic machines for moving liquids and gases. *Recommended:*1, 2, 7.	
	Section 3. Basics of heat transfer	
5.6	**Topic 3.1.**Diffusion transfer of thermal energy	**3**
	*Scheduled:*Types of heat transfer and the concept of temperature gradient, temperature field, heat flux and heat flux density are considered. The basic equation of thermal conductivity is derived and analyzed. The conditions of unambiguity and cases of stationary thermal conductivity are considered. The kinetic coefficients of thermal conductivity, thermal conductivity and heat transfer are considered. *The topic of SRS*: Prepare the topic 3.1. Diffusion transfer of thermal energy. *Recommended:*, 3, 4, 5, 7.	

6.7	**Topic 3.2.**Convective heat transfer. Partial cases of convective heat transfer	**3**
	*Scheduled:*The physical essence of convective heat transfer is considered. The Newton-Richman heat transfer equation is considered. The concept of heat transfer coefficient is introduced. A system of equations of convective heat transfer is derived and the ways of its solution are considered. The method of similarity theory, theorems and criteria of thermal similarity is considered. Criteria equations for determining the heat transfer coefficient and ways of its intensification are given. References 1, 3, 4, 5, 7. VTS topic: Prepare topic 3.2. Convective heat transfer. Partial cases of convective heat transfer and ways of its intensification. References 1, 3, 4, 5, 7.	
8.9	**Topic 3.3.**Heat transfer when the physical state changes and radiation.	**2**
	*Scheduled:*The types and physical essence of boiling and condensation processes are considered. The calculated dependences for determining the heat transfer coefficients during boiling and condensation and the ways of intensification of these processes are given. The mechanism of heat transfer of radiation is considered. The basic laws of radiation are given. Dependences for determination of heat exchange by radiation between bodies and complex heat exchange are analyzed. References 1,2, 5 *SRS topic:*: Give a classification and compile an album of condenser and boiler designs. Highlight cases of application, advantages and disadvantages. Recommended: 1, 3, 4, 5, 7.	
	Section 4. Heat exchange equipment	
10-12	**Topic4.1.**Heating, cooling and heat exchangers.	**4**
	*Scheduled:*Requirements for heat carriers and heating schemes with water, steam, mineral oils and other high-temperature heat carriers, electric current and furnace gases are given. Types of heat carrier motion and methods for determining the driving force of heat transfer are considered. Material and heat balances of heat transfer, and also algorithm of design and check calculation of heat exchangers are resulted. *The topic of SRS*: Give a classification and make an album of heat exchangers. Highlight cases of their advantages and disadvantages. *Recommended:*1, 3, 4, 5, 7.	
13.14	**Topic 4.2.**Evaporation and evaporation plants	**4**
	*Scheduled:*The mechanism and features of concentration of solutions by evaporation are considered. Material and thermal balances of a single-hull evaporator. Temperature losses and the algorithm for determining the heat transfer surface are analyzed. Multihull evaporators. Principle of action. Material and thermal balances. Cases of application. References 1, 3, 4, 5, 7. *The topic of SRS*: Give a classification and make an album of evaporator designs Highlight the cases of advantages and disadvantages. *Recommended:*1, 3, 4, 5, 7.	
15.16	**Topic 4.3.**Drying and drying installations	**4**

	*Scheduled:*The mechanism, stages and types of drying installations are given. The characteristics of moist air as a drying agent and their reflection on the I-X diagram are given. The material and thermal balances of the convective dryer are considered and the concept of an ideal dryer is defined. Variants of drying processes and algorithm for determining heat and air consumption for drying are given. Periods and kinetics of drying are considered. Dependencies are given to determine the duration of drying periods and overall dimensions of dryers. References 1, 3, 4, 5, 7. *The topic of SRS*: Give a classification and make an album of designs of drying units. Highlight the cases of advantages and disadvantages. *Recommended:*1, 3, 4, 5, 6, 7.	
17-18	**Topic 4.4.**Refrigeration units	**3**
	*Scheduled:*The concept of moderate and deep cold is introduced. Methods of obtaining artificial cold, inverse Carnot thermodynamic cycle, cooling capacity and cooling coefficient are studied. The cycles of the steam compression refrigeration machine are considered and analyzed. Thermodynamic bases of deep cooling are studied. The cycles of Linde, Claude, and Kapitza are analyzed. *The topic of SRS*: The processes that take place in a steam compression refrigeration machine are studied and analyzed with the help of a T-S diagram. *Recommended:*1, 2, 3.	
18	MCR	1

5.2. Practical training

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

№ s / n	The name of the topic for practical training	Number of hours
	Section 2. Technical hydraulics	
	Topic 2.2. Hydrodynamics of fluid	
1	Research of constructions of machines for moving liquids and gases and calculations based on the equations of hydrostatics and Bernoulli. Literature 1,2,3,9	2
	Section 3. Basics of heat transfer	
	Topic 3.1. Diffusion energy transfer	
2	Calculation of the thermal conductivity process. Literature 1,2,3,9	2
	Section 4. Heat exchange equipment	
	Topic 4.1. Heat exchangers	
3-4-5	Research of heat exchangers designs and calculation of shell-and-tube heat exchanger. Literature 1,2,3,9	6
	Topic 4.2. Evaporation and evaporation plants.	
6-7	Research of evaporator designs and calculation of evaporator installation.	

		4
	Topic 4.1. Drying and drying installations	
8-9	Research of dryer designs and calculation of convective drying unit. Literature 1,2,3,9	4

5.3. Laboratory classes.

Laboratory classes are not provided for in the plan

6. Independent work of student

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

Lectures aim to summarize and systematize the knowledge acquired by students during independent work.

Practical classes are designed to acquaint students in more detail with individual topics and to better master 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 problems of modern production, gaining experience in the implementation of reporting documentation.

6.1. Individual tasks

When studying the course, students perform one calculation work, the purpose of which is to study the design of equipment and the basics of its calculation. Individual tasks are issued on the topics listed in Annex A.

The result of the work is made 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. Tests

One modular control work is planned.

The main purpose of the test is to check the level of assimilation of the taught material, which will simplify the assimilation of the material by students and provide more complete control by the teacher over the implementation of the curriculum by students.

Tentative questions are listed in Annex B.

Policy and control

Course policy (educational component)

The student must be present at all lectures, practical and laboratory classes except for confirmed valid reasons.
Protection of practical, laboratory works, and also individual tasks is carried out personally according to the established deadlines taking into account incentive and penalty points.

Students have the right to challenge the scores for the task, but must be reasoned, explaining which criteria they do not agree with according to the evaluation letter and / or comments.
Detailed criteria for assessing student learning outcomes are defined in the regulations on RSO disciplines

University policy

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Details: https://kpi.ua/code.

Norms of ethical behavior

Norms of ethical behavior of graduate students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Read more:https://kpi.ua/code.

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

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

1) execution and defense (at the choice of the teacher) of 4 tasks and 4 sections of the synopsis of designs;
2) writing MCR;
3) implementation and protection of PP;
4) answer the exam.

System of rating (weight) points and evaluation criteria

1. **Work on practical classes**

Weight score - 8. The maximum number of points in all practical classes is:
8 points x 4 = 32 points.
Evaluation criteria:

score 8 is given subject to an excellent answer.
score 3-7 is set provided there is a sufficient answer.
score 0-2 is set if the answer is unsatisfactory.

2. Modular control

Weight score - 12.
score 12 is set provided that at least 95% of the questions are answered;
score 7-11 is set provided that 85 to 95% of the questions are answered;
score 4-6 is set subject to answering from 75 to 85% of questions;
score 2-3 is set provided 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.

PP evaluation criteria:
score 14-16 is set if all sections of the work are covered in full, or some inaccuracies;
score 10-13 is set if there are some inaccuracies in the work;
score 9-4 is set if the topic of the work is vaguely covered, mistakes are made in wording, terms and definitions;
score 0-3 is set if the work is performed unsatisfactorily: the presence of significant errors or the absence of individual sections, PP is not credited.

4. Penalty and incentive points for:
- untimely (later than in the control lesson) delivery of the task or section of the synopsis of structures - 2 points.
- untimely (later than in the control lesson) delivery of the device calculation in the practical lesson - 2 points;
- untimely (later than a week) submission of settlement work - 5 points;
- incentive points: performance of tasks on improvement of didactic materials from the credit module - up to 10 points.

Rating scale size RD = Rpr + Rmkr + RRR = 32 + 12 + 16 = 60 points
The size of the examination scale Re = 40 points.

Conditions for positive intermediate certification

To receive "credited" from the first intermediate certification (8 weeks) the student must have at least 8 points (provided that at the beginning of 8 weeks according to the schedule of control, activities "ideal" student must receive 17 points).
To receive "credited" from the second intermediate certification (14 weeks), the student must have at least 22 points (provided that at the beginning of week 14 according to the schedule of control measures "ideal" student must receive 45 points).
Conditions for admission to the exam:enrollment of all practical classes, calculation work, positive result of modular control work, as well as the starting rating Rs> 24 points (not less than 40% of Rs).
Examination evaluation criteria:the examination ticket contains 4 questions, the maximum number of points on questions is distributed equally.

Table of criteria for evaluating answers to ticket questions

Response level	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 a 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 are not met	Not allowed

Additional information on the discipline (educational component)

During their studies, students gain new knowledge, skills and abilities, mainly through specific lectures, practical and laboratory classes under the guidance of the leading NPP of the department. Quite often during their studies, in order to obtain incentive points, students are involved in assisting in the development of educational and methodological documentation (publication of manuals, licensing, development of methodological documentation, etc.). The nature of such assistance must strictly comply with the profile of the discipline and the duration should not interfere with the implementation of the student's study plan.

Work program of the discipline (syllabus):

Compiled:Associate Professor of the Department of Machines and Apparatus for Chemical and Oil Refining, Candidate of Technical Sciences, Associate Professor, Mykola Petrovich Shved

Approved:by the department by the department of machines and devices of chemical and oil refining productions (protocol № 20 from 20.06.2022)

Agreed:methodical commissioncommission of the Faculty of Engineering and Chemistry(Minutes № 10 of 24.06.2022)

Appendix A

Tasks for calculation work

Task №1 to RR

Calculate the heat exchanger for heating / cooling / condensing substance "P". The initial temperature of the substance tr1, the final - tr2; . Heating (cooling) agent - T. Heat loss through the outer surface of the heat exchanger to take ___% of the useful heat. The working pressure of the substance gg. Agent -ra.

Version	Substance "P"	Version	Mass fraction of solute in the solvent,%	Version	G × 10m, kg / s	Version	tr1	Version	tr2
1.	a 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.	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	tkip.
0	benzene	0	100	0	1.50	0		0	tcond.
and		and		and		and	tcond.	and	

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

Agent "T": □ - - water; □ - - 25% aqueous solution of CaCl2; □ saturated water vapor (relative mass fraction of air in the vapor Y = _____% (wt.);

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

The structure of the explanatory note

Content

Task

Introduction

1. Technical characteristics of heat carriers
2. Description and substantiation of the chosen design
3. Parametric calculation of the device
4. Schematic drawing of the device
5. Conclusion
6. References

Recommended Books

1. Kornienko Ya.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, IO Мікульонок, B.JI. Rakytsky, GL Ryabtsev - K .: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Basic processes and devices of chemical technology: A guide to design / Ed. Yu.I. Dytnersky. - M .: Химия, 1982. - 772 c.
3. Pavlov KF, Romankov PG, Noskov VN Examples and problems on the course of processes and devices of chemical technology. - L .: Chemistry, 1987. - 576 p.
4. Machines and apparatus of chemical production / Ed. I.I. Chernobyl. - M .: Mashinostroenie, 1974. - 456 s.
5. Methodical instructions for performing calculation work for students in the direction of training 6.0502 "Computer-integrated technological processes and production" in 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 №2 to RR

Calculate the drum dryer with 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 loss in the environment to take ___% of useful 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.	Kirovograd
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	

Dryer productivity: □: G = G1; □: G = G2;

Drying agent. "A": □ - air; □ - flue gases.

The scheme of movement of the drying agent and the dried material: □ - IIcurrent: □ - countercurrent.

Calculate: □ - for summer conditions; □ - for winter conditions; □ - for average annual conditions; □ - for summer and winter conditions.

Give a graph of changes in the parameters of moist air in the dryer on the .x-and diagram.

The structure of the explanatory note

Content

Task

Introduction

1. Technical characteristics of the material and the drying agent
2. Description and substantiation of the chosen design
3. Parametric calculation of the device
4. Schematic drawing of the device
5. Conclusion
6. References

Recommended Books

1. Kornienko Ya.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, IO Мікульонок, B.JI. Rakytsky, GL Ryabtsev - K .: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Kasatkin AG Basic processes and devices of chemical technology. - M .: Химия, 1973. - 752 c.
3. Basic processes and devices of chemical technology: A guide to design / Ed. Yu.I. Dytnersky. - M .: Химия, 1982. - 772 c.
4. Pavlov KF, Romankov PG, Noskov VN Examples and problems on the course of processes and devices of chemical technology. - L .: Chemistry, 1987. - 576 p.
5. Machines and apparatus of chemical production / Ed. I.I. Chernobyl. - M .: Mashinostroenie, 1974. - 456 s
6. Chernobyl II, Tananaiko Yu.M. Drying plants of the chemical industry. - K .: Техника, 1969. - 280 c.
7. Methodical instructions for performing calculation work for students in the direction of training 6.0502 "Computer-integrated technological processes and production" in 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 №3 to RR

Calculate the vacuum evaporator continuous installation and select the design of the evaporator (type and design) for concentrating the aqueous solution of the substance "P". Mass productivity of the installation 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.* %wt	Version	*p0*,M Pa	Version	t1 ° C	Version	G1, kg / year	*X1* % (wt)	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
d			d		d		d			d	

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

Heat loss to the environment,% of useful heat consumption: 2, 5, 8.

The structure of the explanatory note:

Content

Task

Introduction

1. Technical characteristics of heat carriers
2. Description and substantiation of the chosen design
3. Parametric calculation of the device
4. Schematic drawing of the device
5. Conclusion
6. References

Recommended Books

1. Kornienko Ya.M. Processes and equipment of chemical technology 1: textbook /Y.M. Kornienko, Yu.Yu. Lukach, IO Мікульонок, B.JI. Rakytsky, GL Ryabtsev - K .: NTUU "KPI", 2011 - Part 1 - 300 p.
2. Kasatkin AG Basic processes and devices of chemical technology. - M .: Химия, 1973. - 752 c.
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4. Pavlov KF, Romankov PG, Noskov VN Examples and problems on the course of processes and devices of chemical technology. - L .: Chemistry, 1987. - 576 p.
5. Machines and apparatus of chemical production / Ed. I.I. Chernobyl. - M .: Mashinostroenie, 1974. - 456 s.
6. Chernobyl II Evaporators. - K .: Выща школа, 1970. - 240 c.
7. Methodical instructions for performing calculation work for students in the direction of training 6.0502 "Computer-integrated technological processes and production" in 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 MCR

8. Conditions of unambiguity and their types.
9. Derive the equation for the temperature distribution in a flat wall.
10. Derive the equation for the temperature field in a cylindrical wall.
11. Derive the equation for the temperature distribution in a multilayer wall under boundary conditions of the 1st kind.
12. Derive and analyze the basic equation of heat transfer.
13. What factors affect the body's radiation ability?
14. What is the temperature gradient, isothermal surface and temperature field and what are their properties? Give the basic laws of thermal radiation.
15. How to determine the amount of heat transferred from a hotter body to a less heated one.

16. Give the mechanism of convective heat transfer.
17. Give a system of equations that describes the convective heat transfer.
18. The essence and basic theorems of the method of similarity theory.
19. How do you convert differential equations that describe a process into criterion equations? Give a generalized criterion equation.
20. Name the main criteria of hydrodynamic and thermal similarity. Specify their main physical meaning. Describe the modified similarity criteria.
21. Name the main advantages and disadvantages of similarity theory.
22. What is the difference between the equations for determining the heat transfer coefficient in forced and free convection.
23. What determines the intensity of heat transfer and ways of its intensification.
24. Give the algorithm for calculating the heat transfer coefficient.
25. Give the mechanism of condensation and features of determining the heat transfer coefficient. Name the condensation factors. How does the gas content affect heat transfer?
26. List the types of boiling and explain the concept of critical temperature difference at boiling.
27. Derive and analyze the equation for the average temperature difference between the coolants in the forward and countercurrent.
28. What are the requirements for coolants?
29. What process is called heat transfer?
30. What equation determines the relationship between the amount of heat transferred and the size of the heat exchange equipment?
31. What is the physical significance of the heat transfer coefficient?
32. What process is called heat transfer?
33. What parameters characterize heat transfer at natural and forced convection?
34. Why in computational practice use the criterion equations of convective heat transfer?
35. What criteria of thermal and hydrodynamic similarity are included in the criterion equations of convective heat transfer? What is their physical significance?
36. What are the features of heat transfer in the event of a change in physical state? What criterion takes into account these features? What is the physical essence of this criterion?
37. What is the relationship between heat transfer coefficient and heat transfer coefficients?
38. What are the values of the total thermal resistance of heat transfer?
39. What is the driving force of heat transfer processes?
40. Why in calculations of heat exchange processes use the average driving force
41. force? How is it determined?
42. What are the ways to intensify the heat transfer process?
43. What heating methods are used in chemical industries?
44. From which equation determine the flow rate of the coolant for heating?
45. In what cases it is possible to apply "hot" water steam for heating?
46. In which cases is flue gas heating used? What are the disadvantages of heating with flue gases?
47. What methods of electric heating are used in chemical industries?
48. What are the positive qualities and disadvantages of cooling hot coolants have water and air? How to determine the flow of cooling water in the heat exchanger?
49. How are heat exchangers classified?
50. What is the structure and principle of operation of a single-pass shell-and-tube heat exchanger?
51. Due to what the heat exchange in multi-pass shell-and-tube heat exchangers is intensified?
52. In which cases are temperature compensators used in shell and tube heat exchangers?
53. When are pipe-in-pipe heat exchangers used? What are their advantages and disadvantages compared to shell and tube heat exchangers?
54. How is a spiral heat exchanger built? What are its disadvantages?
55. In which chemical industries are plate heat exchangers used? What are their positive qualities and shortcomings?
56. When are heat exchangers with ribbed heat transfer surfaces used? Give a comparative description of heat exchangers of different types.
57. Give the scheme of design calculation of heat exchangers. What values should be known in the design calculations of heat exchangers?
58. Why perform hydraulic calculation of heat exchangers?
59. What is the optimal calculation of heat exchangers?
60. How does the test calculation of heat exchangers differ from the design one?
61. What is called condensation?
62. What is the purpose of the condensation process in chemical plants?
63. On what grounds are capacitors classified?
64. What is the peculiarity of the calculation of surface capacitors?
65. What determines the efficiency of mixing capacitors?
66. Give the basic requirements for coolants
67. What heating methods are used in chemical industries?
68. From which equation determine the flow rate of the coolant for heating?
69. In what cases it is possible to apply "hot" water steam for heating?
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88. What is the peculiarity of the calculation of surface capacitors?
89. What determines the efficiency of mixing capacitors?
90. What is the mechanism of creating a vacuum in vacuum installations using the condensation process?
91. What is the purpose of a barometric tube?
92. What is the purpose of using a two-stage barometric capacitor?
93. Why calculate the amount of non-condensable gases?
94. How to calculate the height of the barometric tube?
95. Explain the essence of the evaporation process.
96. What solutions are concentrated by evaporation?
97. What methods in the chemical industry carry out the evaporation process?
98. How is the useful temperature difference different from the total difference?
99. What are the temperature losses in the evaporator?
100. What determines the amount of evaporated water?
101. How to determine the consumption of heating steam during evaporation?
102. List ways to save heating steam during evaporation.
103. For what purpose in evaporators create conditions for circulation of the evaporated solution?
104. What is the procedure for calculating evaporators?
105. Why select extra steam?
106. What causes the phenomenon of self-evaporation?
107. How is the total useful temperature difference of a multi-hull evaporator installed among the housings?
108. How to determine the optimal number of housings of a multi-hull evaporator?
109. What are the most common designs of evaporators in the industry?
110. What process is called drying?
111. What is the driving force of the drying process?
112. Explain the concepts: relative humidity, moisture content and enthalpy of moist air.
113. Explain the principles of constructing a diagram of the first state of moist air.
114. List and describe the types of connection between moisture and material.
115. How to determine the flow of air (total and specific) for drying?
116. From what balance is the specific heat consumption and the consumption of heating steam for drying determined?
117. How is the process of theoretical and real drying based on the diagram I?
118. What are the options for the drying process?
119. Explain the principles of construction of drying curves and drying speed.
120. What factors determine the drying rate in the first and second periods?
121. On what grounds are dryers classified?
122. Describe the structure and principle of operation of convective dryers.
123. Describe the structure of contact dryers.
124. Which materials should be dried in convective dryers, and which - in contact?
125. Describe the special types of drying: sublimation, infrared and in the field of high frequency currents.
126. Name the methods of intensification of drying processes.
127. Write down and analyze the equations of thermal conductivity for different types of temperature field.