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

Machines and devices of chemical and oil refining industries

Processes and equipment of chemical technology - 2. Hydromechanical and mechanical 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	*Computer-integrated technologies of chemical engineering equipment design*
Discipline status	*Normative*
Form of education	*full-time (face-to-face/distance)*
Year of training, semester	*3rd year, spring semester*
Scope of the discipline	*210 hours (54 – lecture hours; 18 hours – practical; 18 hours – laboratory; 120 hours – SRS)*
Semester control/ control measures	*Exam*
Lessons schedule	*https://rozklad.kpi.ua/* *https://ecampus.kpi.ua/*
Language of teaching	*Ukrainian*
Information about the course leader / teachers	*Lecturer: doctor of science, professor Yaroslav Mykytovych Kornienko YNK@kpi.ua* *Practical: Ph.D., senior teacher Gaidai Serhiy Serhiyovych ssgaidai@gmail.com* *Laboratory: Ph.D., senior teacher Serhiy Serhiyovych Gaidai ssgaidai@gmail.com*
Placement of the course	*https://ecampus.kpi.ua/*

Program of educational discipline

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

The study of this discipline will allow students to learn the fundamental concepts of the theory of momentum transfer of single-phase and multiphase dispersed systems. It will make it possible to formulate an idea about the ways of separating gas and liquid systems in the field of gravity, centrifugal forces, and in the electric field. It will contribute to the understanding of the dependence of the efficiency of separation of dispersed systems and energy consumption on the implementation of this process. Understanding the essence of the efficiency of extraction from dispersions of particles smaller than 10 μm. Expand the understanding of mixing processes in liquid and bulk systems and master the methods of determining the main criteria for assessing quality - efficiency and energy consumption - intensity.

Familiarize yourself with the basics of grinding theory and the conditions for the implementation of such processes, provided that the "Golden rule of grinding" is followed. Mastering the methods of calculating equipment for hydromechanical and mechanical processes will allow creating a professional basic basis for the successful development of energy-efficient equipment and minimizing its metal consumption.

The subject of the academic discipline

A systematic approach to the study of momentum transfer processes in dispersed systems with different phase composition. calculations of energy consumption during the separation and mixing of heterogeneous systems, as well as mastering the basic principles of grinding materials.

Interdisciplinary connections

The discipline "Processes and equipment of chemical technology - 3. Hydromechanical and mechanical processes" is based on the following disciplines: processes and equipment of chemical technology - 1, 2; theoretical mechanics; theory of machines and mechanisms; machine parts; physical chemistry; mechanics of materials and structures.

The purpose of this educational discipline*there is a thorough familiarization of students with the theoretical foundations of hydromechanical processes, determination of the conditions for the effective implementation of the process, assimilation of practical skills of calculations of hydromechanical devices and machines using computer technologies.*

The main tasks of the academic discipline

After mastering the discipline, students should acquire the following knowledge:

- modern approaches, methods and techniques, solving problems in the design, maintenance, modernization and waste disposal of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer in industrial equipment through hydrodynamics;

- modern approaches, methods and techniques, solving problems in the selection and preparation of raw materials, production and waste disposal of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer in industrial equipment through hydrodynamics.

According to the goal, the training of bachelors requires deepening of the competences formed by students:

- using scientific and technical information, regulatory documents, and professional knowledge to solve problems in the design, maintenance, modernization and disposal of equipment of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer in industrial equipment through hydrodynamics;

- using scientific and technical information, regulatory documents, professional knowledge to independently solve problems in the design and modernization of equipment of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer in industrial equipment through hydrodynamics;

- using scientific and technical information, regulatory documents, and professional knowledge to solve problems in the selection and preparation of raw materials, production and waste disposal of chemical and oil refining industries, taking into account the basic principles of the theory of heat and mass transfer in industrial equipment through hydrodynamics;

- apply computer engineering methods using special software, perform computer design of

chemical and oil refinery equipment taking into account the basic principles of the theory of heat and mass transfer through hydrodynamics.

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:*the ability to apply knowledge in practice when evaluating methods of calculating hydromechanical processes, skills in using information and computer technologies, the ability to search, process and analyze from various sources, the ability to apply knowledge about the basic physical and chemical principles of technological processes of chemical engineering.*

Post-requisites:*the ability to apply knowledge for the practical solution of problems related to the provision of innovative technical solutions for the implementation of hydromechanical processes and the selection of an algorithm for its implementation, the ability to use computerized calculation systems to substantiate technical decisions regarding the improvement of existing equipment to increase its energy efficiency, the ability to evaluate technical economic efficiency of systems and their components based on the application of analytical methods and analysis of analogs, the ability to make decisions regarding the selection of structural materials for the creation of innovative equipment.*

After mastering the academic discipline, students will be able to use knowledge of fundamental disciplines and mathematical apparatus to implement professionally-profiled knowledge and practical skills to solve system engineering tasks of creating effective processes and innovative equipment for their implementation.

3. Content of the academic discipline

Lecture classes

Chapter 1. Hydromechanical processes

Chapter 2. Mechanical processes

Practical training

1. Calculation of the dust settling chamber (gas settling tank).

2. Cyclone calculation.

3. Hydrocyclone calculation.

4. Calculation of the belt vacuum filter.

5. Calculation of the drum vacuum filter.

6. Calculation of a sediment centrifuge.

7. Calculation of a filtering centrifuge.

8. Calculation of a liquid mixer.

9. Calculation of the device with a fluidized bed.

10. Calculation of the jaw crusher.

11. Calculation of a roller crusher.

12. Calculation of runners.

13. Ball mill calculation.

Laboratory classes

1. Study of fluid movement in channels.

2. Study of the process of deposition in the field of gravity.

3. Study of the work of the filter centrifuge.

4. Study of the operation of a stirrer for mixing liquids.

5. Study of fluidized bed hydrodynamics.

6. Study of the operation of a jaw crusher.

7. Study of the operation of a roller crusher.

4. Educational materials and resources

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 C.

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. Tovazhnyanskyi L. L. Processes and devices of chemical technology / L. Tovazhnyanskyi, A. L. Gotlinska, V. O. Nechyporenko. I. S. Chernyshov // Kharkiv, NTU. – 2006. – Part 1. - 540 S.

4. Tovazhnyanskyi, L.L. Processes and devices of chemical technology / L.L. Tovazhnyanskyi, A.L. Gotlinska, V.O. Nechyporenko, I.S. Chernyshov. - Kharkiv, National Technical University. – 2006. – Part 2. - 540 S.

5. Kornienko Y. M. Increasing the efficiency of the process of obtaining granulated humic-mineral fertilizers / Y. M. Kornienko, S. S. Gaidai, O. V. Martyniuk // NTUU "KPI". – 2014. – 349 p.

6. Y. M. Kornienko, The process of dehydration of composite liquid systems in a fluidized bed with the use of a mechanical dispersant / Y. M. Kornienko, D. S. Semenenko, O. V. Martyniuk. S. S. Gaidai // NTUU "KPI". - Kyiv. – 2015. – 167 p.

7. Kornienko, Y.M. The process of obtaining modified granulated humic-mineral fertilizers / Y.M. Kornienko, A.M. Lyubeka, S.S. Gaidai // KPI named after Igor Sikorsky. – Kyiv: KPI named after Igor Sikorsky. – 2017. – 210 p.

8. Kornienko Y. M. Processes of granulation of mineral-humic fertilizers / Y. M. Kornienko, R. V. Sachok // Electronic edition. - 2014 - 158 p.

Additional literature

9. Processes and equipment of chemical technologies: Hydromechanical and mechanical processes: laboratory practice. [Electronic resource]: teacher. manual for students specialty 133 "Industrial mechanical engineering", specialization "Engineering, equipment and technologies of chemical and oil refining industries" / KPI named after Igor Sikorskyi; comp.: Y.M. Kornienko, A.R. Stepaniuk, S.V. Gulienko., S.S. Heyday - Electronic text data (1 file: 4.80 MB). – Kyiv: KPI named after Igor Sikorskyi, 2020. – 151 p. (https://ela.kpi.ua/bitstream/123456789/32178/1/P_ta_OKhT.docx).

10. Monograph on fluidization.Kornienko Y. M. Increasing the efficiency of the process of obtaining granular humic-mineral fertilizers / Y. M. Kornienko, S. S. Gaidai, O. V. Martyniuk // NTUU "KPI". – Kyiv: NTUU "KPI". – 2014. – 349 pp. (http://ela.kpi.ua/handle/123456789/11943)

11. Kornienko Y. M. The process of dehydration of composite liquid systems in a fluidized bed using a mechanical dispersant / Y. M. Kornienko, D. S. Semenenko, O. V. Martyniuk, S. S. Gaidai // NTUU "KPI". – Kyiv: NTUU "KPI". – 2015. – 167 p.

(http://ela.kpi.ua/handle/123456789/11944)

12. Kornienko, Y. M. The process of obtaining modified granulated humic-mineral fertilizers / Y. M. Kornienko, A. M. Lyubeka, S. S. Gaidai // KPI named after Igor Sikorsky. – Kyiv: KPI named after Igor Sikorsky. – 2017. – 210 p.

(http://ela.kpi.ua/handle/123456789/21268)

13. Increasing the efficiency of the granulation process of organo-mineral fertilizers in devices with a fluidized bed [Electronic resource]: monograph for students studying in the field of "Mechanical Engineering", educational program "Computer-integrated technologies of chemical engineering equipment design"/ KPI named after Igor Sikorskyi; structure. Y. M. Kornienko, S. S. Gaidai. – Kyiv: KPI named after Igor Sikorskyi, 2021. – 194 p.

14. Ensuring surface stabilization in dynamic dispersion systems during granulation of organo-mineral fertilizers [Electronic resource]: monograph for students studying Mechanical Engineering, educational program "Computer-integrated design technologies of chemical engineering equipment"/ KPI named after Igor Sikorskyi; structure. Y. M. Kornienko, S. S. Gaidai, O. V. Kurinovskyi.. – Kyiv: KPI named after Igor Sikorskyi, 2021. – 193 p.

Information resources on the Internet

15. *Ministry of Strategic Industries of Ukraine [Electronic resource]. – 2021. – Mode of access:https://mspu.gov.ua.*

16. *Union of Chemists of Ukraine [Electronic resource]. – 2021. – Access mode: http://chemunion.org.ua/uk.*

17. *International congress of chemical process [Electronic resource]. – 2021. – Access mode: https://2020.chisa.cz.*

18. *Digital management of the construction process – developed by entrepreneurs for entrepreneurs [Electronic resource]. – 2021. – Access mode: https://www.chisa.dk.*

Educational content

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

Lecture classes

Lectures are aimed at:

- *provision of modern, comprehensive in-depth knowledge of the discipline, the level of which is determined by the target attitude to each specific topic;*
- *provision of critical creative work together with the teacher in the process of work;*
- *education of students' professional qualities and development of their independent creative thinking;*
- *awareness of world trends in the development of science in the field of intensification of heat and mass exchange processes in industrial equipment through hydrodynamics;*
- *awareness of the methods of processing information resources and determining the main directions for solving specific scientific and technical problems.*

No s/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***
1	*2*	*3*
	Chapter 1.Hydromechanical processes	
1	***Topic 1.1 Introduction. Terms*** *The characteristics of dispersions are presented depending on the aggregate state of the dispersion medium and the dispersed phase.* *Literature [1,2,3].* *Task on SRS: To provide methods for determining the dispersed composition of dust.*	***2***
2	***Topic 1.2 Mechanical cleaning of gases*** *The physical essence of the processes during the separation of heterogeneous gas systems in physical fields of different natures: gravitational, centrifugal and electrostatic, as well as during filtration through a partition and the application of "wet" gas cleaning methods, is considered.* *Literature [1,2,3].* *The task at the SRS: Based on the review materials of domestic and foreign patents, select one design from each method of cleaning and conduct a critical analysis.*	***16***
3	***Topic 1.3 Separation of heterogeneous liquid systems*** *The physical essence of the processes of separation of heterogeneous liquid systems under the action of driving forces of different nature: gravity and centrifugal, as well as during filtration, is considered. Acquaintance with the main kinetic characteristics of various methods of organization. Explanation of the theoretical principles of the separation process in hydrocyclones. Formulation of an idea about the processes of separation in centrifuges of settling and filtering types. Acquiring the skills to calculate energy consumption for the process. Mastering techniques for calculating centrifuges of various types. The physical principles of the process of mixing liquids are considered. Familiarization with the methods of determining the efficiency and intensity of the process, which determines the rational scope of the process. The physical essence and features of the interaction between the dispersed phase and the continuous medium during fluidization are given. The concept of fluidization*	***26***

	number and the conditions for the implementation of active hydrodynamics in homogeneous and heterogeneous fluidization. Mastering the technique of calculating devices. *Literature [1-14].* *The task at the SRS: Based on the materials of the review of domestic and foreign patents, select one design of the device for each of the considered processes and conduct a critical analysis.*	
Chapter 2. Mechanical processes		
4	***Topic 2.1****Shredding of solid materials* *The main concepts, definitions and classification of grinding processes are considered. The essence of the grinding hypotheses is explained. Grinding methods are considered and the main requirements for grinding machines are given. The principle of operation of large, medium and fine grinding machines is given. Familiarized with the basic calculation method of grinding machines. Designs of mills were considered and methods of calculation of ball and vibration mills were introduced.* *Literature [1,2,3].* *The task at the SRS: Based on the materials of the review of domestic and foreign patents, choose one design of machines for grinding and conduct a critical analysis.*	***6***
5	***Topic 2.2****Sorting and classification of solid materials* *The general provisions and classification schemes of solid materials using sieves are considered. The physical essence of the classification processes was considered:* - *hydraulic* - *air* - *magnetic* *and calculation methods for their implementation are given.* *Literature [1,2,3,4].* *The task at the SRS: Based on the materials of the review of domestic and foreign patents, choose one design for each of the considered types of the classification process and conduct a critical analysis.*	***4***
	In total	***54***

Practical training

Students should be helped to acquire the ability to apply theoretical knowledge when calculating equipment for hydromechanical and mechanical processes.

The main tasks of the cycle of practical classes:

–to help students systematize and deepen knowledge of a theoretical nature in the field of transferring the amount of motion in dynamic dispersed systems;

–to contribute to teaching students the methodology of determining the limiting factors of separation and mixing processes in dynamic systems, as well as when grinding solid materials;

–form criteria for evaluating the effectiveness of hydromechanical and mechanical processes and be able to determine specific energy costs and choose the area of rational process management.

No	***The name of the topic of the practical session and the list of main questions (list of***	***Number***

s/p	didactic support, references to the literature and tasks on the SRS)	hours
1	2	3
1	***Practical lesson No. 1.*** ***Calculation of the dust settling chamber (gas sump).*** *To master the technique of a gas settling tank in the field of gravitational forces for two types of solid particles differing in physical and mechanical properties and two different volume flows of dusty gas.* *Literature [1,2,3].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	**2**
2	***Practical lesson No. 2.*** ***Cyclone calculation.*** *Master the method of calculating the apparatus for separating heterogeneous gas systems with two different physical and mechanical characteristics of solid systems and choose a cyclone design that achieves a capture efficiency of at least 95% with minimal hydraulic resistance and metal capacity for a given dusty gas productivity.* *Literature [2,3].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	**2**
3	***Practical lesson No. 3.*** ***Hydrocyclone calculation.*** *Master the method of hydrocyclone calculation. Choose the geometric dimensions and the number of hydrocyclones that ensure high values of the cleaning coefficient.* *Literature [2,3].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	**2**
4	***Practical lesson No. 4.*** ***Calculation of the drum vacuum filter.*** *To master the method of calculation of a drum vacuum filter for the separation of medium-concentrated suspensions.* *Literature [2, 3, 4].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	**2**
5	***Practical lesson No. 5.*** ***Calculation of a sediment centrifuge.*** *To master the method of calculating a centrifuge of the settling type for the specified consumption of the working environment.* *Literature [2, 3, 4].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	**2**
6	***Practical lesson No. 6.*** ***Calculation of the filter centrifuge.*** *To master the method of calculation of a filtration centrifuge. Determine the*	**2**

	filtration speed and power consumption at a given value of the separation factor. *Literature [2,3].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	
7	***Practical lesson No. 7*** ***Calculation of a liquid mixer.*** *To master the method of calculating a liquid mixer and to compare the energy consumption when using different types of mixing devices.* *Literature [2,3].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	***2***
8	***Practical lesson No. 8.*** ***Calculation of the device with a fluidized bed.*** *To master the method of calculating the device with a fluidized bed with homogeneous fluidization for two values of the equivalent diameter of the particles in the layer.* *Literature [2-14].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	***2***
9	***Practical lesson No. 9.*** ***Calculation of the jaw crusher.*** *To master the method of calculating the jaw crusher with different parameters of the crushing chamber. Compare the specific energy consumption for the grinding process.* *Literature [2, 3, 4].* *Task on SRS: Make a comparison with the selected design from the patent examination.*	***2***
	Together	***18***

Laboratory classes

Students should be helped to acquire the ability to apply theoretical knowledge in the study of equipment for conducting hydromechanical and mechanical processes.

*The main tasks of the cycle of laboratory work consist in a thorough study of the features and mechanism of implementation of hydromechanical and mechanical*processes.

No s/p	***The name of the topic of the laboratory session and the list of main questions (list of didactic support, references to the literature and tasks on the SRS)***	***Number hours***
1	*2*	*3*
1	***Laboratory session No. 1.*** ***Study of fluid movement in channels.*** *Get an idea of different modes of fluid movement in a cylindrical channel and master the method of calculating the Reynolds criterion for different flow modes.* *Literature [1,2,3,9].* *Task on SRS: Compare how the flow rate of a continuous medium and its thermophysical parameters affect the mode of fluid movement.*	***2***
2	***Laboratory lesson No. 2.***	***3***

	Study of the process of deposition in the field of gravity. *Determine the influence on the rate of deposition of solid bodies with different physical and mechanical properties in environments with different thermophysical parameters and modes of motion.* *Literature [1,2,3,9].* *Task on SRS: To determine how the temperature of the liquid medium affects the rate of deposition.*	
3	***Laboratory session No. 3.*** ***Study of the work of the filter centrifuge.*** *The idea of the cycles of the centrifuge of the filtration type of periodic action is expanding. The power consumption in the start-up and working periods, the time of the suspension separation process in the field of centrifugal forces and the moisture content of the obtained sludge are determined experimentally. Attention is paid to changing the number of revolutions of the centrifuge drum during sediment discharge.* *Literature [1,2,3,9].* *Task for SRS: Analyze the effect of reducing the centrifugation time and the centrifuge start-up time on energy consumption.*	***3***
4	***Laboratory session No. 4.*** ***Study of the operation of a stirrer for mixing liquids.*** *Conduct an experimental determination of mixing costs during the start-up and working periods. Determine the power criteria and their dependence on the number of revolutions of the stirrer.* *Literature [1,2,3,9].* *The task at the SRS: To conduct an analysis of energy consumption for mixing and justify a technical decision to reduce energy consumption based on patent research materials.*	***3***
5	***Laboratory lesson No. 5.*** ***Study of fluidized bed hydrodynamics.*** *Experimentally determine the dependence of the hydraulic resistance of the layer depending on the reduced gas velocity in the cross section of the apparatus. To determine the regions of existence of a stable regime of homogeneous fluidization. Find out the physical essence of the fluidization number. Determine the coefficient of hydraulic resistance of the gas distribution device.* *Literature [1,2,3,9].* *The task at SRS: To analyze the designs of gas distribution devices and evaluate their influence on the hydrodynamics of the fluidized bed.*	***3***
6	***Laboratory lesson No. 6.*** ***Study of the operation of a jaw crusher.*** *To determine the influence of the design of the working crushing chamber and the method of suspension of the movable cheek on the productivity and degree of crushing. Determine energy consumption at different degrees of grinding.* *Literature [1,2,3,9].* *Task on SRS: Analyze the influence of the method of suspension of the movable cheek on energy consumption.*	***2***

7	***Laboratory lesson No. 7.*** ***Study of the operation of a roller crusher.*** *Determination of the maximum particle size at which the material can be drawn in. Determine the energy consumption at different degrees of grinding.* *Literature [1,2,3,9].* *The task at the SRS: To justify proposals for the implementation of the "Golden rule of grinding for roller crushers.*	***2***
	Together	***18***

6. Independent work of the student

The purpose of independent work consists in the in-depth study of methods, methods and constructions of equipment for conducting hydromechanical processes by familiarizing with domestic and foreign patents on the specified topics. The results of SRS are entered into the design album (SRS report).

No s/p	***The name of the topic submitted for independent processing***	***Number hours***
1	*2*	*3*
	Chapter 1.Hydromechanical processes	
1	***Topic 1.1 Introduction. Terms*** *Analysis of the main types of existing designs of devices for the separation of heterogeneous gas systems with patents for the last 10 years.* *Comparison of the performance of the basic designs of devices for the separation of liquid heterogeneous systems with the corresponding patents for the last 10 years.* *Literature: [Literature [1,2,3].*	***24***
2	***Topic 1.2. Mixing of liquids and loose materials.*** *Calculation of energy-power parameters of mixing devices and their comparison with modern technical solutions given in patents.* *Calculation of the main parameters of the fluidized bed apparatus to ensure stable hydrodynamics.* *Literature: [Literature [1,2,3-14].*	***24***
	Chapter 2. Mechanical processes	
3	***Topic 2.1 Grinding***. *Based on the review of patents, provide designs of crushers in which the "golden rule of mechanics" is implemented, or propose your own improvement of the selected design.* *Based on the materials of the patent review, select a patent for an individual task and substantiate proposals for improving the design.* *Literature: [1, 2, 3].*	***19***
4	***Topic 2.2****Sorting and classification of solid materials* *Based on the review materials of domestic and foreign patents, choose one design for each of the considered types of the classification process and conduct a critical analysis.* *Literature [1,2,3,4].*	***6***
5	***Preparation for modular control work***	***7***

6	***Performing calculation work***	***10***
7	***Preparation for the exam***	***30***
	Together	***120***

Policy and control

Policy of academic discipline (educational component)

The system of requirements for the student:

–attending lectures, practical and laboratory classes is a mandatory component of studying the discipline;

–at lectures, the teacher uses his own presentation material, uses Google Drive to teach the materials of the current lecture, additional resources, practical and laboratory work, etc., the teacher opens access to a certain directory for downloading methodical materials in electronic form;

–during lectures, it is not desirable to distract the teacher from teaching the material, all questions, clarifications, etc. are asked by students at the end of the lecture in the time allotted for this purpose;

–laboratory works are performed in two stages - the first stage: students confirm their necessary preparation and conduct laboratory work; second stage: protection of laboratory work. Points for laboratory work are credited only if the report is available;

–modular control work is written in lectures without the use of aids (mobile phone, tablet, etc.). The result is sent in a file to the corresponding Google Drive directory;

–incentive points are awarded for active participation in lectures, participation in faculty and university olympiads in academic disciplines, in work competitions, preparation of reviews of scientific works; presentations on one of the topics of the SRS discipline, etc. The number of incentive points is no more than 10.

Teaching methods

When teaching an educational discipline, the use of such educational technologies as problem-based lectures, work in small groups, etc. is provided for the activation of the educational process.

Problem lectures*are aimed at the development of students' logical thinking and are characterized by the fact that the range of questions of the topic is limited to two or three key points, the students' attention is concentrated on the material that was not reflected in the textbooks, the experience of foreign educational institutions is used with the distribution of printed material to students during the lecture and the selection of the main conclusions on the issues under consideration. During lectures, students are given questions for independent reflection, but the lecturer answers them himself, without waiting for the students' answers. The system of questions during the lecture plays an activating role, forces students to concentrate and start thinking actively in search of the right answer.*

Mini-lectures*involve the presentation of educational material in a short period of time and are characterized by a significant capacity, complexity of logical constructions, images, proofs and generalizations. Mini-lectures are held, as a rule, as part of a research class.*

Case method*(method of analysis of specific situations) makes it possible to bring the learning process closer to the real practical activity of specialists and provides consideration of production,*

management and other situations, complex conflict cases, problem situations, incidents in the process of learning educational material.

***Tools and software**, the use of which is provided by the educational discipline "Processes and equipment of chemical technology - 3. Hydromechanical and mechanical processes".*

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

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

Semester	Training time		Distribution of study hours				Control measures		
	Credits	Acad. hours	Lectures	Practical	Lab. do	SRS	MKR	RR	Semester control
6	4	210	54	18	18	120	2	1	exam

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

- *performance of practical tasks (18 hours)*
- *performance of laboratory work (18 hours)*
- *execution of a modular inspection*
- *performance of calculation work*

System of rating (weighted) points and evaluation criteria

Practical work

Performance of practical work is evaluated:

- "excellent" - a complete answer, on time, the task was completed during the lesson (at least 90% of the required information) - 2 points;

- "good" - a sufficiently complete answer, on time, the task was completed during the lesson (at least 75% of the required information) - 0.75 points;

- "satisfactory" - incomplete answer, untimely, after class, completed task (at least 60% of the required information) - 0.6 points;

- "unsatisfactory" - the answer does not meet the requirements for "satisfactory" - 0 points.

Laboratory work

- "excellent" - a complete answer, on time, the task was completed during the lesson (at least 90% of the required information) - 2 points;

- "good" - a sufficiently complete answer, on time, the task completed during the lesson (at least 75% of the required information) - 0.75 points;

- "satisfactory" - incomplete answer, untimely, after class, completed task (at least 60% of the required information) - 0.6 points;

- "unsatisfactory" - the answer does not meet the requirements for "satisfactory" - 0 points.

Analytical review (Abstract)

- creative work - 8 points;

- the work was completed with minor defects - 7-6 points;

- the work was completed with certain errors - 5-4 points;

- the work is not credited (the task is not completed or there are gross errors) - 0 points.

For each week of delay in submitting the calculation work for verification, a penalty of 1 point is charged (no more than -5 points in total).

Modular control work

- "excellent" - complete answer (at least 90% of the required information) - 6 points;

- "good" - a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 5-4 points;

- "satisfactory" - an incomplete answer (at least 60% of the required information) and minor errors - 3 points;

- "unsatisfactory" - the answer does not meet the requirements for "satisfactory" - 0 points.

Incentive points

- for active work at lectures - 1-3 points

Intersessional certification

According to the results of work for the first 7 weeks, the maximum possible number of points is 20 points. At the first certification (8th week), the student receives "certified" if his current rating is at least 10 points.

According to the results of 13 weeks of training, the maximum possible number of points is 32 points. At the second certification (week 14), the student receives "certified" if his current rating is not less than 16 points.

Thus, the rating semester scale for the credit module is:

$$R = 2\ r_{practical} + 2\ r_{laboratory} + 1\ r_{Ref} + 2\ r_{MKR} = 2\ 8 + 2\ 7 + 1\ 8 + 2\ 6 = 50 \text{ points}$$

Exam

A condition for a student's admission to the exam is the enrollment of all practical and laboratory work, calculation work and a starting rating of at least 26 points.

At the exam, students perform written work (50 points).

The exam ticket contains four questions. The first, second and third are theoretical, the fourth is the construction of equipment based on the materials of the student's patent examination, therefore the maximum number of points is distributed as follows: question 1 – 18 points, question 2 – 9 points, question 3 – 9 points, question 4 – 14 points .

The system for evaluating answers to questions

- "excellent" - complete answer, at least 90% of the required information (complete, error-free solution of the task), respectively:

And - 18-16; II – 9-8; III – 9-8; IV – 14-12.

- "good", sufficiently complete answer, at least 75% of the required information or minor inaccuracies (complete solution of tasks with minor inaccuracies), respectively: I - 15-13; II – 6-5; III – 6-5; IV - 11-9.

- "satisfactory", incomplete answer, at least 60% of the required information and some errors (the task was completed with certain shortcomings), respectively: I - 12-10; II – 3-2; III – 4-3; IV – 8-6.

- "unsatisfactory" answer does not meet the requirements for "satisfactory" - 0 points

The sum of starting points and points for the examination control work is transferred to the examination grade in accordance with table:

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

7. Additional information on the discipline (educational component)

The list of theoretical questions submitted for semester control is given in Appendix 1
Tasks for calculation work are given in Appendix 2

Working program of the academic discipline (syllabus):

Approved*by the Department of the Academy of Medical Sciences (protocol No. 20 dated June 20, 2024)*

Agreed*Methodical Council of the IHF*[1]*(protocol No. 11 dated June 28, 2024)*

[1]Methodical council of the university - for general university disciplines.

Appendix 1

LIST

theoretical questions that are submitted for semester control

from the discipline "Processes and equipment of chemical technology - 3. Hydromechanical and mechanical processes"

for the specialty

133 Industrial engineering

educational program

Computer-integrated technologies of chemical engineering equipment design

Modular control work No. 1 is completed after studying Chapter 1.

1. *Explain the mechanism of separation of heterogeneous gas systems in the field of gravitational forces. Derive the differential equation of the settling of solid particles and give the method of obtaining similarity criteria.*
2. *Give the procedure for calculating the power for centrifugation in the start-up period.*
3. *Formulate the advantages and disadvantages of cyclones.*
4. *Formulate a physical model of the separation of heterogeneous gas systems in the field of centrifugal forces. Derive differential and criterion equations.*
5. *Perform the transformation of the basic filtration equation for the case of constant filtration rate.*
6. *Evaluate the advantages and disadvantages of a dust deposition chamber.*
7. *Explain the physical model of the suspension filtration process. Derive the differential equation of fluid movement through the sediment.*
8. *Give the method of calculating the power of the mixer during the working period.*
9. *Justify the advantages and disadvantages of battery cyclones.*
10. *Explain the physical model of the separation process in a centrifuge. Write down the material balance equation of the centrifugation process. Determine the separation factor. Derive the equation of the liquid surface in the centrifuge.*
11. *Give the method of calculating a gas settling tank.*
12. *Formulate the advantages and disadvantages of liquid filters that work under excess pressure.*
13. *Formulate a physical model of the separation process in a filtration centrifuge. Explain the essence of the separation factor. Determine the driving force of the filtration process for a filter centrifuge.*
14. *Give the method of calculating power for liquid mixers during the start-up period.*
15. *To justify the advantages and disadvantages of bag filters for the separation of heterogeneous gas systems.*
16. *To justify the physical model of the process of filtration of suspensions. Carry out the transformation of the main filtering equation for the case when* $\Delta P = const.$
17. *Give the method of calculating a gas settling tank.*
18. *Evaluate the advantages and disadvantages of electrostatic precipitators.*
19. *List the main methods of wet gas cleaning.*
20. *Give the transformation of the Reynolds and Euler criteria for liquid mixers. Determine the power consumption for mixing during the working period.*
21. *Evaluate the advantages and disadvantages of the apparatus for wet gas cleaning.*
22. *Explain the physical model of the interaction of the liquid phase with a heterogeneous gas system during wet gas cleaning.*
23. *Explain the principle of operation of the wet gas cleaning foam apparatus and evaluate its effectiveness.*
24. *List the advantages and disadvantages of hydrocyclones.*
25. *Give the main technical methods of creating a field of centrifugal forces. Derive the differential equation for the deposition of solid particles in the field of centrifugal forces.*
26. *To substantiate the conditions of application of wet gas cleaning. List the advantages and disadvantages of the "SIOT" high-speed gas washer.*
27. *To justify the advantages and disadvantages of a filter centrifuge of continuous action.*
28. *Explain the physical model of the suspension filtration process. Derive the differential equation of motion of a viscous liquid in sediment layers.*
29. *Give the order of calculation of stirrers for liquids.*
30. *List the advantages and disadvantages of a liquid settling tank.*
31. *Formulate a physical model of trapping solid particles in cyclones with a water film.*
32. *Formulate a physical model of trapping solid particles in low-pressure venturi scrubbers.*
33. *State the advantages and disadvantages of the apparatus with a fluidized bed.*

34. *Explain the physical model of the process of gas filtration through a porous partition.*
35. *Formulate the essence and obtain an expression for determining the separation factor in centrifuges. Derive the equation of the liquid surface in the centrifuge drum.*
36. *State the advantages and disadvantages of a liquid filter operating under vacuum.*
37. *Explain the physical model of the wet gas cleaning process in impact-inertia devices (rotoclon, Doyle scrubber).*
38. *Formulate the physical essence of the separation factor and what values it acquires for cyclones and centrifuges.*
39. *List the advantages and disadvantages of a sediment centrifuge.*
40. *State the advantages and disadvantages of a direct-flow cyclone.*
41. *Explain the physical model of separation in centrifuges. Give the equation of the material balance of the process.*
42. *List the advantages and disadvantages of a filter for continuous liquids.*
43. *List the advantages and disadvantages of paddle mixers.*
44. *Explain the relationship between efficiency and intensity when mixing liquid systems.*
45. *Give the procedure for calculating power consumption for liquid mixers during the working period.*
46. *Carry out the transformation of Re and Eu criteria for mixers. Determine the procedure for calculating power consumption during the working period.*
47. *State the advantages and disadvantages of mixing devices for loose materials.*

Modular control work #2 is completed after studying chapter 2.

1. *Define grinding.*
2. *Grinding methods.*
3. *Grinding classes.*
4. *Degree of grinding.*
5. *Formulate the hypothesis of surface grinding. Determine the scope of its application.*
6. *Formulate the hypothesis of volume grinding. What is the main drawback of the hypothesis?*
7. *Formulate a unified hypothesis of grinding.*
8. *Give ways of suspending a movable cheek. What is the effect of these methods on the size of pieces of the final product?*
9. *What method of suspension of the movable cheek should be used when grinding solid materials $\sigma \geq 200$ MPa?*
10. *How is the grip angle determined in a jaw crusher? Can it be arbitrary?*
11. *What should be the angle between the rod and the spacer plate in the jaw crusher?*
12. *How does the grip angle affect the performance of a jaw crusher?*
13. *Under what condition is the number of revolutions of the eccentric shaft of a jaw crusher determined?*
14. *What class of machines does a roller crusher belong to?*
15. *What ratio of the diameter of the rolls and the initial dimensions of the material is the most appropriate for smooth rolls?*
16. *Is there a limit to the number of revolutions of the rollers of a roller crusher? Explain why.*
17. *To what class of machines do runners belong? What method of grinding is implemented in this case?*
18. *How to increase the effective force of the process when using runners?*
19. *How to increase the performance of runners?*
20. *What class of machines do hammer crushers belong to?*
21. *Is there a "Golden Rule" of crushing when working in hammer crushers?*
22. *What is the main disadvantage of hammer crushers?*
23. *What method of crushing is implemented in jaw crushers?*
24. *What class of machines are ball mills?*

25. *Name the shape and material of working bodies in ball mills.*
26. *What method of grinding is implemented in ball mills and in what range of sizes of the initial and final material?*
27. *To achieve uniformity of grinding, what design features do ball mills have?*
28. *Compare the power consumption in the ball mill in working and "idle" mode. Which ones are bigger and why?*
29. *What force holds the working body on the inner surface of the ball mill?*
30. *Name the proportion of filling with grinding bodies of the ball mill drum.*
31. *Is there a limit to the number of rotations of the ball mill? How is the working speed of a ball mill determined?*
32. *How is crushed material unloaded from a ball mill during dry and "wet" grinding?*
33. *How is the drive of the working drum of the ball mill carried out?*
34. *What class of grinding machines do vibratory mills belong to?*
35. *What method of grinding is implemented in vibrating mills?*
36. *Name the range of values of the final particle sizes after grinding in colloidal mills.*
37. *What method of grinding is implemented in jet mills?*
38. *What is the maximum degree of crushing in jaw crushers?*
39. *What is the maximum degree of grinding in hammer crushers?*
40. *How can the force transmitted through the spacer plate in a jaw crusher be increased?*

Appendix 2

Task

for calculation works in the discipline "Processes and equipment of chemical technologies - 3. Hydromechanical and mechanical processes"

Calculate according to the design method cyclones of the NDIOGAZ type for catching particles with a median diameter dt, density of solid particlesρ_h, with the initial concentration of solid particles C and volume flow rate of dusty gas V, which has a dynamic viscosity coefficient μ, and choose a cyclone design with a capture coefficient $\eta \geq 95\%$

Var	Type cyclone	*V*, m3/hour·103	d_t, μm	ρ_h, kg/m3	Dustiness, C, g/m3	$lg\sigma_\eta$	t_{Mr}, °C
1.	ЦН-11	25	26	2300	150	0.36	75
2.	SK-ЦН-33	35	28	1900	180	0.30	65
3.	SK-ЦН-34M	25	25	1650	100	0.34	55
4.	ЦН-24	15	20	2050	180	0.35	45
5.	TsN-15y	10	25	2150	100	0.32	35
6.	SK-ЦН-33	17	28	2350	150	0.29	25
7.	ЦН-11	12	21	2400	120	0.31	65
8.	ЦН-24	13	29	1930	175	0.34	70
9.	ЦН-15	15	25	1750	190	0.34	85
10.	SK-ЦН-34	16	27	2000	170	0.34	60
11.	ЦН-11	18	20	1000	100	0.34	40
12.	ЦН-15	25	25	1300	150	0.30	30

13.	ЦН-24	15	20	1500	150	0.38	50
14.	SK-ЦН-33	15	28	1700	180	0.30	70
15.	SK-ЦН-34	18	20	1900	100	0.29	35
16.	ЦН-15	18	22	2200	170	0.34	80
17.	ЦН-24	18	20	1800	150	0.33	90
18.	ЦН-24	10	15	1800	100	0.34	20
19.	TsN-15y	15	20	1930	200	0.30	40
20.	ЦН-11	20	25	2100	300	0.28	60
21.	ЦН-15	30	18	1750	400	0.32	80
22.	SK-ЦН-34	20	17	2400	50	0.30	90

Appendix 3

Subjects of essays on the discipline"Processes and equipment of chemical technologies - 3. Hydromechanical and mechanical processes"

1. Separation of heterogeneous gas systems in the field of gravity. Dust deposition chamber.
2. Separation of heterogeneous gas systems in the field of centrifugal forces. Cylindro-conical cyclones.
3. Separation of heterogeneous gas systems in the field of centrifugal forces. Conical cyclones.
4. Separation of heterogeneous gas systems in the field of centrifugal forces. Cyclones with a reverse cone
5. Separation of heterogeneous gas systems in the field of centrifugal forces. Apparatus with opposite swirling flows.
6. Wet gas cleaning. Hollow scrubber.
7. Wet gas cleaning. Attachment scrubber.

8. Wet gas cleaning. Foam scrubber.
9. Wet gas cleaning. Devices with a movable nozzle.
10. Wet gas cleaning. Doyle's scrubber.
11. Wet gas cleaning. Centrifugal scrubber with tangential gas supply.
12. Wet gas cleaning. Cyclone with a water film.
13. Wet gas cleaning. Venturi scrubbers.
14. Gas purification by filtration. Sleeve filter.
15. Gas purification by the method of filtration gas filter with a movable partition.
16. Gas purification by filtration. Ceramic filters.
17. Gas purification by filtration. Metal-ceramic filters.
18. Deposition in the field of an electric field. Electrofilters.
19. Separation of heterogeneous liquid mixtures. Liquid clarifiers.
20. Separation of heterogeneous liquid mixtures. Periodic filter.
21. Separation of heterogeneous liquid mixtures. Filter press.
22. Separation of heterogeneous liquid mixtures. Cartridge filter
23. Separation of heterogeneous liquid mixtures. Belt vacuum filter.
24. Separation of heterogeneous liquid mixtures. Drum vacuum filter.
25. Separation of heterogeneous liquid mixtures. Disk vacuum filter.
26. Separation of heterogeneous liquid mixtures. Carousel vacuum filter.
27. Separation of heterogeneous liquid systems in the field of centrifugal forces. Cylindroconic hydrocylon.
28. Separation of heterogeneous liquid systems in the field of centrifugal forces. Conical hydrocyclone.
29. Separation of heterogeneous liquid systems in the field of centrifugal forces. Cylindrical hydrocyclones.
30. Separation of heterogeneous liquid systems in the field of centrifugal forces. Turbohydrocyclone
31. Separation of heterogeneous liquid systems in the field of centrifugal forces. Settling centrifuges of periodic action.
32. Separation of heterogeneous liquid systems in the field of centrifugal forces. Centrifuges of continuous action.
33. Separation of heterogeneous liquid systems in the field of centrifugal forces. Intermittent filtering centrifuges.
34. Separation of heterogeneous liquid systems in the field of centrifugal forces. Filtering centrifuges of continuous action.
35. Separation of heterogeneous liquid systems in the field of centrifugal forces. Drum separator.
36. Separation of heterogeneous liquid systems in the field of centrifugal forces. Ultracentrifuges
37. Mixing materials. Liquid stirrers with flat blades.
38. Mixing materials. Propeller liquid mixers
39. Mixing materials. Frame liquid mixers
40. Mixing materials. Turbine liquid mixers

41.Mixing materials. Propeller liquid mixers
42.Mixing materials. Propeller liquid mixers
43.Mixing materials. Anchor liquid mixers
44.Mixing materials. Cavitation mixers.
45.Mixing of loose materials. Screw mixers.
46.Pseudo-liquefaction. Devices with a fluidized bed.
47.Pseudo-liquefaction. Devices with a fluidized bed.
48.Pseudo-liquefaction. Devices with a gushing layer.
49.Pseudo-liquefaction. Devices with jet-pulsation fluidization.
50.Pseudo-liquefaction. Air fountain dryers
51.Shredding of solid materials. Jaw crusher.
52.Shredding of solid materials. Cone crusher.
53.Shredding of solid materials. Roll crushers
54.Shredding of solid materials. Hammer crushers.
55.Shredding of solid materials. runners
56.Shredding of solid materials. Disintegrators.
57.Shredding of solid materials. Dismembrators
58.Grinding machines. Ball mills.
59.Grinding machines. Pneumatic mills.
60.Grinding machines. Jet mills.
61.Grinding machines. Colloid mills
62.Grinding machines. Vibromills