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

Machines and apparatuschemical and oil refining

Intensification of hydrodynamic processes

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	*Third (Doctor of Philosophy)*
Branch of knowledge	*13 mechanical engineering*
Specialty	*133 branch mechanical engineering*
Educational program	*Computer-integrated technologies of chemical engineering equipment design*
Discipline status	*Selective*
Form of study	*daily*
Year of preparation, semester	*2nd year, spring semester*
The scope of discipline	*120 hours (18 - hours of lectures)* *18 hours - practical* *84 years - SRS*
Semester control / control measures	*test*
Timetable	*https://ecampus.kpi.ua/*
Language of instruction	*Ukrainian*
Information about the course leader / teachers	*Lecturer: Doctor of Technical Sciences, Professor Kornienko Ya.M.* *YNK@kpi.ua* *Practical: Kornienko Ya.M.*
Course placement	*https://ecampus.kpi.ua/*

Curriculum of the discipline

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

The course is aimed at deepening the ideas of graduate students about the essence of the processes of energy transfer, mass and momentum in continuous and dispersed environments. When considering the various processes of heat transfer, it is necessary to assess the influence of the modes of motion of continuous media on the efficiency of transfer processes. Various ways of increasing the intensity of diffusion-controlled processes in gas-liquid, solid-liquid systems, as well as technological processes in the presence of phase transitions, in particular dehydration and granulation, are considered. Especially mass crystallization in obtaining solid components with given properties.

The main attention is paid to reducing energy consumption for heat and mass transfer processes while achieving high quality kinetic characteristics.

The subject of the discipline

The main modern theories and approaches to the intensification of heat and mass transfer processes through the use of different methods of interaction of a continuous medium with inhomogeneous motion or with the use of the phenomenon of cavitation. Features of application of various factors of intensity of hydrodynamic processes without disturbance of functioning of devices and ecological safety.

The purpose of this discipline *is the formation of graduate students a set of knowledge in the field of transfer processes in the equipment of chemical technology in order to increase their intensity and develop the principles of energy efficient equipment.*

In accordance with the purpose of training doctors of philosophy requires the deepening of the competencies formed in graduate students:

- *ability to abstract thinking, analysis and synthesis of working hypotheses;*
- *ability to generate new ideas (creativity);*

– ability to comprehend the philosophical and ideological principles, modern trends, directions and patterns of development of domestic science in the context of globalization and internationalization.

Postgraduate students after mastering the discipline must acquire the following knowledge:

Know the priority areas of development of science, technology and engineering in Ukraine and abroad;

To know modern methods and ways of hydrodynamic activation of continuous and dispersion media.

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

The study of the discipline is based on the principles of integration of various knowledge acquired by graduate students during the bachelor's and master's degree, the study of disciplines of natural and engineering-technological direction.

The presented discipline is a fundamental basis that will contribute to the solution of complex problems in the field of development of innovative energy efficient processes of chemical technology and equipment for their implementation.

3. The content of the discipline

Section 1. Transfer processes in the presence of a phase transition

Topic 1. Theoretical principles of heat and mass transfer in the processes of drying, dehydration and granulation.

Topic 2. Critical analysis of processes and equipment for drying, dehydration and granulation processes.

Topic 3. Theoretical principles of improving the energy efficiency of dryers.

Section 2. Improving the efficiency of transfer processes in the fluidized bed.

Topic 4. Theoretical principles of heat and mass transfer in devices with a fluidized bed.

Topic 5. Estimation of energy consumption for the creation of active hydrodynamics in devices for dehydration and granulation of liquid systems in a fluidized bed.

Topic 6. Theoretical principles of inhomogeneous fluidization. Criterion for assessing the quality of hydrodynamics of inhomogeneous fluidization.

Topic 7. Determination of basic characteristics of jet-pulsation fluidization in self-oscillating mode.

Topic 8. Evaluation of the kinetic characteristics of the granulation process using inhomogeneous fluidization.

Topic 9. Methods of generalization of research results and principles of industrial apparatus design.

4. Training materials and resources

Basic literature

1.Kornienko Ya. M. Processes and equipment of chemical technology 1: textbook / Ya. M. Kornienko, Yu. Yu. Lukach, IO Mikulyonok, VL, Rakytsky, GL Ryabtsev // K .: NTUU "KPI". - 2011. -

Part 1. - 300 C.

2. Kornienko Ya. M. Processes and equipment of chemical technology 2: Textbook / Ya. M. Kornienko, Yu. Yu. Lukach, IO Mikulyonok, VL Rakytsky, GL Ryabtsev // K .: NTUU "KPI". - 2011. - Part 2. - 416 p.

3. Tovazhnyansky LL Processes and apparatus of chemical technology / LL Tovazhnyansky, AL Gotlinskaya, VO Nechiporenko. IS Chernyshov // Kharkiv, NTU. - 2006. - Part 1. - 540 C.

4. Tovazhnyansky LL Processes and apparatus of chemical technology / LL Tovazhnyansky, AL Gotlinskaya, VO Nechiporenko IS Chernyshov. - Kharkiv, NTU. - 2006. - Part 2. - 540 C.

5. Kornienko Ya. M. Increasing the efficiency of the process of obtaining granular humic and mineral fertilizers / Ya. M. Kornienko, SS Gaidai, OV Martyniuk // NTUU "KPI". - 2014. - 349 C.

6. Kornienko JM The process of dehydration of composite liquid systems in a fluidized bed using a mechanical dispersant / Ya. M. Kornienko, DS Semenenko, OV Martyniuk. SS Gaidai // NTUU "KPI". - Kyiv. - 2015. - 167 p.

7. Kornienko Ya. M. The process of obtaining modified granular humic and mineral fertilizers / Ya. M. Kornienko, AM Lubeka, SS Gaidai // KPI im. Igor Sikorsky. - Kyiv: KPI named after Igor Sikorsky. - 2017. - 210 p.

8. Kornienko JM Processes of granulation of mineral and humic fertilizers / Ya. M. Kornienko, RV Sachok // Electronic edition. - 2014 - 158 p.

Additional literature

9. Nagursky OA Regularities encapsulationsubstances in a state of fluidization and their diffusion release: monograph / OA Nagursky // Ministry of Education and Science, Youth and Sports of Ukraine, Nat. Lviv Polytechnic University. - L .: Lviv Publishing House. Polytechnic. - 2012. - 188 p.

10. Nikitenko NN Molecular radiation theory and methods for calculating heat and mass transfer. Monograph / NN Nikitenko, YF Snezhkin, NN Sorokova, YN Kolchik // SPE "Publishing House of Scientific Thought". - NAS of Ukraine. - 2014. - 567 C.

Information resources on the Internet

11. Ministry of Strategic Industries of Ukraine [Electronic resource]. - 2021. - Access mode:https://mspu.gov.ua.

12. Union of Chemists of Ukraine [Electronic resource]. - 2021. - Access mode: http://chemunion.org.ua/uk.

13. International congress of chemical process [Electronic resource]. - 2021. - Access mode: https://2020.chisa.cz.

14. Digital management of the construction process - developed by enterpreneurs for enterpreneurs [Electronic resource]. - 2021. - Access mode: https://www.chisa.dk.

Educational content

1. **Methods of mastering the discipline (educational component)**

Lectures

Lectures are aimed at:

- *providing modern, holistic in-depth knowledge of the discipline, the level of which is determined by the target setting for each topic;*
- *providing in the process of critical creative work together with the teacher;*
- *education of professional qualities in graduate students and the development of their independent creative thinking;*
- *awareness of world trends in the development of science in the field of intensification of heat and mass transfer processes in industrial equipment;*
- *awareness of methods of processing information resources and determining the main directions for solving specific scientific and technical problems;*
- *teaching research materials in clear and high-quality language on the observance of structural and logical connections, explanation of all the above terms and concepts available for perception by the audience.*

№ s / n	***Title of the lecture topic and list of main questions (list of teaching aids, references to literature and tasks on VTS)***	***Number hours***
1	*2*	*3*
Section 1. Transfer processes in the presence of phase transitions		
1	***Theoretical principles of heat and mass transfer processes in the processes of drying, dehydration and granulation*** *Analysis of heat and mass transfer processes in the systems: gas - solid, gas - liquid, accompanied by isothermal crystallization.* *Literature: [1, 2, 3, 4]* *Tasks on VTS. Identify the limiting stages of the process of moisture removal during drying, dehydration and granulation of mono- and multicomponent liquid systems.*	***2***
2	***Critical analysis of processes and equipment for drying, dehydration and granulation processes*** *Analysis of energy costs for heat and mass transfer processes accompanied by phase transitions. Efficiency of use of driving forces on heat and mass transfer. Design of drying equipment.* *Literature: [1, 2, 3, 4, 5]* *Tasks on VTS. Justify technical solutions for the supply of drying agent to increase the intensity of moisture removal in the first and second drying period.*	*2*
3	***Theoretical bases of increase of energy efficiency of drying installations*** *Methods for evaluating the efficiency of dryers for different forms of moisture are given. Methods of regulating the driving force during mass transfer* *Literature: [1, 2, 3, 4]* *Tasks on VTS. Analyze the schemes of drying units with open and closed cycles. Compare energy consumption when using schemes with a heat pump.*	*2*

Section 2. Improving the efficiency of transfer processes in the fluidized bed		
4	***Theoretical principles of heat and mass transfer in devices with a fluidized bed*** *Implementation of interphase contact in devices with a fluidized bed. Homogeneous fluidization. Features of heat exchange during drying and dehydration and granulation of liquid systems.* *Literature: [12, 67, 8]* *Tasks for S.R.S. To determine the influence of hydrodynamic modes of fluidization on the efficiency of transfer processes during drying and dehydration and granulation of liquid systems.*	***2***
5	***Estimation of energy consumption for creation of active hydrodynamics in devices for dehydration and granulation of liquid systems in a fluidized bed*** *To analyze the structures of gas distribution devices (FDD) to determine the rational design in which the risk of stagnant zones is minimized. Determine the method of introduction of heat carrier with high temperature in case of dehydration and granulation of liquid systems. To calculate the coefficient of hydraulic resistance of fracturing, at the value of the given speeds from 25 to 40 m / s.* *References: [2, 5, 6, 7, 8]* *Tasks on VTS. Calculate the hydraulic resistance of fracturing for the three selected types and determine the reliability of their work by the method of Professor Taguti*	***2***
6	***Theoretical principles of inhomogeneous fluidization. Criterion for estimating inhomogeneous fluidization.*** *Methods of intensification of heat and mass transfer processes of the gas - solid body system during dehydration and granulation processes are considered:* *Factors influencing the intensity of diffusion-controlled processes at the contact of the heated coolant with the surface of solid particles are considered. Ability to increase the intensity of volumetric three-dimensional mixing of granular material with inhomogeneous fluidization.* *Literature: [5, 6, 7, 8]* *Tasks on VTS. To get acquainted with the peculiarities of the course of transfer processes in the gas - solid body system at the pulsation mode of gas coolant supply and change of the direction of movement of the granular material in the apparatus.* *Get acquainted with the methods of realization of inhomogeneous fluidization.*	***2***
7	***Determination of basic characteristics of jet-pulsation mode of fluidization in self-oscillating mode*** *Physical model of jet - pulsation mode of hydrodynamics of inhomogeneous fluidization in self - oscillating mode. Condition and formation of gas bubbles and the ratio of their size to the geometric dimensions of the granulator chamber. Influence of working reduced gas velocity on pulsation frequency and intensity of granular material movement on fracturing working surfaces. The concept of*	***2***

	determining the number of fluidizations Kw = w_p / w_{kr}, and the inhomogeneity index i_N = εII / εI (εIII / εI) *Literature [5, 6, 7, 8].* *Tasks on VTS. To analyze the influence of the equivalent particle diameter on the conditions of realization of the jet-pulsation mode of fluidization in the self-oscillating mode. Determine Kw et al.*	
8	***Evaluation of kinetic characteristics of the granulation process using inhomogeneous fluidization*** *Under constant conditions of the process: the temperature of the coolant at the inlet to the apparatus and in the layer, as well as at a constant flow rate of the liquid phase, which is fed to the granulator with an interval of 20 min are determined:* - *dynamics of change de = f (τ);* - *dynamics of change of mass percent of separate fractions x = f (τ);* - *dynamics of change of granulation coefficient ψ = f (τ), ψmin ≥ 85%* *Literature [5, 6, 7, 8].* *Tasks on VTS. With a useful temperature difference ΔT = T_{ent} - T_w= 100 ºC, calculate heat consumption for evaporation of 1 kg of moisture and compare with theoretical values. To analyze the dynamics of changes in the mass percentage of individual fractions and determine the mechanism of granulation - layered or agglomeration.*	***2***
9	***Methods of generalization of research results and principles of industrial device design development.*** *Carrying out statistical processing of results of measurements of physical quantities. Graphical interpretation of results and application of different methods of approximation: Determination of errors of the received correlation dependences. Formation of criteria for mass transition and calculation of components of the industrial apparatus.* *Literature [6, 7, 8]* *Tasks on VTS. Comparison of basic kinetic characteristics in dehydration of liquid systems with different concentrations of dry matter.* *To form the design of a block-modular industrial apparatus in the implementation of the jet-pulsation mode of fluidization in the self-oscillating mode.*	***2***
	Total	***18***

Practical training

They should help postgraduate students to develop creative thinking, a creative approach to the scientific substantiation of the direction and methodology of research.

The main tasks of the cycle of practical classes:

- *to help postgraduate students to systematize and deepen theoretical knowledge in the field of heat and mass transfer in dynamic dispersed systems;*
- *to promote the training of graduate students in the methodology of determining the limiting factors of the processes of transfer of momentum, heat and mass in dynamic systems in the presence of a phase transition;*
- to form criteria for assessing the efficiency of transfer processes and be able to determine the level of specific energy consumption.

№ s / n	***The name of the topic of the practical lesson and the list of main questions (list of didactic support, references to literature and tasks on VTS)***	***Number hours***
1	*2*	*3*
1	***Mass transfer in drying processes and in dehydration and granulation of solutions in a fluidized bed.*** *Factors that determine the drying rate in the first and second periods. Thermal balance of drying processes. Calculation of the driving force of the mass transfer process.* *Determination of the driving force of mass transfer during dehydration of solutions and granulation. Suggestions for maintaining the driving force.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Determine the temperature of the "wet thermometer" for convective drying processes.* *Calculate the rational temperature of the coolant in the layer during dehydration and granulation of 40% ammonium sulfate solution.*	***2***
2	***Critical analysis of drying methods, their design and determination of the difference from granulation in the fluidized bed.*** *Methods for assessing the impact of the design of units of devices for dehydration and granulation on the stability of process kinetics and the proposal of technical solutions to eliminate the identified shortcomings.* *Literature: [6, 7, 8].*	***1***

	Tasks on VTS. *Analyze the methods of feeding the liquid phase to the granulator.* *Determine a rational way of contact of granular material with gaseous coolant.* *Formulate requirements for the design of gas distribution devices (FDD) for fluidized bed granulators.*	
3	***Ways to increase the energy efficiency of dryers.*** *Improving the efficiency of heat use in dryers of different types depending on the forms of bound moisture.* *Development of a working hypothesis for evaluating the performance of three types of devices in the granulation of liquid systems. Methods to increase the efficiency of transfer processes.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Calculate the efficiency of heat use for dryers of conductive and convective types. Compare this parameter for devices with a fluidized bed.*	***1***
4	***Calculation of the process of dehydration and granulation in the fluidized bed.*** *Determination of heat consumption for evaporation of 1 kg of moisture at three values of the useful temperature difference ΔT = 100, 200 and 300 oC at a temperature in the 96oC layer.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Analyze the value of the working fluidization rate for a mono- and polydisperse layer with an equivalent particle diameter de = 2.0; 2.5; 3.0 mm.*	***2***
5	***Evaluation of the effectiveness of ensuring the active movement of granular material on the working surfaces of fracturing.*** *Calculation of the kinetic energy of the gas jet directed along the working surface of the fracturing to prevent the formation of stagnant zones.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Analyze fracturing structures that minimize the risk of stagnation on the working surface of fracturing and promote the creation of active directional mixing of granular material in the apparatus.*	***2***
6	***Ways to create inhomogeneous fluidization.***	***2***

	Types of constructions of units of pulsation supply of gas heat carrier to the granulator chamber with mechanical pulsators. *Features of fracturing design and methods of introducing coolant to the granulator during jet-pulsation inhomogeneous fluidization.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Establish the dependence of the pulsation frequency on the height of the initial layer and the reduced number of fluidizations.*	
7	***Determination of the granulation mechanism and evaluation of the efficiency of the process kinetics.*** *Using known techniques to calculate:* – *the equivalent diameter of the granules in the apparatus in a given time interval;* – *to estimate the intensity of the increase in the mass of the layer in the apparatus due to the increase in the average values of the hydraulic resistance of the layer;* – *to analyze the dynamics of changes in the mass percentage of individual factions and the nature of the exchange between factions;* – *analyze the dynamics of changes in the granulation coefficient and in the case $\varphi \leq 80\%$ to propose a working hypothesis of increasing this parameter, based on the basic principles of heat and mass transfer in dynamic dispersed systems.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Based on the results of the process analysis, determine the limiting stage of the dehydration and granulation process and determine the significance of the impact on the process of technological and hydrodynamic parameters.*	***2***
8	***Transfer processes in inhomogeneous fluidization.*** *Features of interphase contact during heat and mass transfer processes in the conditions of inhomogeneous jet-pulsation fluidization in the self-oscillating mode.* *Influence of pulsation supply of heat carrier on layer porosity in separate zones of the device and mirror change of velocity vectors of separate clusters of granular material.* *Literature: [6, 7, 8].*	***2***

	Tasks on VTS. *Evaluate the dynamics of changes in porosity in individual areas of the apparatus and the pulsation change in velocity of individual solid particles.*	
9	***Generalization of results.*** *The use of certain physical quantities to solve the selected mathematical model. Obtaining correlation dependencies and limits of their application and verification. Formulation of similarity criteria for calculation of designs of units of the industrial device.* *Literature: [6, 7, 8].* *Tasks on VTS.* *Solve the heat balance equation for gas and solid phases during dehydration and granulation of liquid systems with different porosity dynamics.*	***2***
10	***Test***	***2***
	Together	***18***

6. Independent work of a student / graduate student

Independent work is 70% of the study of the credit module, which includes preparation for the test. The main task of independent work of graduate students is to deepen the worldview and scientific knowledge in the areas identified in the lectures, by finding the necessary information, forming perseverance and creative search in the formation of working hypotheses to intensify the transfer process.

№ s / n	***The name of the topic that is submitted for independent study***	***Number hours***
1	*2*	*3*
Section 1. Transfer processes in the presence of a phase transition		
1	***The main types of transfer of momentum, energy and mass in the processes of drying and dehydration of liquid systems.*** *Influence of hydrodynamics on transfer processes in the gas-solid system.* *Conditions for removal of surface moisture from porous bodies.* *Heat transfer during mass crystallization of solutions on the surface of a solid.* *Evaluation of heat exchange efficiency in conductive and convective methods of heat supply to the liquid phase.* *Mass crystallization of ammonium sulfate from one-component solutions and in the presence of impurities of organic and mineral origin.* *Literature: [6, 7, 8].*	***30***

	Section 2. Improving the efficiency of transfer processes in the fluidized bed	
2	*Basic modes of hydrodynamics in the system of interaction of gas and granular material: bubbling, gushing, piston.* *Calculation of the critical velocity and the reduced number of fluidization.* *Carry out a critical analysis of the designs of gas distribution devices and chamber devices, which provide intensive volumetric mixing of mono- and polydisperse materials.* *Determine the size of solid particles at which active hydrodynamics is possible without the formation of stagnant zones on the working surface of the fracturing.* *Features of heat exchange in homogeneous fluidization.* *How does the height of the layer on which the useful temperature difference is realized in the case of the following modes: bubbling, gushing and piston change?* *To substantiate the method of determining the limiting stages of heat transfer in the implementation of different modes of fluidization during drying of granular materials in the first and second periods.* *Master the theoretical foundations of the process of dehydration and granulation of liquid systems.* *Formulate the basic principles of stable kinetics of the process depending on the mechanism of granulation.* *Features of fracturing structures when using a coolant with a temperature exceeding the melting point of the material.* *Critical evaluation of methods and designs of distributors for the introduction of the liquid phase into the granulator.* *Conditions for the implementation of the process with a granulation coefficient $\psi \geq 90\%$ while maintaining the driving force of mass transfer.* *Determining the limiting stage of the process and formulating proposals to increase the intensity of diffusion-controlled processes.* *Features of hydrodynamics of inhomogeneous fluidization and expediency of application of this method for process intensification.* *Basic design and technological principles of the granulator for the implementation of inhomogeneous fluidization in self-oscillating mode.* *Determination of kinetic characteristics, according to which it is expedient to compare the efficiency of dehydration and granulation processes for bubbling and inhomogeneous jet-pulsation modes of fluidization.* *Literature: [6, 7, 8].*	***48***

3	***Preparation for the test***	***6***
	Together	***84***

Policy and control

Course policy (educational component)

Rules for attending classes and behavior in class

Attendance is mandatory. Postgraduate students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without good reason, not to interfere with the teacher to conduct classes and not to be distracted by actions that are not related to the educational process.

Rules for assigning incentive and penalty points

- *incentive points can be awarded by the teacher only for the implementation of creative works and working hypotheses.*
  But their amount cannot exceed 25% of the rating scale.
- *penalty points within the academic discipline are not provided.*

Policy of deadlines and rearrangements

In the event of academic arrears in the discipline or any force majeure, graduate students should contact the teacher to agree on the algorithm of actions related to solving existing problems.

The policy of academic integrity

Plagiarism and other forms of dishonesty are not allowed. Plagiarism includes the lack of links when using printed and electronic materials, citations, opinions of other authors. Inadmissible hints and write-offs when writing tests, conducting classes.
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". Read more:https://kpi.ua/code

Policy of academic behavior and ethics

Postgraduate students must be tolerant, respect the opinion of others, formulate objections in the correct form, adequately maintain feedback in the classroom.
Norms of ethical behavior of 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

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

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

Semester	*Training time*		*Distribution of teaching hours*				*Control measures*		
	Loans	*acad. year*	*Lectures*	*Practical*	*Lab. slave.*	*CPC*	*MCR*	*RR*	*Semester control*
4	*4*	*120*	*18*	*18*	*-*	*84*	*-*	*-*	*test*

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

The graduate student's rating from the credit module consists of the points he receives for his work in practical classes.

Semester control is a test.

System of rating (weight) points and evaluation criteria

System rating points and evaluation criteria:

Performing tasks in practical classes.

The weight score for 1 and 2 practical classes is 15 points each; in practical classes 3 - 9 - 10 points.

Criteria for evaluating the implementation of a practical task

Completeness and signs of task performance	***Bali***	
The task is completed in full	*15*	*10*
Minor shortcomings under paragraph 1	*13-14*	*8-9*
Late performance of the task	*10-12*	*7*
Untimely performance of the task, shortcomings under item 1	*2-9*	*2-6*
Poor task performance	*1*	*1*
Failure to complete the task	*0*	*0*

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

$$R = 2 \cdot 15 + 7 \cdot 10 = 100 \text{ points}$$

According to the results of educational work for the first 7 weeks, the "ideal graduate student" must score 40 points. At the first certification (8th week) the graduate student receives "credited" if his current rating is at least 20 points.

According to the results of educational work for 13 weeks of study, the "ideal graduate student" must score 90 points. At the second certification (14th week) the graduate student receives "credited" if his current rating is not less than 40 points.

The maximum amount of points is 100. To get credit from the credit module "automatic" you must have a rating of at least 60 points.

A necessary condition for admission to the test is a rating of at least 40% of the rating scale (R), ie 40 points.

Postgraduate students who scored less than 0.6 R during the semester, as well as those who want to increase the overall rating, perform a test. In this case, all points obtained by them during the semester are canceled. Test tasks contain questions that relate to different sections of the credit module. The list of test questions is given in Section 9.

To obtain a credit score, the sum of all received during the semester rating points R translated according to the table:

Scores	***Rating***
95 ... 100	*perfectly*
85 ... 94	*very good*
75 ... 84	*fine*
65 ... 74	*satisfactorily*
60 ... 64	*enough*
RD <60	*unsatisfactorily*

Admission conditions are not met	*not allowed*

3. Additional information on the discipline (educational component)

An indicative list of questions to be submitted for semester control

1. *Mass transfer processes. Mass transfer mechanism.*
2. *Material balance of mass transfer. Derivation of the equation of the working line of the process in mass exchangers.*
3. *Equilibrium. Phase rule.*
4. *Calculation of the average driving force of the process when the equilibrium line is straight.*
5. *Convective diffusion. Schukarev's law.*
6. *Molecular diffusion. Physical essence.*
7. *Determination of the average driving force of the process for the case when the equilibrium line is curved.*
8. *Derivation of similarity criteria for mass transfer processes.*
9. *The physical essence of convective diffusion.*
10. *Mass transfer coefficients. Physical essence.*
11. *Physical model of molecular diffusion. Fick's first law.*
12. *Derivation of the differential equation of molecular diffusion.*
13. *Conversion of the basic equation of mass transfer for packed columns.*
14. *Number of transfer units. Height of the transfer unit.*
15. *Equilibrium. Phase rule. Henry's law.*
16. *Physical model of the mass transfer process.*
17. *Features of mass transfer in the gas-solid system.*
18. *The main parameters of the gas coolant as a drying agent.*
19. *Factors influencing the first and second drying period. Methods of intensification of the drying process during convective and conductive drying.*
20. *Explain the essence of diffusion-controlled processes. Identify forms that limit the speed of the process and provide suggestions for its intensification.*
21. *The physical essence of the process of fluidization. Process characteristics, porosity ε, fluidization number Kw, hydraulic resistance of the layer.*
22. *The method of calculating the equivalent diameter of the particles in the layer and the total surface of the layer through the hydraulic resistance of the layer.*
23. *Explain how the shape of the device and the design of fracturing affect the nature of fluidization*
24. *To form the basic requirements to the gas-distributing device (hydraulic fracturing).*
25. *To substantiate the methods of averaging stagnant zones on fracturing working surfaces.*
26. *Method of determining the coefficient of hydraulic resistance of fracturing, what is the physical essence of this parameter?*
27. *Method of calculating the critical rate of fluidization (according to Todes and Lyashchenko)*
28. *Determination of the activity of the hydrodynamic regime through the Archimedes criterion.*
29. *Principles of organization of inhomogeneous fluidization without installation of pulsation gas supply unit.*
30. *The method of introducing gas jets to create conditions for their combination and the creation of a gas bubble.*
31. *Calculation of the size of the gas bubble at equilibrium in the granular layer.*
32. *Conditions for the formation of gas bubbles to provide three-dimensional 3D circulation with a frequency of more than 2 Hz.*
33. *Method of calculating the main kinetic characteristics of the process of dehydration and granulation.*

Work program of the discipline (syllabus):

Folded *prof., doctor of technical sciences, Kornienko Ya. M.*

Approved at the meeting of the Department of Machines and Apparatus of Chemical and Oil Refining (Protocol № 26 of 19 June 2021)

Agreed metodic commission of the Faculty of Engineering and Chemistry (Protocol № 11 of June 25, 2021)