Intensification of hydrodynamic processes

Working program of the academic discipline (Syllabus)

Details of the academic discipline

Level of higher education	*Third (Ph.D.)*
Branch of knowledge	*13 mechanical engineering*
Specialty	*133 industrial engineering*
Educational program	*Industrial engineering*
Discipline status	*Selective*
Form of education	*Denna*
Year of training, semester	*2nd year, spring semester*
Scope of the discipline	*120 hours (18 hours of lectures)* *18 hours - practical* *84 hours - SRS*
Semester control/ control measures	*Test*
Lessons schedule	*https://ecampus.kpi.ua/*
Language of teaching	*Ukrainian*
Information about the course leader / teachers	*Lecturer: Professor Y.M. Kornienko, Ph.D.YNK@kpi.ua* *Practical: Kornienko Y.M.*
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 discipline is aimed at deepening the ideas of graduate students regarding the essence of the processes of energy transfer, mass and the amount of movement in solid and dispersion media. When considering various heat exchange processes, it is necessary to evaluate the influence of the modes of movement of solid media on the efficiency of transfer processes. Various methods 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 when obtaining solid components with specified properties.

The main attention is paid to the reduction of energy costs for heat and mass exchange processes while achieving high-quality kinetic characteristics.

The subject of the academic discipline

The main modern theories and approaches regarding the intensification of heat and mass exchange processes through the use of various methods of interaction of a continuous medium during non-homogeneous movement or using the phenomenon of cavitation. Features of the application of various factors of the intensity of hydrodynamic processes without disturbing the functioning of the devices and environmental safety.

The purpose of this discipline*is the formation of post-graduate students' complex of knowledge in the field of carrying out processes of transferring chemical technology in equipment with the aim of increasing their intensity and developing the principles of energy-efficient equipment.*

In accordance with the goal of training doctors of philosophy, deepening of competencies developed in graduate students is required:

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

–the ability to understand philosophical and worldview foundations, modern trends, directions and patterns of development of domestic science in the conditions of globalization and internationalization.

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

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

To know modern methods and methods of hydrodynamic activation of continuous and dispersed media.

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

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

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. Content of the academic discipline

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

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

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

Topic 3. Theoretical principles of increasing the energy efficiency of drying plants.

Chapter 2. Increasing the efficiency of transfer processes in a fluidized bed.

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

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

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

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

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

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

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. Y. M. Kornienko Processes and equipment of chemical technology 2: Textbook / Y. M. Kornienko, Y. Yu. Lukach, I. O. Mikulonok, V. L. Rakytskyi, G. L. Ryabtsev // K.: NTUU "KPI". - 2011. - Part 2. - 416 p.

3. Tovazhnyansky 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 granular 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. Granulation processes of mineral-humic fertilizers / Y. M. Kornienko, R. V. Sachok // Electronic edition. - 2014 - 158 p.

Additional literature

9. Nagursky O. A. Regularitiesencapsulationsubstances in a state of fluidization and their diffusion release: a monograph / O. A. Nagurskyi // Ministry of Education and Science, Youth and Sports of Ukraine, Nat. Lviv Polytechnic University. - L.: Vid-vo Lviv. polytechnics – 2012. – 188 p.

10. Nikytenko N.N. Molecular radiation theory and methods of calculating heat and mass transfer. Monograph / N.N. Nikytenko, Yu.F. Snezhkin, N.N. Sorokovaya, Yu.N. Kolchyk // NVP "Naukova Dumka Publishing House". - National Academy of Sciences of Ukraine. – 2014. – 567 p.

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 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 postgraduate 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;*
- *awareness of the methods of processing information resources and determining the main directions for solving specific scientific and technical problems;*
- *teaching research materials in a clear and high-quality language in compliance with structural and logical connections, clarification of all given terms and concepts available for perception by the audience.*

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. Transfer processes in the presence of phase transitions	
1	***Theoretical principles of heat and mass exchange processes in drying, dehydration and granulation processes*** *Analysis of heat and mass transfer processes in systems: gas – solid, gas – liquid, accompanied by isothermal crystallization.* *Literature: [1, 2, 3, 4]* *Tasks on SRS. To determine the limiting stages of the moisture removal process during drying, dehydration and granulation of mono- and multi-component 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. The efficiency of the use of driving forces for heat and mass transfer. Design of drying equipment.* *Literature: [1, 2, 3, 4, 5]* *Tasks on SRS. To substantiate the technical solutions of supplying the drying agent to increase the intensity of moisture removal in the first and second drying periods.*	*2*
3	***Theoretical principles of increasing the energy efficiency of drying plants*** *Techniques 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 SRS. Analyze schemes of drying plants with open and closed cycles. Compare energy consumption when using schemes with a heat pump.*	*2*

Chapter 2. Increasing the efficiency of transfer processes in a 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. Peculiarities of heat exchange during drying and dehydration and granulation of liquid systems.* *Literature: [12, 67, 8]* *Tasks on S.R.S. To determine the influence of hydrodynamic regimes of fluidization on the efficiency of transfer processes during drying and dehydration and granulation of liquid systems.*	***2***
5	***Estimation of energy consumption for the creation of active hydrodynamics in devices for dehydration and granulation of liquid systems in a fluidized bed*** *Conduct an analysis of gas distribution devices (GDP) designs to determine a rational design that minimizes the risk of stagnant zones. Determine the method of introducing a coolant with a high temperature in the case of dehydration and granulation of liquid systems. Calculate the coefficient of hydraulic resistance of hydraulic fracturing, with the value of the reduced velocities from 25 to 40 m/s.* *Literature: [2, 5, 6, 7, 8]* *Tasks on SRS. Calculate the hydraulic resistance of hydraulic fracturing for three selected types and determine the reliability of their operation according to Professor Taguti's method*	***2***
6	***Theoretical principles of heterogeneous fluidization. Evaluation criterion of heterogeneous fluidization.*** *Methods of intensification of the heat and mass exchange processes of the gas-solid system during the dehydration and granulation processes are considered:* *Factors affecting the intensity of diffusion-controlled processes when the heated heat carrier is in contact with the surface of solid particles are considered. The possibility of increasing the intensity of volumetric three-dimensional mixing of granular material during heterogeneous fluidization.* *Literature: [5, 6, 7, 8]* *Tasks on SRS. Familiarize yourself with the features of transfer processes in the gas-solid system during the pulsating mode of gas coolant supply and changing the direction of movement of the granular material in the apparatus.* *Familiarize yourself with the ways of implementing non-homogeneous fluidization.*	***2***
7	***Determination of the basic characteristics of the jet-pulsation mode of fluidization in the self-oscillating mode*** *A physical model of the jet-pulsation regime of the hydrodynamics of inhomogeneous fluidization in the self-oscillating regime. The condition and formation of gas bubbles and the ratio of their sizes to the geometric dimensions of the granulator chamber. The influence of the working reduced gas velocity on the frequency of pulsations and the intensity of movement of granular material on the working surfaces of hydraulic fracturing. The concept of determining the fluidization number Kw = w_p/w_{Cr}, and the heterogeneity index i_N= εII / εI (εIII / εI)*	***2***

	Literature [5, 6, 7, 8]. *Tasks on SRS. To analyze the influence of the equivalent diameter of particles on the conditions of implementation of the jet-pulsation mode of fluidization in the self-oscillating mode. Determine Kw and in.*	
8	***Evaluation of the kinetic characteristics of the granulation process when using non-homogeneous fluidization*** *Under constant conditions of process implementation: the temperature of the coolant at the entrance to the apparatus and in the layer, as well as under constant consumption of the liquid phase, which is fed to the granulator with an interval of 20 minutes, are determined:* - *dynamics of change de = f(τ);* - *dynamics of changes in mass percentages of individual fractions x = f(τ);* - *dynamics of changes in the granulation coefficient ψ=f(τ), ψmin ≥ 85%* *Literature [5, 6, 7, 8].* *Tasks on SRS. With a useful temperature difference ΔT = $T_{entrance} - T_{sh}$ = 100 ºC, calculate the heat consumption for the evaporation of 1 kg of moisture and compare with the theoretical values. Conduct an analysis of the dynamics of changes in the mass percentages of individual fractions and determine the granulation mechanism - layer-by-layer or agglomeration.*	***2***
9	***Methods of summarizing research results and principles of industrial apparatus design development.*** *Carrying out statistical processing of the results of measurements of physical quantities. Graphical interpretation of results and application of various approximation methods: Determination of errors of obtained correlation dependences. Formation of mass transfer criteria and calculation of nodes of industrial apparatus.* *Literature [6, 7, 8]* *Tasks on SRS. Comparison of basic kinetic characteristics during dehydration of liquid systems with different concentrations of dry substances.* *Form the design of a block-modular industrial apparatus when implementing the jet-pulsation mode of fluidization in the self-oscillating mode.*	***2***
	In total	***18***

Practical training

Postgraduate students should be helped to develop creative thinking, a creative approach to the scientific justification of the research direction and methodology.

The main tasks of the cycle of practical classes:

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

No s/p	***The name of the subject of the practical session and a list of the main questions (list of didactic support, references to the literature and tasks on the SRS)***	***Number hours***
1	*2*	*3*
1	***Mass transfer in drying processes and during dehydration and granulation of solutions in a fluidized bed.*** *Factors that determine the rate of drying in the first and second periods. Heat 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. Proposals for the preservation of driving force.* *Literature: [6, 7, 8].* *Tasks on SRS.* *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 a 40% ammonium sulfate solution.*	***2***
2	***Critical analysis of drying methods, their design and definition of the difference from granulation in a fluidized bed.*** *Methodology for assessing the influence of the design of units of dehydration and granulation devices on the stability of the kinetics of processes and the proposal of technical solutions to eliminate the identified shortcomings.* *Literature: [6, 7, 8].*	***1***

	Tasks on SRS. *Analyze methods of supplying the liquid phase to the granulator.* *Determine a rational method of contact of granular material with a gas coolant.* *Formulate requirements for the design of gas distribution devices (GRP) for fluidized bed granulators.*	
3	***Methods of increasing the energy efficiency of drying units.*** *Increasing the efficiency of heat use in dryers of various types depending on the forms of bound moisture.* *Development of a working hypothesis for evaluating the performance of three types of devices during granulation of liquid systems. Methods of increasing the efficiency of transfer processes.* *Literature: [6, 7, 8].* *Tasks on SRS.* *Calculate the efficiency of heat use for conductive and convective dryers. Compare this parameter for fluidized bed machines.*	***1***
4	***Calculation of the process of dehydration and granulation in a fluidized bed.*** *Determination of heat consumption for the 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 layer of 96 oC.* *Literature: [6, 7, 8].* *Tasks on SRS.* *Analyze the value of the working speed of fluidization for a mono- and polydisperse layer with an equivalent particle diameter of 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 hydraulic fracturing.*** *Calculation of the kinetic energy of the gas jet directed along the working surface of the hydraulic fracturing to prevent the formation of stagnant zones.* *Literature: [6, 7, 8].* *Tasks on SRS.* *Analyze hydraulic fracturing structures that minimize the risk of stagnant zones on the hydraulic fracturing surface and promote the creation of active directional mixing of granular material in the apparatus.*	***2***
6	***Methods of creating heterogeneous fluidization.***	***2***

	Types of constructions of units for pulsating gas coolant supply to the granulator chamber with mechanical pulsators. *Peculiarities of hydraulic fracturing design and methods of introducing the coolant to the granulator during jet-pulsation inhomogeneous fluidization.* *Literature: [6, 7, 8].* *Tasks on SRS.* *Determine the dependence of the frequency of pulsations on the height of the initial layer and the reduced number of fluidization.*	
7	***Determination of the granulation mechanism and evaluation of the effectiveness of the kinetics of the process.*** *Using known methods, calculate:* – *the equivalent diameter of the granules in the apparatus in the 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 mass percentages of individual factions and the nature of exchange between factions;* – *analyze the dynamics of changes in the granulation coefficient and in the case$\varphi \leq 80\%$ to propose a working hypothesis for the increase of this parameter, based on the basic principles of heat and mass exchange in dynamic dispersed systems.* *Literature: [6, 7, 8].* *Tasks on SRS.* *Based on the results of the process analysis, determine the limiting stage of the dehydration and granulation process and determine the importance of the influence of technological and hydrodynamic parameters on the process.*	***2***
8	***Transfer processes during heterogeneous fluidization.*** *Peculiarities of interphase contact during heat and mass transfer processes under conditions of inhomogeneous jet-pulsation fluidization in self-oscillating mode.* *The influence of the pulsating supply of the heat carrier on the porosity of the layer in individual zones of the apparatus and the mirror change of the velocity vectors of individual clusters of granular material.* *Literature: [6, 7, 8].*	***2***

	Tasks on SRS. *To evaluate the dynamics of changes in porosity in individual zones of the apparatus and the pulsating change in the speed of individual solid particles.*	
9	***Generalization of results.*** *The use of defined physical quantities for the solution of the selected mathematical model. Obtaining correlation dependences and limits of their application and verification. Formulation of similarity criteria for the calculation of constructions of industrial apparatus nodes.* *Literature: [6, 7, 8].* *Tasks on SRS.* *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 makes up 70% of the study of the credit module, which also includes preparation for the credit. The main task of the independent work of graduate students is to deepen worldview and scientific knowledge in the directions specified in the lectures, by searching for the necessary information, forming perseverance and creative search in the formation of working hypotheses for the intensification of transfer processes.

No s/p	***The name of the topic submitted for independent processing***	***Number hours***
1	*2*	*3*
Chapter 1. Transfer processes in the presence of a phase transition		
1	***The main types of transfer of the amount of movement, energy and mass in the processes of drying and dehydration of liquid systems.*** *The influence of hydrodynamics on transfer processes in the gas-solid system.* *Conditions for removal of surface moisture from porous bodies.* *Heat exchange during mass crystallization of solutions on the surface of a solid body.* *Evaluation of the efficiency of heat exchange with conductive and convective methods of supplying heat to the liquid phase.* *Mass crystallization of ammonium sulfate from single-component solutions and in the presence of impurities of organic and mineral origin.*	***30***

	Literature: [6, 7, 8].	
	Chapter 2. Increasing the efficiency of transfer processes in a 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 reduced fluidization number.* *To carry out a critical analysis of the designs of gas distribution devices and apparatus chambers, which provide intensive volumetric mixing of mono- and polydisperse materials.* *To 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.* *Peculiarities of heat exchange during homogeneous fluidization.* *How the height of the layer changes, at which the useful temperature difference is realized in the case of the following modes: bubbling, gushing and piston.* *To substantiate the methodology for determining the limiting stages of heat transfer when implementing different modes of fluidization during drying of granular materials in the first and second periods.* *To master the theoretical principles of the process of dehydration and granulation of liquid systems.* *Formulate the main principles of stable kinetics of the process depending on the granulation mechanism.* *Peculiarities of hydraulic fracturing structures when using a coolant with a temperature higher than the melting point of the material.* *Critical assessment of the methods and designs of distributors for introducing the liquid phase to the granulator.* *Conditions for implementing the process with a granulation coefficient of ψ≥90% while maintaining the driving force for mass transfer.* *Determination of the limiting stage of the process and formulation of proposals for increasing the intensity of diffusion-controlled processes.* *Peculiarities of the hydrodynamics of inhomogeneous fluidization and the expediency of using this method for process intensification.* *Basic structural and technological principles of the granulator for the implementation of non-homogeneous fluidization in self-oscillating mode.*	***48***

	Determination of kinetic characteristics, according to which it is expedient to compare the efficiency of dehydration and granulation processes for bubbling and non-homogeneous jet-pulsation modes of fluidization. *Literature: [6, 7, 8].*	
3	***Preparation for the test***	***6***
	Together	***84***

Policy and control

Policy of academic discipline (educational component)

Rules of attending classes and behavior in classes

Attending classes is mandatory. Graduate students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without valid reasons, not to interfere with the teacher conducting classes and not to be distracted by activities unrelated to the educational process.

Rules for assigning incentive and penalty points

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

Policy of deadlines and rescheduling

In case of academic debts arising from the academic discipline or any force majeure circumstances, graduate students should contact the teacher to coordinate the algorithm of actions related to the solution of existing problems.

Policy of academic integrity

Plagiarism and other forms of dishonest work are unacceptable. Plagiarism includes the absence of references when using printed and electronic materials, quotes, opinions of other authors. Inadmissible tips and write-offs during writing tests, conducting classes.
The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details:https://kpi.ua/code

Policy of academic behavior and ethics

Graduate students must be tolerant, respect the opinion of others, formulate objections in the correct form, adequately support feedback during classes.
Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details:https://kpi.ua/code

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
4	4	120	18	18	–	84	-	–	test

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

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

Semester control is credit.

System of rating (weighted) points and evaluation criteria

The system of rating points and evaluation criteria:

Performing tasks in practical classes.

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

Criteria for evaluating the performance of a practical task

Completeness and signs of task completion	***Points***	
The task is fully completed	*15*	*10*
Minor defects according to point 1	*13-14*	*8-9*
Untimely completion of the task	*10-12*	*7*
Untimely completion of the task, deficiencies under clause 1	*2-9*	*2-6*
Poor performance of the task	*1*	*1*
Failure to complete the task	*0*	*0*

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

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

According to the results of academic work in the first 7 weeks, the "ideal graduate student" should 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 academic work for 13 weeks of study, the "ideal graduate student" should score 90 points. At the second certification (14th week), the graduate student receives "credited" if his current rating is at least 40 points.

The maximum number of points is 100. To receive credit from the credit module "automatically" you need to have a rating of at least 60 points.

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

Graduate students who scored less than 0.6 R during the semester, as well as those who want to improve the overall rating, complete a credit test. At the same time, all the points they received during the semester are cancelled. Test tasks contain questions that refer to different sections of the credit module. The list of assessment questions is given in Chapter 9.

*To obtain a passing grade, the sum of all rating points received during the semester 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 not met	*not allowed*

3. Additional information on the discipline (educational component)

An approximate list of questions submitted for semester control

1. *Mass transfer processes. Mass transfer mechanism.*
2. *Material balance of mass exchange. Derivation of the equation of the working line of the process in mass transfer devices.*
3. *A state of equilibrium. Phase rule.*
4. *Calculation of the average driving force of the process when the equilibrium line is straight.*
5. *Convective diffusion. Shchukarev's law.*
6. *Molecular diffusion. Physical entity.*
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 entity.*
11. *Physical model of molecular diffusion. Fick's first law.*
12. *Derivation of the differential equation of molecular diffusion.*
13. *Transformation of the basic mass transfer equation for packed columns.*
14. *Number of transfer units. The height of the transfer unit.*
15. *A state of equilibrium. Phase rule. Henry's Law.*
16. *Physical model of the mass transfer process.*
17. *Peculiarities of mass transfer in the gas-solid system.*
18. *The main parameters of the gas coolant as a drying agent.*
19. *Factors affecting 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 the forms that limit the speed of the process and provide proposals for its intensification.*
21. *The physical essence of the fluidization process. Characteristics of the process, porosity ε, fluidization number Kw, hydraulic resistance of the layer.*
22. *Methodology for calculating the equivalent diameter of particles in the layer and the total surface of the layer due to the hydraulic resistance of the layer.*
23. *Explain how the shape of the apparatus and the structure of the hydraulic fracturing affect the nature of fluidization*
24. *Form the basic requirements for the gas distribution device (GRP).*
25. *To justify the methods of averaging stagnant zones on hydraulic fracturing surfaces.*
26. *The method of determining the coefficient of hydraulic resistance of hydraulic fracturing, what is the physical essence of this parameter?*
27. *Methodology for calculating the critical velocity of fluidization (according to Todes and Lyashchenko)*
28. *Determination of the activity of the hydrodynamic regime through the Archimedes criterion.*
29. *The principles of the organization of heterogeneous fluidization without installing a pulsating gas supply unit.*
30. *The method of introducing gas jets to create the conditions for their unification and the creation of a gas bubble.*
31. *Calculation of the size of a gas bubble in a state of equilibrium in a granular layer.*
32. *Conditions for the formation of gas bubbles to ensure volumetric 3D circulation with a frequency of more than 2 Hz.*

33. *Methodology for calculating the main kinetic characteristics of the dehydration and granulation process.*

Working program of the academic discipline (syllabus):

Folded*prof.., Doctor of Technical Sciences, Y. M. Kornienko*

Approved*by the Department of the Academy of Sciences of the Russian Academy of Sciences (protocol No. 29 dated 06.29.2021)*