MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION

Federal State Autonomous Education “Ural Federal University named after the first President of Russia B.N. Yeltsin”

Institute of Construction and Architecture

Signed and Approved

Vice-rector for Research

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ V.V. Kruzhaev

«\_\_\_» \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2018 г.

COURSE PROGRAM

**MATHEMATICAL MODELING OF heat and mass transfering**

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| **Information about the course program** | **Accounting data** |
| **Education program**  The main education doctoral graduate program | **Specialty code**  08.06.01/20.01 |
| **Major**  Engineering and Construction Technologies **Training program**  Heat supply, ventilation, air conditioning, gas supply and lighting | **Training program code**  08.06.01 |
| **Level of training**  the highly qualified personnel |
| **Federal State Educational Standard** | **The Ministry of Education and Science of the Russian Federation approval FSES HE order details:**  July 30, 2014 No. 873  (revised April 30, 2015) |

**Ekaterinburg**

**2018**

1. **GENERAL CHARACTERISTICS OF THE course**

**Mathematical Modeling Of Heat And Mass Transferring**

* 1. **Abstract of the course content**

Main goal of the course is to give students an introduction to the ideas and methods of mathematical physics, to form the skills of working with mathematical and physical literature, the experience of solving physical problems by using mathematical methods, and clarify the peculiarities of connection between the properties of mathematical objects and the properties of real physical systems.

**1.3. Planned learning outcomes**

After mastering this discipline, the graduate student must acquire the following competencies:

* willingness to join Russian and international research teams to take part in researches solving scientific and scientific-educational problems (UC-3);
* readiness to use modern methods and technologies of scientific communication in native and foreign languages ​​(UC-4);
* the ability to follow ethic standards in professional activities (UC-5);
* the ability to plan and solve the tasks of one's own professional and personal development (UC-6).
* possession of the methodology of theoretical and experimental research in the field of construction (GPC-1);
* owning the culture of scientific research in the field of construction, including using the latest information and communication technologies (GPC -2);
* the ability to observe norms of scientific ethics and copyrights (GPC -3);
* the ability to use modern research equipment and instruments professionally (GPC -4);
* the ability to present the results of research professionally in the form of scientific publications and presentations (GPC -5);
* the ability to develop new research methods and their application in independent research and development activities in the field of construction (GPC -6);
* the ability to develop physical and mathematical models of objects and processes in the design of engineering structures, structures and processes (PC-1);
* the ability to analyze and synthesize engineering structures, technologies and structures, and develop existing methods for their calculation and optimization (PC-2);
* knowledge of software and programming languages ​​in the field of design and engineering, means of automated product, systems and processes design (PC-3);
* the ability to develop and improve contamination, technology of production and use of building materials, products and structures (PC-4).

After mastering this discipline, the graduate student must to:

Know:

- basic physical properties of liquids and gases;

- laws of conservation and transformation of energy in relation to systems of transmission and transformation of heat;

- laws and basic physico-mathematical models of heat transfer and mass transfer in relation to energy, heat engineering and heat engineering installations and systems;

Be able to:

- analyze the results of solving specific problems in order to build more advanced models and develop methods for their implementation;

- calculate the hydrodynamic parameters of the flow of liquid (gas) with external flow around bodies and flow in channels (pipes);

- calculate the transmitted heat fluxes;

- calculate the temperature fields (fields of substance concentrations) in the flows of process fluids and gases, in the elements of the designs of heat and heat engineering plants in order to intensify heat and mass exchange processes, ensure a normal temperature regime of the equipment elements operation and minimize heat losses;

- analyze scientific publications independently;

Be capable of (demonstrate skills and experience):

- using methods of differentiation, integration of functions, basic analytical and numerical methods for solving algebraic and differential equations and their systems;

- knowing the basis for calculating the processes of heat and mass transfer in the elements of heat and heat engineering equipment;

- operating with the main methods of measuring, processing the results and estimating the measurement error.

**2. COURSE CONTENTS**

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| **Code** | **Section, topic** | **Contents** |
| **Р1** | Processes of heat and mass transfer and their mathematical description. Equationsof heat conduction (diffusion) and their classification | Basic equations of mathematical models of heat and mass transfer processes. Empirical regularities of Fourier and Fick. Paradoxes of the classical theory of heat conduction. Wave equations for non stationary heat and mass transfer. |
| ***Р2*** | The concept of fractal formulation of transport equations and methods of fractional differentiation. | Operations of fractional differentiation and their application to a new formulation of transfer problems. Approximate solution of the problems of thermal conductivity (diffusion) using the apparatus of fractional differentiation. |
| ***Р3*** | Approximate analytical methods for solving heat and mass transfer problems. Variational formulation of the problems of heat conduction and diffusion. Direct methods for solving variational problems. | Fundamentals of the calculus of variations. Variational functional in heat conduction problems. Variational formulation of boundary conditions. The concept of local potential with respect to the variational formulation of nonstationary problems. The Ritz, Treftz, Kantorovich, Bubnov-Galerkin’s methods. |

**7 METHODICAL AND INFORMATION SUPPORT**

## 7.3.Software

1. Microsoft Excel.
2. Internet Explorer browser
3. Graphics editing Compas 8-12
4. MathCad 2014

**7.4. Search systems and information and reference systems**

1. proekt-gaz.ru/load/4
2. gumarika.kz/publ/perechen
3. normativa.ru/content/view/283/33

**7.5. Electronic educational resources**

<URL:http://lib.urfu.ru/>

**8 base of materials for current academic performance Evaluation and interim assessment**

**8.2.4. Sample credit questions**

1. Schematic diagrams of systems of water, steam, air, radiant, gas and furnace heating. Central and local heating systems. Modern and perspective heating systems for buildings of various purposes.

2. Hydraulic mode of the systems, calculation of gravity and pumping systems of water heating. Thermal regime for panel-radiant heating.

3. Starting and operational qualitative and quantitative regulation of heat transfer by heating systems, accounting for heat consumption. Energy saving in the design and operation of heating systems.

4. Use of non-traditional energy sources.

5. Sanitary and hygienic and technological basis of ventilation. Classification of ventilation systems.

6. Properties of moist air as a working body of ventilation processes. Thermal, humid and gas modes of the ventilated room. Required and calculated air exchange in the room for major hazards: heat, moisture, gases, dust. Non-stationary mode of ventilated room.

7. Aerodynamic basis for the organization of air exchange in the room. Aerodynamic characteristics of supply and exhaust jets. The movement of air near the exhaust and supply holes. Convective streams.

8. Basic provisions for the design of building ventilation systems.

9. Aerodynamic calculation of ventilation systems with gravitational and mechanical motivation of air movement.

10. Devices for air heating and heat recovery. Schematic diagrams, classification, constructive device and calculation.

11. Aerodynamic characteristics of the building, modeling of the aerodynamics of the building and industrial sites.

12. Fundamentals of methods for calculating the dispersion of harmful emissions in the atmosphere. Ecological evaluation of systems.

13. Models of heat and mass transfer in air conditioning units, limiting equilibrium states.

14. Air conditioning processes in central and local air conditioning systems (SLE). Schematic diagrams and solutions of SLE in buildings for various purposes. Methods of calculation.

15. Cold and heat supply of central, local and central-local SLE.

16. Assessment of the efficiency and feasibility of heat recovery systems. Design features and methods for selecting devices for heat recovery.

17. Justification of the choice of schemes for connecting local heating systems, hot water supply and ventilation to external heating networks. Calculation of heat exchangers for heating and hot water supply systems. Selection of methods and regulation of heat supply:

18. Technical and economic calculation of pipeline diameters. Reliability of heat networks, basic concepts and reliability indicators.

19. Schemes, designs and equipment of heat networks. Elements of heat pipes, their calculation and selection.

20. Basic physical and chemical properties of combustible gases used for gas supply. Processing and main gas transportation.

21. Schemes of urban gas supply systems. Construction, equipment and installation of gas pipelines. Protection of gas pipelines against corrosion.

22. Norms and graphs of gas consumption. Regulation of uneven consumption. Determination of estimated gas flow.

23. Hydraulic calculation of gas networks. Calculation of flow distribution in ring networks. Reliability of gas networks, basic concepts and reliability criteria.

24. Industrial and in-house gas supply systems, device, classification, selection of design parameters and feasibility study of schemes.

25. Liquefied hydrocarbon gases, their main properties. Technological scheme and basic equipment of gas distribution stations.

26. Theoretical basis of gas combustion. Chemical balance of the combustion reaction. The main provisions of the theory of chain ignition. Propagation of a flame in laminar and turbulent flows.

27. Heat balance of air in the room. Complete system of heat transfer equations in the room.

28. Stationary and non-stationary heat transfer through a fence, calculation methods.

29. Breathability of building materials and structures. Air mode of the building. Heat transfer through fences in the presence of air permeability fences.

30. Fundamentals of the thermodynamics of moist air. Accounting for the moisture regime in the calculation of heat transfer through the fence.

31. Heat and mass transfer in external fences. Methods of calculation.

32. Winter and summer heat regimes of residential, public, industrial and agricultural buildings, calculation and regulation. Heat resistance of the room.

33. Methods for calculating energy consumption and energy savings in the operation of buildings. Development and optimization of space-planning and structural solutions of buildings taking into account the processes occurring in them and the natural and climatic conditions.