Course Description

Discipline/Course: Thermophysical phenomena in modern technologies
The Basic Educational Program specialty: Mechanical engineering

Department of High Technology Physics in Mechanical Engineering
Instructor: Anna G. Knyazeva, Professor
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Learning Outcomes:
After studying this discipline, the student must know the mechanisms of heat transfer in solid, liquid and gaseous media, the form of recording the heat equation in various coordinate systems, must know and be able to formulate possible variants of boundary conditions, to know such concepts as stationary problem, non-stationary problem, heat capacity, density , thermal conductivity; Must know the basic concepts and definitions of the theory of phase transitions and formal chemical kinetics, master engineering methods for constructing solutions to thermophysical problems and problems similar to them; Should be able to use the resulting analytical solutions, be able to analyze them; Should understand the criteria for similarity and the possibilities of the method of analysis of dimensions; Must know for what type of technology the thermophysical methods of description are applicable.

Course Objectives and Content:
To give students the necessary theoretical knowledge on modern high-temperature technologies, their mathematical modeling; Teach students, formulate the thermophysical tasks necessary for the analysis of high-temperature technological processes; Identify the main physical phenomena in the formulation of tasks, apply engineering methods to obtain the simplest estimates, and understand what methods are required to solve problems. The course is focused on preparing students for research work.

Course Outline:

1. Modern high temperature technologies. Energy sources. Main characteristics of heat transfer. Units. The ratio of heat transfer to thermodynamics. Heat capacity. The production of entropy. - 2 hours
2. Mechanisms of heat transfer: thermal conductivity, convection, radiation. The concept of mass exchange. Thermal conductivity in various media. The Fourier law. Coefficient of thermal conductivity. Dependence of thermophysical properties on temperature. Equation of heat conductivity. Formulation of boundary conditions. Particular examples. - 2 hours
3. Convective heat transfer. Newton-Richmann law. Application of the theory of similarity to the study of heat transfer. Examples of calculation of heat transfer coefficients - 2 h.
4. The equation of thermal conductivity in different coordinate systems. Equations of heat conductivity for bodies of canonical form. Stationary problems of heat conductivity in different coordinate systems. Critical diameter of thermal insulation. - 2 hours
5. Heat exchange by radiation. Basic laws of thermal radiation. Radiant heat exchange between bodies. Complex heat transfer. Features of the impact of various energy sources on materials. - 2 hours
6. Nonstationary problems of heat conduction. Problems with boundary conditions of the first, second, third kind; Related problems. Types of effective heat sources are distributed and point, fixed and mobile, constant and time-dependent, volumetric and superficial. - 2 hours
7. Heat transfer in the processes of melting and crystallization. Stefan's tasks. The concept of the theory of a two-phase zone. - 2 hours

8. Heat transfer in systems with chemical reactions. Chemical sources of heat. Physical classification of chemical transformations. Mass transfer. Mechanisms of diffusion in gases, liquids and solids. Thermodiffusion and diffusion heat conductivity. Multicomponent diffusion. - 2 hours
9. Examples of simplified models of high-temperature technological processes of oxygen and laser cutting, arc welding, electron-beam and electroslag surfacing, diffusion soldering, heat treatment using various energy sources (selectively). - 2 hours

Course Delivery: one semester, 16 hours of lectures, 16 hours of laboratory work.

Prerequisites: To successfully master the discipline, the student must know the fundamental foundations of the courses: "Higher Mathematics" - know the simplest methods of solving the ODE; Integral and differential calculus, "Physics", "Informatics" - must own any application package (for example, MATHCAD)

Final Assessment: pass/fail exam

Course Developer: Anna G. Knyazeva, Professor