Syllabus of the educational component

Program of educational discipline

Resource-saving technologies and melting of alloys with special properties

Specialty
131 – Applied mechanics

Institute
NNI of Mechanical Engineering and Transport

Educational program
Applied mechanics. Computerized foundry production, artistic and jewelry casting

Department
Foundry production (142)

Level of education
Master's degree

Course type
Special (professional).

Semester
1

Language of instruction
Ukrainian, English

Lecturers and course developers

Olga Ivanivna Ponomarenko,

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doctor of technical sciences, professor of the department of foundry production of NTU "KhPI"

Work experience - 35 years. the author of more than 380 scientific and educational and methodological works, of which 20 are of an educational and methodological nature, 8 methodological manuals with the stamp of the Ministry of Education of Ukraine, 1 textbook, 3 monographs and 17 author's certificates and patents.
Courses:"Forming materials and mixtures", "Theory of the formation of castings", "Physico-chemical foundations of foundry production", "Working processes of modern productions", "Design of cast products and equipment", "Additive technologies in foundry production"
Learn more about the teacher on the department's website

General information

Summary

The course of lectures contains extensive information about non-ferrous alloys that are actively used in industry today for the production of castings, such as titanium, nickel, magnesium, copper, and zinc alloys. Information is provided on the general principles of developing foundry alloys, charge calculation methods. The overview of specific groups of alloys is based on the fundamental concepts of the theory of state diagrams. The general characteristics of alloys and their interactions with other elements are given. For each group of alloys, the physico-chemical and technological bases of smelting are laid out, options for their production in modern smelting units are given. The entire cycle of obtaining castings from these alloys is considered, from the molding mixtures used for the production and the technological process of obtaining the alloy to pouring the metal into the mold.

Course objectives and goals

The purpose of the course- to give future specialists knowledge on the technology of production of castings with special properties, from the selection and preparation of the alloy to obtaining high-quality castings in the form.

As a result of studying the course, the student should know:

- principles of development of foundry alloys;
- to be able to choose an alloy depending on the needs of the reserve;
- develop a melting technology for a specific melting unit;
- calculate the charge; to develop a technological process for obtaining castings;
- choose the method of its manufacture, choose the material of the form and rods;
- justify the chosen technological process from an economic point of view.

Format of classes

Lectures, laboratory and practical works, pcalculation task,independent work, consultations. Final control -exam.

Competencies

GC1. Ability to identify, pose and solve engineering and technical and scientific and applied problems
GC2. Ability to make informed decisions.
GC5. Ability to develop and manage projects.
GC8. Ability to learn and master modern knowledge
FC1. The ability to apply specialized conceptual knowledge of the latest methods and techniques of designing and researching structures, machines and/or processes in the field of mechanical engineering.
FC3. Application of appropriate methods and resources of modern engineering based on information technologies to solve a wide range of engineering problems using the latest approaches, forecasting methods with awareness of the invariance of solutions.
FC7. Ability to describe, classify and model a wide range of technical objects and processes, based on deep knowledge and understanding of mechanical theories and practices, as well as basic knowledge of related sciences.
FC8. The ability to generate new ideas and the ability to substantiate new innovative projects and promote them on the market.
FC11. The ability to plan and carry out experimental research, to process the results of the experiment based on the use of modern information technologies and microprocessor technology, to interpret the results of natural or model experiments.

Learning outcomes

LR1. Apply specialized conceptual knowledge of the latest methods and techniques of design, analysis and research of structures, machines and/or processes in the field of mechanical engineering and related fields of knowledge.
LR 2. Develop and put into production new types of products, in particular, perform research and design work and/or develop technological support for the process of their production.
LR 5. Independently set and solve problems of an innovative nature, argue and defend the obtained results and decisions.
LR 10. Search for necessary information in scientific and technical literature, electronic databases and other sources, assimilate, evaluate and analyze this information.
LR 11. Plan and carry out experimental and theoretical research in the field of applied mechanics, analyze their results, substantiate conclusions. (1.9).
LR 11 Develop managerial and/or technological solutions under uncertain conditions and requirements, evaluate and compare alternatives, analyze risks, predict possible consequences. (1,4)
LR 18. Demonstrate knowledge and understanding of the basics of organizing the research (scientific) process.

Student workload

The total scope of the discipline is 180 hours. (6 ECTS credits): lectures – 48 hours, laboratory work – 16 hours, practical work – 16 hours, independent work – 100 hours.The course provides ppreparation of a calculation task on an individual topic.

Course prerequisites

To successfully complete the course, you must have knowledge and practical skills in the following disciplines: "Chemistry", "Ecology","Forming materials and mixtures", "Theory of the formation of castings","Fundamentals of the theory of foundry alloys", "Foundry alloys and smelting technology", "Furnaces of foundry shops".

Features of the course, teaching and learning methods, and technologies

Lectures are conducted interactively using multimedia technologies. The classes use a project-based approach to learning, game methods, and focus on
application of information technologies in the industrytechnologies for the production of castings with special propertiesand physical and chemical foundations of foundry production. Study materials are available to students through OneNote Class Notebook.

Program of the course

Topics of lectures

Introduction.Meaning and tasks of the discipline. Literature.

Topic 1.Classification of foundry alloys
General classification of foundry alloys with special properties by properties, composition, purpose. General requirements for foundry alloys.
Principles of development of foundry alloys. Alloy components (basic elements, alloys, modifying additives, impurities). Synthesis of alloys.
Topic 2.Nickel alloys.
General characteristics of nickel and its interaction with other elements. Influence of elements: carbon, sulfur, magnesium, lead, bismuth, antimony, arsenic, phosphorus, oxygen on the properties of nickel alloys. Interaction of nickel with alloying elements. Marking. Corrosion-resistant, heat-resistant, heat-resistant nickel alloys. Corrosion-resistant alloys of the Ni-Cu, Ni-Cu-Sn, Ni-Si type. Properties, advantages, disadvantages, application.
Heat-resistant Ni-Cr alloys. Alloying, properties, advantages, disadvantages, application. Heat-resistant alloys. Alloying. Microstructure of heat-resistant alloys. Properties, advantages, disadvantages, application.
Melting of nickel alloys. Features of melting. Stacking and loading sequence. Melting furnaces. Vacuum, induction, arc, lining. Process sequence of different furnaces. Fluxes, deoxidizers. Melting in low- and high-frequency induction furnaces. Refinement. Melting in arc furnaces.
Features of the production technology of shaped castings from nickel alloys. Requirements for core and molding mixtures. Calculation of shower systems. Refrigerators, applications. Lithuania in sand molds, in ceramic molds and on models that are melted.
Topic 3.Refractory metals and alloys.
Classification by temperature, density, location in the earth's crust, etc. Properties, application.
Topic 4.Alloys for castings based on titanium, properties. Modifications of titanium, chemical activity, interaction with gases O2, N2, H2, C, water vapor. Action of Fe, Si. Application. The influence of alloying elements on the properties of Ti alloys. Classification of Ti α-alloys. Marking. Foundry properties: fluidity, shrinkage, formation of defects. Characteristics of the most frequently used alloys VT5L, VTZ-1L.
Melting of titanium alloys. Features. Melting furnaces: vacuum-arc, electro-beam and plasma. Melting in vacuum-arc garnish furnaces for shaped castings. Use of graphite crucibles. Shihtovka Melting mode. Ugar elements. Production of castings in vacuum-arc furnaces. Shihtovka Production of expendable electrodes.

Materials, manufacturing process by pressing and sintering. The sequence of melting with a consumable electrode.
Features of the production technology of shaped T-castings. Requirements for different groups of Ti castings. Manufacturing difficulties. Disposable high-refractory stamped and ceramic molds, metal and graphite molds. Scheme of the technological process for casting in disposable forms. Magnesite graphite mixtures. Binders The mechanism of solidification of mixtures. Duration of mixing. Production of forms from graphite mixtures. Their strengthening due to firing and the presence of catalysts. Firing mode. Cooling forms. Production of molds from graphite mixtures by casting according to models that are melted. Shell forms. Designing technology for manufacturing castings from Ti-alloys. Sprinkler systems, applications, their sizes.
Topic 5.Copper alloys. General characteristics of Cu and its interaction with other elements. Marking of copper alloys. Foundry bronzes. Tin bronzes. Mechanical and foundry properties of bronze. Lead bronzes. Al-bronzes.
Foundry brass. Mechanical and foundry properties of brass.
Melting of copper alloys. Refinement. Melting technology. Ligatures, their preparation. Melting of double and multi-component brass. Melting of tin-free bronzes, lead, beryllium, siliceous bronzes. Modification. Development of the technological process of melting bronze or brass of a certain brand. Deoxidation of copper.
Evaluation of the effectiveness of various methods of refining Cu-alloys from non-metallic inclusions.
Topic #6.Magnesium alloys. General characteristics of Mg and its interaction with other elements. Interaction with alloying elements: cadmium, lithium, zirconium, cerium, La, Nd, Th, Mn. Classification of magnesium casting alloys. Marking. Alloys of the Mg-Al-Zn system (ML4, ML5, ML6), Mg-Zn-Zr-Me (ML-8, ML12, ML15, ML17), Mg-Nd-Zr (ML9, ML10, ML19), Mg-P3M -Zr (Ml11). Technological, foundry, mechanical properties.
Melting of magnesium alloys. Physico-chemical characteristics of the process. Methods of protecting the melt from interaction with the gas atmosphere. Methods of refining Mg alloys. Melting technology. Furnaces Modification. Melting in crucible furnaces.
The technology of melting Mg-alloys due to the remelting of lump alloy with the addition of reverse. Melting of Mg alloys in 2 stages: preparation of preliminary and working alloys. Features of pouring Mg alloys.
Study of the effectiveness of various methods of refining Mg alloys from oxide or slag inclusions. Study of the effectiveness of chalk and hexachloroethane in the modification of alloys of the magnesium-aluminum-zinc system.
Topic 7.Zinc casting alloys. General characteristics of zinc, application. Alloying elements, marking. Zn-Al, Zn-Cu system alloy. Technological, mechanical and foundry properties.
Melting of zinc alloys. Refinement.
Topic #8.Jewelry casting, bearing alloys, stone casting... Production of castings from gold, silver, platinum
Bearing alloys. Requirements, classification, structure and properties of bearing alloys. Alloys based on tin, lead, lead-tin, cadmium, zinc, Al, Cu and Fe. Metal-ceramic and antifriction materials. Lithuania from non-metallic materials. Plastics. Application, properties. Stone casting. Application, properties. Raw materials, composition and properties of castings. Production of stone casting from diabase, basalt, light stone, slag.

Topics of laboratory and practical classes

Topic 1.Methods of calculating the charge for smelting foundry alloys with special properties. Analytical method, method of sequential adjustment.
Topic 2.Deoxidation of copper.
Topic 3.Evaluation of the effectiveness of various methods of refining Cu-alloys from non-metallic inclusions.
Topic 4.Study of the effectiveness of various methods of refining Mg alloys from oxide or slag inclusions.
Topic 5.Study of the effectiveness of chalk and hexachloroethane in the modification of alloys of the magnesium-aluminum-zinc system.

Self-study

The course providescalculation task on an individual topic.
On the basis of the specified alloy grade of the casting and the chemical composition of the metal:
1. Describe the physical and chemical properties of the alloy.

2. To develop a technological process of melting an alloy with special properties.
3. Calculate the alloy charge.
4.. Provide a list of used literature
Students are also recommended additional materials for independent study and analysis.

Course materials and recommended reading

Basic literature

1. Metallurgy of rare metals: textbook / I.F. Chervony, I.V. Pitak, O.I. Ponomarenko and others. - Kharkiv: "Madrid Printing House", 2019. - 162 p.
2.Pelikh V.F. Physico-chemical foundations of foundry production: Training. Guide / V.F. Pelikh - K.: ISDO, 1996. -156 p.
3. Sabirzyanov T.G. Thermotechnics of foundry processes [Text]: study guide / T.G. Sabirzyanov, V.M. Kropivny - Kirovohrad: KRTU, 2005. - 402p.

Additional literature

1. Methods of calculating the charge for melting foundry alloys. A systematic approach. Education manual/V.F. Pelikh, O.I. Ponomarenko, A.V. Nikiforov - K.: ISDO, 1998. - 72 p.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

100% of the final grade consists of evaluation results in the form ofexamin (40%) and current assessment (60%).

Exam: written task (2 questions from theories) and an oral report.
Current assessment: 2 modular control and calculation task(20% each).

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": show discipline, education, benevolence, honesty, responsibility. Conflict situations should be openly discussed in study groups with the teacher, and if it is impossible to resolve the conflict, it should be brought to the attention of the employees of the institute's directorate.
Regulatory and legal support for the implementation of the principles of academic integrity of NTU "KhPI" is posted on the website:http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by

22.08.2023

Date, signature

Head of the department
Oleg AKIMOV

22.08.2023

Date, signature

Guarantor of the educational program
Oleksandr SHELKOVY