**INDUSTRIAL HEAT POWER ENGINEERING**

1. GENERAL DESCRIPTION OF THE DISCIPLINE

The work programme of the discipline is compiled according to the Federal State Higher Professional Education Standards

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| Code of the field of study and attainment level | Field of study | Details of the order of the Ministry of Education and Science of the Russian Federation on approval and commissioning of the Federal State Higher Educational Standard |
| Date | Number of order |
| 13.06.01 | Electrical- and Thermal Engineering | 30 July 2014 | 878 |

* 1. Abstract of the discipline content

Industrial heat power engineering refers to a technology part that includes a set of human activity tools, methods and techniques designed to develop and apply installations and systems that produce, transform, distribute and consume energy carriers that support the operation of industrial enterprises. The purpose of studying the discipline for post-graduate students is to acquire additional knowledge in the field of thermodynamics and heat-and-mass transfer, the main energy-saving technological processes for the production of heat and heat transfer with minimal heat losses.

* 1. Discipline mastering outcome requirements

As a result of mastering the discipline, a postgraduate student should obtain the competences as follows:

* the ability to formulate tasks for the development of design solutions related to upgrading the process equipment, measures to improve performance, improve environmental safety and save resources (Professional Competence-2);
* the readiness to use in the practical activities the theoretical foundations of working processes in power machines, units and installations, the methods for the calculating analysis of professional activity items (Professional Competence-5);
* the readiness on the basis of a systematic approach to build and use models to describe and predict various phenomena, to carry out a qualitative and quantitative analysis of them (Professional Competence-6);
* the ability to understand contemporary problems of the scientific and technical development of power engineering, know up-to-date energy and resource saving technologies (Professional Competence-7);
* the ability to assess the technical condition of professional activity facilities, analyse and develop recommendations for their further operation (Professional Competence-8).

As a result of mastering the discipline, a postgraduate student should:

Know:

* modern requirements for installations producing heat;
* economic indicators of sources of useful energy;
* technological schemes of heat production, schemes and designs of process units, their auxiliary equipment;
* methods for predicting the reliability of the equipment, systems and their components in operation;
* Modern methods of diagnostics of the state of heat power equipment, maintenance of installed main and auxiliary equipment of the thermal part of the heat technological facilities of enterprises, heat networks.

Be able:

* to determine the thermodynamic cycle parameters and the thermal efficiency indicators of equipment;
* to analyse the quantitative effects of various factors on the economy of heat production sources;
* to adjust and conduct thermal tests and determine the operability of the installed and repaired equipment with the development of a draft process flow diagram;
* to choose new state-of-the-art equipment in terms of energy saving based on the use of rapid analysis of the thermal and hydraulic calculation results in the field of design and information technology.

Demonstrate skills and experience:

in the field of calculations, testing and research of thermal networks, fuel supply systems and the equipment of power terminals.

## 1.3 Scope of the discipline

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| **Types of educational activity, forms of control** | **Total, hours** | **Term number** |
| **6** |
| **In-class learning, hours** | 4 | 4 |
| Lectures, hours | 4 | 4 |
| Practical exercises,hours | - | - |
| Laboratory research,hours | - | - |
| **Self-guided** **of graduate students, hours** | 104 | 104 |
| **Type of** **interim attestation (test, exam)** | - | Exam |
| **Total work input by curriculum, hours** | 108 |
| **Total work input by curriculum, credits** | 3 |

**2. DISCIPLINE CONTENT**

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| **Section and subject code** | **Section, subject of****the discipline** | **Content** |
| **1** | Section I.Industrial heat and mass transfer units and installations. | Main issues (to be considered by post-graduate students on their own): Heat and mass transfer in units and installations. The convective heat and mass transfer. The Fourier’s and Fick’s laws. The bases of the boundary layer theory. Internal tasks of the heat and mass transfer. Heat transfer during phase transformations. The heat transfer mechanism during local boiling. Film and droplet condensation. Heat and mass transfer upon evaporation of liquid into the vapour-gas medium and in the sublimation processes.Radiation heat transfer. The radiation and absorption laws. Heat exchange by radiation in solids systems separated by transparent and absorbing media.The classification and use of heat and mass transfer units. Classification by design characteristics, types of coolants and the method of contact between them. The design perfection, operational and economic performances. The heat and hydrodynamic characteristics of heat exchangers. Recuperative, regenerative and mixing heat exchangers. Their application and calculation methods. The periodic and continuous action devices.Rectification installations. Basic conditions for the distillation of binary and multi-component mixtures. The Raoul, Dalton and Henry laws. Rectification process schemes. Types and features of distillation columns. The methods of calculation and selection of equipment for rectification plants.The heat-and-mass transfer processes in drying installations. The features of internal and external heat-and-mass transfer for various wet material heating methods.Heat transfer and mass transfer coefficients. The physical essence of the convective, contact, radiation and other methods of drying materials. Types of drying installations and their design procedures.Refrigeration and heat transformers. Refrigerants and coolants. Methods and levels of obtaining artificial cold. The schematic diagrams of compression, absorption and vapour-jet refrigerating plants. Their economic, energy and operational characteristics. Heat transformers, their types and purpose. Equipment element design procedures. Heat pumps. |
| **2** | Section II.Heat supply systems for industrial enterprises | Main questions (to be considered by post-graduate students on their own): Energy efficiency of heating. District heating systems for industrial enterprises and districts. The flow charts of heat sources and heat supply systems. Energy and technical and economic assessment of steam and water as coolants.The mode for regulating district heating. The thermal characteristics of heat exchangers and plantsThe hydraulic mode of heat supply systems. The hydraulic characteristics of the system and methods for determining it. The hydraulic stability of the system. A calculation of flow distribution in ring networks and networks supplied by several sources. The hydraulic impact and its calculation and prevention methods.The equipment of thermal substations. Schemes, devices and methods for calculating condensate collection facilities. Schemes and methods for calculating steam-water and water-water heating installations. Mixing units, their characteristics and calculation methods. The protection of heat supply systems against corrosion, sludge and scale. The technical and economic calculation of heat supply systems. The heat supply system optimisation methods. The determination of unit investment in installations and district heating systems. The determination of the annual fuel costs. The determination of estimated costs and operating costs. |
| **3** | Section III.Secondary energy resources (SER) and bases of energy-technological combination | Main questions (to be considered by post-graduate students on their own): Flammable secondary energy resources (SER). Gaseous combustible SER. Fire detoxification of combustible slurries of the metallurgical productions. Water-tube boilers. Gas-tube boilers. The thermal calculation of tube boilers. Tube boilers for iron pyrite roasting furnaces. Dry coke quenching plants. The thermal balance of a coke dry quenching plant. Determination of the volume of a dry coke quenching chamber. Tube boilers converter gas cooler. Energy-efficient combination in rolling production. A black-liquor recovery unit. An energy technological combination in the production of hydrogen. Energy combining in blast-furnace production. The main types of CCGT. The thermal efficiency of CCGT. The quantitative indicators of thermodynamic cycles of CCGT. CCGT with steam injection. The relationship between the parameters of the gas and steam cycle in the CCGT. Utilisation of the heat of contaminated liquids in the instant boiling apparatus. Corrosive liquid cooling. Wet air and moist combustion products of natural gas. Determination of the temperature of a wet thermometer. Determination of the temperature of the dew point. Contact heat exchangers with ceramic packing. A calculation of the contact heat exchanger with ceramic packing. A gas turbine expansion plant. Energy saving in boiler houses. Energy saving in boiler and heating networks. The systems for infra-red heating of premises. |

**3. EVALUATION MEANS**

Based on the results of studying the discipline, an examination is conducted, which is a candidate in the specialty.

**List of sample questions for the exam**

1. Definition and classification of heat transformers (PC-7).

2. Energy value of heat and cold (PC-2, PC-5).

3. Scheme and process of operation of an ideal steam-compression heat transformer (PC-5).

4. Scheme of a real vapour-compression heat transformer and processes that determine its cycle (PC-5).

5. Construction of a real cycle of a single-stage vapour-compression heat transformer in thermal diagrams *T-S, i-S* (PC-5).

6. Comparison of schemes and processes of the ideal and a vapour-compression heat transformer (PC-5, PC-6).

7. Comparison of unit operating costs for ideal and real vapour-compression heat transformers with equal temperatures for the upper and lower sources (PC-5, PC-6).

8. Calculation of a real vapour-compression single-stage refrigeration machine (PC-5).

9. Calculation of a real vapour-compression single-stage heat pump (PC-5).

10. Equation of heat balance and transformation coefficients of a vapour-compression heat transformer (PC-5).

11. Analysis of the efficiency of using single-stage and two-stage heat pumps in heat supply systems (PC-6).

12. Methods for regulating the power of heat transformers (PC-7).

13. An ideal gas cycle of a heat transformer with heat exchange by isobars (PC-5).

14. Real gas cycle of the heat transformer (PC-5).

15. Regeneration of heat in an ideal gas cycle (PC-5).

16. Comparison of ideal and real gas cycles of heat transformers (PC-5).

17. Comparison of energy costs in the ideal and real gas cycles at equal temperatures of the lower and upper sources (PC-5, PC-6).

18. Regeneration of heat in a real gas cycle of a refrigerating machine (PC-5).

19. A gas chiller with open cycle under supercharging (PC-5).

20. The open cycle of a gas refrigerating machine under vacuum (PC-5).

21. An ideal absorption heat transformer (PC-5).

22. Comparison of the ideal and real single-stage absorption heat transformers (PC-5).

23. Real single-stage absorption heat transformer with a two-stage generator (PC-5).

24. The operation scheme of a lithium-bromide absorption unit (PC-5).

25. The operation of a real batch absorption unit (PC-5).

26. Hydrocarbon gases: basic concepts, laws and relationships (PC-5).

27. Norms of consumption and modes of consumption of hydrocarbon gases (PC-8).

28. the structure of the gas transportation system (PC-8).

29. Gas supply schemes for enterprises from urban gas pipelines (PC-8).

30. Gas supply to workshops. Requirements for units using gas fuel (PC-8).

31. Gas equipment for boilers (PC-2, PC-8).

32. Gas equipment for drying plants (PC-8).

33. The application of infrared radiation gas burners for heating (PC-2, PC-8).

34. Features of gas supply to GTU, CCGT and GPA (PC-8).

35. Basic natural gas liquefaction schemes (PC-5).

36. LNG regasification plants (PC-5).

37. LPG regasification methods. LPG regasification plants (PC-5).

38. LPG preparation for combustion in boilers (PC-5).

39. Safety rules in the gas economy (PC-2).

40. Surging and ways to deal with it (PC-8).

41. The operation of blade propellers on the network. Parallel and series connection of superchargers (PC-8).

42. Axial and radial forces in centrifugal superchargers. Compensation methods (PC-5).

43. The composition and principle of operation of rotary superchargers (PC-5).

44. The composition and principle of operation of jet superchargers (PC-5).

45. Compressor process. Methods of increasing the energy efficiency of gas compression (PC-5).

46. Multistage compression. Selection of the optimum degree of pressure increase in a multi-stage compressor (PC-5).

47. Cooling of compressor machines (PC-8).

48. Compressor efficiency (PC-5).

49. Principal diagram, operating principle and scope of reciprocating compressors (PC-5).

50. Indicator diagram of a reciprocating compressor (PC-5).

51. Operating parameters of reciprocating compressors (PC-5).

52. Basic design diagrams of reciprocating compressors (PC-8).

53. Centrifugal compressors. Diagrams, operating parameters and scope (PC-5).

54. Screw compressors. Diagrams, operating parameters and scope (PC-5).

55. Diagram of a screw compressor unit (PC-5).

56. Axial compressors. Diagrams, operating parameters and scope (PC-5).

57. Cavitation in pumps. The effect of cavitation on the pump characteristics (PC-8).

58. Calculation of the permissible pump suction height (PC-5).

59. Classification and application of pumps in power engineering (PC-8).

60. Designs and operating parameters of general-purpose pumps (PC-8).

61. Designs and operating parameters of feed pumps (PC-8).

62. Designs and operating parameters of condensate pumps (PC-8).

63. Designs and operating parameters of network pumps (PC-8).

64. Designs and operating parameters of circulating pumps (PC-8).

65. Methods for regulating vane pumps (PC-8).

66. Classification and application of fans in power engineering (PC-8).

67. The main structural elements and operating parameters of centrifugal fans (PC-8).

68. Self-protection of the ventilation system and its effect on the parameters of the draught systems (PC-8).

69. Principle of operation and basic elements of the turbine stage (PC-5).

70. Thermodynamic process of the turbine stage. Energy conversion into stages (PC-5).

71. Active and reactive stages of the turbine. Degree of stage reactivity (PC-5).

72. Regulating stage of a steam turbine. Partial steam supply. The degree of partiality (PC-8).

73. Advantages of multi-stage turbines (PC-8).

74. Operating modes of the steam turbine. Turbine operation with variable mode (PC-8).

75. Regulation of steam turbines (PC-8).

76. Static regulation characteristic (PC-8).

77. Adjustable and unregulated steam sampling in a multi-stage steam turbine. Standard steam parameters (PC-8).

78. Heating. Heating turbines (PC-7).

79. Parameters of cost-efficiency of steam-turbine installations (PC-2, PC-8).

80. Methods for increasing the efficiency of the cycle of a steam-turbine plant (PC-2).

81. Combustible SER (PC-7).

82. Gaseous combustible SER (PC-7).

83. Fire detoxification of combustible slurries of metallurgical productions (PC-7).

84. Water-tube boilers (PC-7).

85. Gas-tube boilers (PC-7).

86. Thermal calculation of tube boilers (PC-5, PC-7).

87. A tube boiler for sulphur pyrite roasting furnaces (PC-7).

88. Installations for dry quenching of coke (PC-7).

89. Thermal balance of dry quenching of coke (PC-7).

90. Determination of the volume of the chamber for dry quenching of coke (PC-5, PC-7).

91. Tube boilers are converter gas coolers (PC-7).

92. Energy-technology combination in rolling production (PC-7).

93. A black-liquor recovery energy technology engineering unit (PC-7).

94. Energy-technological combination in the production of hydrogen (PC-7).

95. Energy technology engineering combining in blast-furnace production (PC-7).

96. The main types of vocational schools (PC-7).

97. Thermal efficiency of a CCGU (PC-7).

98. Quantitative indicators of thermodynamic cycles of CCGU (PC-7).

99. CCGU with steam injection (PC-7).

100. The relationship between the parameters of the gas and steam cycle in a CCGU (PC-7).

101. Low-pressure steam accumulators (PC-7).

102. High-pressure steam accumulators (PC-7).

103. Recovery of the heat of contaminated liquids in flash boilers (PC-7).

104. Cooling aggressive liquids (PC-7).

105. Moist air and moist combustion products of natural gas (PC-5).

106. Determination of the temperature of a wet thermometer (PC-5).

107. Determination of the dew-point temperature (PC-5).

108. Contact heat exchangers with ceramic packing (PC-7).

109. Calculation of the contact heat exchanger with ceramic packing (PC-5, PC-7).

110. Gas-turbine expansion plant (PC-7).

111. Energy saving in boiler and heating networks (PC-7).

112. Infra-red heating systems for premises (PC-7).

## Electronic educational resources

1. Zonal Scientific Library of UrFU http://lib.urfu.ru/

2. The Russian State Library http://www.rsl.ru/

3. The Russian National Library http://www.nlr.ru/

4. The State Public Scientific and Technical Library of Russia http://www.gpntb.ru/

5. Public Internet Library http://www.public.ru/

6. Students Library http://www.lib.students.ru/

7. Scientific Library of the St. Petersburg State University http://www.lib.pu.ru/

8. Scientific Electronic Library http://www.eLIBRARY.ru/