RTU Course "Theory of Boundary Layer"

15016 Siltumenerģētisko sistēmu katedra

General data

Code	MSE541
Course title	Theory of Boundary Layer
Course status in the programme	Compulsory/Courses of Limited Choice
Course level	Post-graduate Studies
Course type	Academic
Field of study	Heat Engineering, Heat, Gas and Water Technology
Responsible instructor	Turlajs Daniels
Academic staff	Jaundālders Sigurds
Volume of the course: parts and credits points	1 part, 4.0 Credit Points, 6.0 ECTS credits
Language of instruction	LV, EN, RU
Possibility of distance learning	Planned
Maximum auditorium capacity	50
Maximum number of students per semester	50
Abstract	Study course ``Theory of Boundary Layer `` is planned for extended studies of heat and mass transfer, fluid mechanics and aerodynamic theory and practical applications. The main emphasis is on the convective heat exchange and the related phenomena of flow mechanics. Basic topics: Hydrodynamic and thermal boundary layers. Laminar, transient and turbulent flows. Viscosity, compressible and incompressible flows. Differential equations of flow dynamics and heat mass transfer. Boundary layer evaluation and empirical relationships. Analytical and numerical methods for solving equations. Modeling and simulation methods. Empirical methods of heat exchange and flow mechanics.
Goals and objectives of the course in terms of competences and skills	Gain knowledge of the boundary layer theory of the key issues: hydrodynamic and thermal boundary layer, laminar and turbulent boundary layer. Skills of evaluation, calculus and empirical relationship application. Ability to use the boundary theory concepts for equipment thermodynamics, heat transfer and fluid mechanics calculations and design.
Structure and tasks of independent studies	Studies of specialized scientific and technical literature. Individual calculus and practical work. Elaboration of report (5000 printed signs) and presentation of boundary layer theory and applications in heat and mass transfer and hydro- and gas dynamics in processes and equipment.
Recommended literature	1.Lienhard J.H.,IY, Lienhard J.H.,Y. A Heat Transfer Handbook. 4-rd edition, Phlogiston Press, 2006, 760 p. http://web.mit.edu/lienhard/www/ahtt.html 2.Schlichting H, Gersten G. Boundary Layer Theory. 8-th Revised and Enlarged Edition, Springer, Heidelberg, Germany, 2000. 3.Tavoularis S. Measurement in Fluid Mechanics. Cambridge University Press, 2005 4.Ķirsis T., Lielpēters P. Fluidu mehānika. Rīga, 1999, 84 lpp. 5.Grivcovs V. Robežslāņa teorija. RTU TMF SES katedra, ESF projekts, 2006, 25 lpp. 6.Г.Шлихтинг.Теория пограничного слоя. М. Наука, 1974, 711с. 7.Н.В. Лыков. Теория теплопроводности. М. Высшая школа, 1967, 600с с ил. 8.В.П. Исаченко и др.Теплопередача. Учебник для вузов. Изд. 3-е, перераб. и доп., М.,Энергия ,1975, 488с. 9.Жукаускас А.А. Конвективный перенос в теплообменниках, М., Наука, 1982, 472 с. 10.Laboratorijas darbu apraksti. TMF SES katedra, 2007 – 2010. g.
Course prerequisites	Physics, technical termodynamics

Course outline

Theme	Hours
Types and main laws of heat transfer. Convective heat transfer. Overall heat transfer indexes.	2
Complex heat transfer. Enhancement of heat transfer rates. Design methods of heat exchangers.	6
Similarity of thermal, aero- and hydrodynamic, heat and mass transfer processes.	4
Classification of flows. Basic laws of viscous flows. Real and ideal liquids. Hagan – Poiseuille flow inside tube.	2
Basic elements of boundary layer theory. Boundary layer concepts. The main equations of flow dynamics.	4
Navier-Stokes equations, the common characteristics and solutions. Frictional resistance of flow.	4
Laminar boundary layers. Boundary layer equations for a flat surface. Compilations of boundary layer equations.	4
Axis symmetric and three-dimensional boundary layers E exact and approximate calculations of symmetric boundary layers.	2
The relationships between the axis symmetrical and planar boundary layer.	2
Temperature boundary layer (BL) of laminar flow, the properties in forced and free flow. Management methods of boundary.	4
Unsteady boundary layers (BL). Formation of BL in suddenly accelerated motion.	1
Periodical boundary layer. Compressible non-stationary boundary layer.	1
Laminar to turbulent flow transition movement. First formation of turbulence.	2
Laminar flow stability theory foundations, comparison with experimental data. Formation of the second turbulence.	2
An active force, the external effects of heat transfer and compressibility effects on the laminar to turbulent boundary	4

Turbulent flow elements. Averaged and pulsation movement.	4
Stability of boundary layer. Measurement turbulence fluctuations. Wind tunnels.	4
Turbulent flows in pipes, ducts, diffusers.	2
The relationship between resistance and speed of distribution. Surface form and roughness effects.	2
Turbulently BL without pressure gradient. Smooth and rough plates. Free turbulence. Reighardt equation.	2
Turbulently BL in compressible flow. The relationship between velocity and temperature distribution. Mach number.	2
Experimental methods of profile resistance measurements in flows. Losses of energy in blade grid.	4

Learning outcomes and assessment

Learning outcomes	Assessment methods
Ability to explain and analyze the heat and mass transfer, hydro-and aerodynamic processes taking place in nature and technological equipment in the terms and laws of boundary layer theory.	Assessment methods: Practical work, home calculation work, discussions, preparation and presentation of the paper, exam. Criteria: Knowledge of heat and mass transfer laws, the ability to use the boundary layer theory concepts and frameworks in analysis.
The ability to perform independent heat transfer and flow dynamic calculations in technical facilities and installations with the viscous flow convective heat exchange.	Assessment methods: Practical work, home calculation work, discussions, preparation and presentation of the paper, exam. Criteria: Knowledge of the boundary layer theory and laws of heat transfer, the ability to use the boundary theory concepts and framework for practical calculations.
Spēja analizēt eksperimentālās metodes un datormodelēšanas iespējas robežslāņa pētījumos.	Assessment methods: Practical work, discussions, exam. Criteria: Technical means and methods of measuring, knowledge and skills to operate with them. Ability to justify the choice of measurement methods.

Study subject structure

Part	CP	ECTS	Hours per Week			Tests		
			Lectures	Practical	Lab.	Test	Exam	Work
1.	4.0	6.0	3.0	1.0	0.0		*	