INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Transport Phenomena I			Field of study	Thermodynamics and Transport Phenomena		
Bachelor in	Chemical Engineering			School	School of Technology and Management		
Academic Year	2023/2024	Year of study	2	Level	1-2	ECTS credits	6.0
Type	Semestral	Semester	2	Code	9125-755-2203-00-23		

Workload (hours)	162	Contact hours	T	TP	PL	TC	S	E	OT	O
			30	-	30	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s): Hélder Teixeira Gomes

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Demonstrate the acquisition of knowledge on the basic concepts involved in heat transfer processes
2. Formulate and solve heat transfer problems applied to chemical engineering involving steady-state one-dimensional conduction. Recognise the importance of heat transfer in fins
3. Formulate and solve heat transfer problems applied to chemical engineering involving transient one-dimensional conduction. Recognise the physical meaning of Biot number
4. Identify and apply correlations for the determination of heat transfer natural and forced convective coefficients
5. Recognise the importance of heat exchangers on chemical engineering industrial processes. Perform the project of heat exchangers
6. Recall the nature of thermal radiation. Formulate and solve problems involving heat transfer by radiation

Prerequisites

Before the course unit the learner is expected to be able to:
1. Demonstrate strong knowledge on Mathematics
2. Demonstrate strong knowledge on fundamentals of engineering sciences
3. Demonstrate strong knowledge on the formulation of mass and energy balances
4. Demonstrate strong knowledge on the use of computers

Course contents

Heat Transfer Fundamentals. Steady-State Heat Transfer by Conduction. Concept of Thermal Resistance. Systems with and without Internal Energy Generation. Fins. Transient Heat Transfer by Conduction. Systems with and without Appreciable Internal Resistance. Heat Transfer by Convection. Correlations for the Determination of Convective Heat Transfer Coefficients. Project of Heat Exchangers. Heat Transfer by Radiation.

Course contents (extended version)

1. Heat Transfer Fundamentals
   - Conduction
   - Fourier law for conduction
   - Convection
   - Newton law for heat transfer by convection
   - Radiation
   - Stefan-Boltzmann law for thermal radiation
2. Steady-State Conduction
   - One-dimensional conduction. Conduction in walls, cylinders and spheres
   - Concept of thermal resistance. Analogies with the electric circuits theory
   - Conduction in series and in parallel. Thermal resistance for convection
   - Simultaneous conduction and convection. Overall heat transfer coefficient
   - Thermal resistance by contact
   - Conduction in systems with internal energy generation. Wall with homogeneous energy generation
   - Cylinder and sphere with homogeneous energy generation
   - Fins. Rectangular fins with constant cross-section
   - Circular fin with constant thickness. Fin efficiency
   - Determination of fins efficiency by graphical methods. Efficiency of finned surfaces
3. Transient Conduction
   - Heat capacity. Internal and external resistances
   - Biot number. Systems with neglecting internal resistance and without internal energy generation
   - Conductive materials with internal energy generation and dissipation by convection
   - Fourier second law. Application to systems with varying geometries and boundary conditions
   - Semi-infinite wall
   - Finite wall
   - Resolution of problems by Laplace transforms and the variable separations method
   - Cylinder exposed to convection
   - Sphere exposed to convection
4. Convection
   - Heat transfer by convection
   - Local convective heat transfer coefficient
   - Reynolds, Nusselt and Prandtl numbers
   - Mean convective heat transfer coefficient: correlations
5. Heat Exchangers
   - Types of heat exchangers
   - Energy balances
   - General heat exchangers equation
   - Overall heat transfer coefficient
   - Mean logarithmic temperature
   - Counter-current and co-current heat exchangers
   - Heat exchanger efficiency
   - Project of heat exchangers
6. Radiation
   - Nature of radiation. Thermal radiation
   - Reflectivity, absorptivity and transmitivity. Directional and spectral characteristics
   - Black bodies. Planck law
   - Wien law. Stefan-Boltzmann law
   - Intensity. Emissive power
   - Irradiation. Radiosity
   - Emissivity. Kirchhoff law.
   - Grey surfaces

Course contents (extended version)

- Heat transfer by radiation between black bodies. Form factors
- Heat transfer by radiation between grey surfaces

Recommended reading

1. Introduction to Heat Transfer, F. P. Incropera, D. P. DeWitt, T. L. Bergman, A. S. Lavine, Wiley, 5th edition, 2007.
2. Transferencia de Calor, Y. A. Çengel, McGraw-Hill, segunda edición, 2003.
3. Fundamentos de Transferência de Calor e de Massa, F. P. Incropera, D. P DeWitt, LTC, quarta edição, 1996.
4. Heat Transfer, J. P. Holman, McGraw-Hill, 8th edition, 1997.
5. Fundamentals of Momentum, Heat and Mass Transfer, J. R. Welty, C. E. Wicks, R. E. Wilson, G. L. Rorrer, Wiley, 5th edition, 2008.

Teaching and learning methods

Theoretical classes: exposition of the concepts involved in heat transfer processes, discussion and presentation of practical examples. Practical classes: guided resolution of application exercises and critical analysis. Non-presencial period: study of subjects, with reading of bibliography, resolution of exercises and home assignments.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final)
   - Practical Work - 15%
   - Intermediate Written Test - 35%
   - Final Written Exam - 50%
2. Alternative 2 - (Regular, Student Worker) (Supplementary, Special)
   - Final Written Exam - 100%
3. Alternative 3 - (Student Worker) (Final, Supplementary, Special)
   - Final Written Exam - 100%

Language of instruction

English

Electronic validation

Hélder Teixeira Gomes	Simão Pedro de Almeida Pinho	António Manuel Esteves Ribeiro	José Carlos Rufino Amaro
01-03-2024	01-03-2024	01-03-2024	02-03-2024