

Academic Year: ( 2020 / 2021 )

Review date: 10-07-2020

Department assigned to the subject: Thermal and Fluids Engineering Department

Coordinating teacher: GARCIA GUTIERREZ, LUIS MIGUEL

Type: Compulsory ECTS Credits : 6.0

Year : 3 Semester : 1

**REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)**

Thermal Engineering (2nd course)

**OBJECTIVES**

The main goal is the study of heat and mass transfer. The student must acquire a series of concepts, capacities and attitudes.

The student will be able to:

- Solve and analyze heat transfer problems where there may be more than one heat transfer mode: conduction, convection and radiation.
- Solve and analyze mass transfer problems in non-reactant mixtures.
- Evaluate the performance of heat exchangers.

Regarding the specific capacities, the student will be able to:

- Determine the thermal power exchanged in different processes.
- Dimension equipment of heat and mass transfer: determine temperature, flow rates, concentration...
- Characterize mixtures of water-air.
- Dimension, specify and characterize heat exchangers.

Regarding the acquired skills, during the course the student will work on:

- His/her capacity of solving problems.
- His/her capacity of solving, communicating and discriminating which is the relevant information to characterize a facility (from a thermodynamic and technique point of view)
- His/her capacity to apply his/her knowledge of heat and mass transfer to solve certain problems.
- His/her team-working skills.

Regarding the student's attitudes:

- He/she should possess a critical attitude regarding the way to identify and evaluate the performance of heat and mass transfer equipment in an industrial facility.
- He/she should possess a collaborative attitude that might allow him/her to obtain the information and knowledge needed to carry out complex tasks.

**DESCRIPTION OF CONTENTS: PROGRAMME**

1. Introduction to convection heat transfer. 1.1 Introduction. 1.2. Boundary layer in convective processes: hydrodynamic and thermal boundary layer, laminar and turbulent flow. 1.3 Boundary layer equations. 1.4 Non-dimensional equations of convective processes: Reynolds number, Nusselt number. 1.5 Turbulent boundary layer.
2. External flow: 2.1 Introduction 2.2 Determination of convection heat transfer coefficients. 2.3 Correlations for flat plates in parallel flow (Laminar and turbulent flow, Critical Reynolds number), cylinders and spheres in cross flow, non-circular cylinders, tube bank and impinging jets.

3. Internal flow. 3.1 Hydrodynamics: laminar and turbulent flow, critical Reynolds number, fully developed conditions, pressure drop in tubes. 3.2 Thermal aspects. 3.3 Energy balance: constant surface heat flux, constant surface temperature, external flow; the log mean temperature difference. 3.4 Internal flow correlations.

4. Free convection. 4.1 Introduction 4.2 Conservation equations: introduction of the buoyancy force in the conservation equations. 4.3 Non-dimensional equations: Grashof and Rayleigh numbers, transition to turbulent flow in a vertical surface, combined free and forced convection. 4.4 Correlations: external free convection, free convection within parallel plate channels and enclosures.

5. Boiling and condensation. 5.1 Introduction: non-dimensional parameters 5.2 Boiling: pool boiling, forced convection boiling. 5.3 Condensation: film condensation on a vertical plate, film condensation on tubes and spheres, condensation on a vertical tier of tubes, film condensation in horizontal tubes, drop condensation on a horizontal surface.

6. Heat exchangers. 6.1 Types of heat exchangers, parallel and counter-current heat exchangers. 6.2 Global heat transfer coefficient and total thermal resistance. 6.3 Heat exchanger analysis: log-mean temperature difference, Epsilon-NTU method, P-NTU method, characteristic curves. 6.4 Shell-and-tube heat exchangers. 6.5 Plate heat exchanger. 6.6 Cross-flow heat exchangers and compact heat exchangers.

7. Psychrometry. 7.1 Moist air. 7.2 Moist content parameters. 7.3 Mass and energy balance, mixture enthalpy. 7.4 Air saturation processes: dew point, adiabatic saturation temperature, wet-bulb temperature. 7.5 Psychrometric charts. 7.6 Psychrometric applications: sensible heating/cooling, humidification, evaporative cooling, dehumidification, adiabatic mixing and cooling towers.

8. Radiation. 8.1 Introduction to thermal radiation. 8.2 Black body radiation. 8.3 Radiation intensity and radiation power. 8.4 Real surfaces radiation: emissivity, absorptivity, reflectivity, transmissivity. Kirchhoff's law. 8.5 Solar radiation. Net radiation exchange at a surface. 8.6 Radiation exchange between surfaces: view factor relations, net radiation exchange between black surfaces, net radiation exchange between gray diffuse surfaces, radiation network, application examples (radiation shields, the reradiating surface), and multimode heat transfer.

## LEARNING ACTIVITIES AND METHODOLOGY

- Lectures on theory and applications.
- Solving problems individually and in groups.
- Performing tasks individually and in groups.
- Lab (computer rooms).

All of the activities are aimed at obtaining general and specific skills listed above.

## ASSESSMENT SYSTEM

<b>% end-of-term-examination:</b>	60
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	40

30% Midterm examinations  
10% Laboratory  
60% Final exam

- Continuous evaluation with partial exams and labs.
- Final exam mainly covering practical contents.

## BASIC BIBLIOGRAPHY

- Incropera F.P., DeWitt D.P., Bergman T.L., Lavine A.S. Fundamentals of heat and mass transfer, John Wiley & Sons, 2007
- Moran M.J, Shapiro H.N. Fundamentals of engineering thermodynamics : SI version , John Wiley & Sons, 2010

#### ADDITIONAL BIBLIOGRAPHY

- G.F. Hewitt, G.L. Shires and T.R. Bott. Process heat transfer, CRC Press, 2000
- Adrian Bejan Convection heat transfer, Wiley, 2013
- Jhon H. Lienhard IV, Jhon H. Lienhard V A heat transfer textbook, Available online , <http://web.mit.edu/lienhard/www/ahtt.html>