Heat Transfer

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 acquires 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 posses a critic attitude regarding the way to identify and evaluate the performance of heat and mass transfer equipment in an industrial facility.
- He/she should posses 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, combines free and forces 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. Psychometry. 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 Psychometric 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

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	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, Avalaible online , http://web.mit.edu/lienhard/www/ahtt.html