Heat Transfer

Academic Year: (2021 / 2022) **Review date: 09-09-2021**

Department assigned to the subject: Department of Thermal and Fluids Engineering

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

OBJECTIVES

By the end of this content area, students will be able to have:

1. a systematic understanding of the key aspects and concepts of heat and mass transfer, and the perfomance of heat exchangers.
2. the ability to apply their knowledge and understanding to identify, formulate and solve problems of heat and mass transfer using established methods;
3. the ability to select and apply relevant analytic and modelling methods in heat transfer.
4. the ability to apply their knowledge and understanding to develop and realise designs of thermal systems to meet defined and specified requirements;
5. an understanding of design methodologies in heat transfer, and an ability to use them.
6. the ability to design and conduct appropriate experiments in heat transfer, interpret the data and draw conclusions;
7. the ability to select and use appropriate equipment, tools and methods to solve problems of heat transfer;
8. the ability to combine theory and practice to solve problems of heat and mass transfer;
9. an understanding of applicable techniques and methods in heat transfer, and of their limitations.

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.
- Lab (computer rooms).

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

ASSESSMENT SYSTEM

30% Midterm examinations
10% Laboratory
60% Final exam

- Continuous evaluation with partial exams and labs.

- Final exam mainly covering practical contents.

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

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

- Adrian Bejan Convection heat transfer, John Wiley & Sons, Inc, 2013
- G.F. Hewitt, G.L. Shires and T.R. Bott. PROCESS HEAT TRANSFER, CRC Press, 2000
- Jhon H. Lienhard IV, Jhon H. Lienhard V A heat transfer textbook, Avalaible online, http://web.mit.edu/lienhard/www/ahtt.html