EN1120 Heat Transfer

Professor : Christophe LAUX

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Basic notions of thermodynamics and partial differential equations

Period : S8 elective 12 between february and june

Course Objectives

- Master the basic notions of conductive, convective, and radiative heat transfer
- Understand how to derive balance equations for heat transfer
- Develop abilities to build elementary models for applications of practical interest

On completion of the course, students should be able to

- understand the fundamental principles and mathematical basis underlying the balance equations for heat transfer
- decompose a physical problem for conduction, convection, and radiation into a simple model
- formulate an order of magnitude analysis on the governing differential equations for heat transfer to determine how variables scale with parameters
- compute radiative exchange between surfaces
- design a heat exchanger with given constraints (physical size, heat flux, temperature drop)

Course Contents

- The three modes of heat transfer: conduction, radiation, convection. Phenomenological approach to the heat transfer coefficient: coupling between conduction and convection.
- Steady-state energy balance in fixed systems.
- Steady-state heat conduction. Fin approximation. Ideal and infinite fins.
- Opaque bodies and transparent media. Spectral and directional intensity and flux of radiation. Expression of the radiative flux for radiative transfer between opaque bodies through a transparent medium.
- Conservation of energy fluxes and boundary conditions.
- Equilibrium radiation. Spectral and directional absorptivity, reflectivity, and emissivity. Emitted, absorbed, and radiative flux. Study of radiative transfer: a) Special case of transfer between opaque bodies subjected to equilibrium radiation or

surrounded by an isothermal black body. Linearization of the radiative flux. b) General case of transfer between opaque bodies through a transparent medium. View factors. Incident and leaving intensity matricial approach (equivalent to radiative resistance arrays).

- Unsteady conduction. Characteristic times and lengths, dimensional analysis, Fourier and Biot numbers. The semi-infinite wall (or short time response) model. Spectral analysis of a thermal signal. Modeling of finite systems.
- Dimensional approach to forced convection. Notions of mechanical and thermal boundary layers. Reynolds, Prandtl and Nusselt numbers. Laminar-turbulent transition.
- Standard cases (tube, flat plate) of internal and external convection in the fully developed regime.
- Notions of heat exchangers. Temperature fields in co- and counter-flow heat exchangers. Number of Transfer Units. Exchanger efficiency.
- Notions of natural convection. Grashoff and Rayleigh numbers.

The tutorials are devoted to the study of practical problems taken from industrial or everyday cases. Emphasis is placed on the analysis of the problem and the development of an appropriate model. Note: EN1120 covers all the topics taught in EN1100, and also additional subjects such as the general method of radiative transfer between opaque bodies through a transparent medium.

Course Organization

Lectures: 16.5 hr, Tutorials: 16.5 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

A First Course in Heat Transfer, J. Taine and E. Iacona, Dunod (2011)

Evaluation

1-hr midterm exam (M) without documents or computer + 3-hr written final exam (F) consisting of a first part (1 hr) without documents or calculator, and a second part (2 hr) with documents and calculator. Final mark = Sup(F, 0.3M + 0.7F).