
Applied thermal fluid dynamics

Finalità

To make the students acquainted with the application of transport phenomena principles to the processes involved in engineering applications, with particular reference to the food industry.

See also the teacher's web page devoted to this course: <http://pcfarina.eng.unipr.it/TFD-2010.htm>

Programma

Convection

Principles of convection. The boundary layers equations. External flow. The flat plate in parallel flow. The cylinder and the sphere in cross flow. Flow across banks of tubes. Internal flow. Hydrodynamic and thermal considerations. The energy balance: constant surface heat flux and constant surface temperature. Laminar flow in circular tubes. Convection correlations. Noncircular tubes.

Free convection

Physical consideration. The governing equations. External free convection: the vertical plate, inclined and horizontal plates, the long horizontal cylinder, the sphere. Empirical correlations. Free convection within channels. Vertical and inclined channels. Empirical correlations. Enclosures. Rectangular cavities, concentric cylinders and spheres. Empirical correlations. Combined free and forced convection.

Boiling and Condensation

Dimensionless parameters in boiling and condensation. Pool boiling. The boiling curve. Pool boiling correlations. Nucleate pool boiling, critical heat flux, minimum heat flux, film pool boiling. Forced convection boiling. Condensation. Laminar film condensation on a vertical plate. Turbulent film condensation. Film condensation on radial systems. Dropwise condensation.

Heat Exchangers

Heat exchanger types. The overall heat transfer coefficient. Heat exchanger analysis. The log mean temperature difference method. The parallel and counter flow heat exchanger. Multipass and cross flow heat exchangers. The effectiveness NTU method. Compact heat exchangers.

Heat transfer enhancement

Principles of enhanced heat transfer. The enhancement techniques. Passive techniques. Active techniques. Benefits of enhancement. Plate and fin extended surfaces. Externally finned tubes. Insert devices for single-phase flow. Internally finned tubes and annuli. Integral roughness.

Mass transfer

Fick's law. Mass diffusion coefficient. The conservation of chemical species. Dimensional analysis. Schmidt number. Diffusion through a stationary medium. Boundary conditions. Mass transfer coefficient. Sherwood number. Convection. Forced convection in laminar boundary layer flow. Other external forced convection configurations.

Analogy between momentum, energy and mass transfer

Reynolds analogy. Chilton-Colburn analogy. Turbulent flow in smooth pipes. Cylinder in cross flow. Infinite plate in parallel flow. Simultaneous heat and mass transfer. Evaporative cooling. The wet-and dry-bulb psychrometer.

Rheology

General concepts of rheology. Generalized treatment of Non-Newtonian fluids. Non-Newtonian models: Bingham, shear thickening, shear thinning, power law. Analysis of capillary flow without Newtonian assumption. Rheological measurement. The capillary tube rheometer and the rotational viscometer.

Training in computer room

The students will make two training sessions in a computer room: in the first session, they have to develop an Excel spreadsheet for numerical simulation of thermal transients. in the second session, they will solve the same problem employing a commercial FEM program (Comsol)

Modalità d'esame

Traditional oral examination. The student can consult tables, charts, and other material made available during the course. He is not required to remember all the equations and formulas. He is required, instead, to be able to solve problems different from those employed as example during the lessons.

Propedeuticità

Fisica Tecnica (Applied Physics)

Testi consigliati

F. KREITH: "Principi di trasmissione del calore" - Liguori Editore, Napoli, 1976

F. P. INCOPRERA, D P DE WITT: " Fundamentals of Heat and Mass Trasfer ", John Wiley & Sons, New york, 1985.