ADVANCED HEAT TRANSFER

Course Code: 13ME2303

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Pre requisites: Fluid mechanics and basic heat transfer

Course Educational Objectives:

To make the student understand

1. fin heat transfer for certain special geometries
2. solution methods for problems of two dimensional steady state heat conduction
3. transient heat conduction for different boundary conditions
4. heat transfer in laminar and turbulent flows over a flat plate and through pipe
5. external and internal boiling and condensation
6. radiation exchange between surfaces, and gas radiation

Course Outcomes:

The student will be able to

1. calculate fin effectiveness for rectangular and triangular fins
2. solve numerically 2-D steady state heat transfer problems for specified boundary conditions
3. find heat transfer rates in transient heat conduction for specified boundary conditions
4. obtain heat transfer coefficients in laminar and turbulent forced convection
5. explain boiling and condensation outside and inside pipes
6. construct networks for radiation exchange between surfaces

UNIT-I

General heat conduction equation: Heat conduction equation in Cartesian, cylindrical, and spherical coordinates.

One-dimensional steady state heat conduction: Heat transfer from extended surfaces – infinitely long fin - rectangular and triangular fins – boundary conditions - fin performance.

Two-dimensional steady state heat conduction: Steady state two-dimensional heat conduction equation – boundary conditions – numerical solution by finite difference method.

Definition of conduction shape factor – conduction shape factor for a three-dimensional wall and for different other geometries.

UNIT-II

Unsteady-state heat conduction: Lumped heat capacity system - transient heat conduction in a semi-infinite rod - transient heat conduction in an infinite plate with convection boundary condition at the surface.

Transient heat conduction in an infinite cylinder exposed to a convection environment - transient heat conduction in a sphere - Heisler's charts.

Forced convection-I: Laminar boundary layer on a flat plate – Von Karman analysis through integral equations for hydrodynamic boundary layer thickness – energy balance equation and thermal boundary layer on a flat plate, turbulent boundary layer – mixing length and eddy viscosity.

UNIT-III

Forced convection-II: Heat transfer in laminar tube flow – turbulent flow in a tube, heat transfer in high speed flow – liquid metal heat transfer – high speed heat transfer for a flat plate.

Boiling: Regimes of saturated pool boiling – Rohsenow's correlation for nucleate pool boiling, flow boiling: external flow boiling, internal flow boiling, two-phase flow regimes.

UNIT-IV

Condensation: Nusselt's analysis for laminar film condensation on a vertical plate – condensate Reynolds number – film condensation inside horizontal tubes.

Heat pipe: Heat pipe components, materials and working fluids – Applications of heat pipe – Cooling of electronic components.

UNIT-V

Radiation heat transfer: Radiation properties – Kirchhoff's law – Wien's displacement law – Planck's distribution law – black body - gray body. Radiation heat exchange between black isothermal surfaces - radiation shape factor, Irradiation–radiosity– space resistance – surface resistance – radiation networks – radiation between two hot plates enclosed by a room.

Gas radiation: Radiation exchange between a gas and a heat transfer surface - absorption in a gas layer - radiation network for an absorbing and transmitting medium, interaction of radiation with conduction and convection.

TEXT BOOKS:

1. Holman, J.P., "*Heat Transfer"*, 10th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.

2. David Reay and Peter Kew, "*Heat pipes – Theory, Design and Applications"*, 5th Edition, Butterworth and Heinemann (Elsevier), 2006.

REFERENCES:

1. M. Thirumaleswar, "*Fundamentals of Heat and Mass Transfer"*, 2nd Edition, Pearson Education, New Delhi, 2009.

2. Incropera, F.P., Dewitt, D.P., Bergman, T.L., Lavine, A.S., Seetharamu, K.N. and Seetharam,T.R., "*Fundamentals of Heat and Mass Transfer*",1st Edition, WileyIndia, 2013.

3. Sachdeva, T.R., "*Fundamentals of Engineering Heat and Mass Transfer" (SI UNITs)*, 4th Edition, New Age International, 2010.