TWO PHASE FLOW AND HEAT TRANSFER
(Professional Elective IV)

II Semester

Course Code: 19ME2259	L	P	C
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Prerequisites: Fluid Mechanics and Heat Transfer

Course Outcomes: At the end of the course the student shall be able to

CO1: Explain types of two-phase flow, define properties of two-phase flow, and derive homogeneous flow model.
CO2: Summarize separated model for two-phase flow, and explain Lockhart-Martinell and Martinelli-Nelson correlations to compute pressure drop in two-phase flow.
CO3: Analyze drift flux model, and explain regions of heat transfer in convective boiling and critical heat flux.
CO4: Illustrate saturated forced convection boiling in a circular tube, and use empirical correlations to calculate heat transfer coefficients in convective boiling.
CO5: Explain forced convection condensation in a horizontal tube, and use correlation equations to compute convective condensation heat transfer coefficients.

UNIT-I: (10-Lectures)

Flow types and definitions: Single phase flow, two-phase flow, adiabatic and diabatic two phase flows – volumetric concentration, void fraction, volumetric flux, relative velocity, drift velocity – flow regimes, flow maps
Analytical two-phase flow models: Basic equations of two-phase flow – Approaches for homogeneous and separated flow models – Derivation of homogeneous flow model

Learning outcomes: At the end of this unit, the student will be able to

1. Describe and distinguish between single phase and two phase flow and explain adiabatic and diabatic flows (L2)
2. Define various flow properties and flow regimes and develop basic equations for two phase flow (L1&L4)
3. List out and discuss various approaches for homogeneous and separated flow models and derive homogeneous flow model (L1)

UNIT-II: (10-Lectures)

Two-phase flow pressure drop: The separated flow model – balance equations – Martinelli parameter – two-phase multiplier - Lockhart- Martinelli correlation for adiabatic flow - computational procedure for two-phase flow pressure drop – Martinelli-Nelson correlation for diabatic flow – Baroczy correlation

Learning outcomes: At the end of this unit, the student will be able to

1. Calculate the pressure drops by applying Lockhart- Martinelli correlation for adiabatic flow (L4)
2. Describe the computational procedure for two-phase flow pressure drop (L2)
3. Determine the pressure drops by applying Martinelli-Nelson correlation for diabatic flow (L4)

UNIT-III: **(10-Lectures)**

Empirical treatments of two-phase flow: Derivation of drift flux model for bubbly flow
Convective boiling: Regions of heat transfer in convective boiling in a vertical tube – boiling map – critical heat flux condition in two-phase forced convection boiling

Learning outcomes: At the end of this unit, the student will be able to

1. Derive drift flux model for bubbly flow (L5)
2. List out various regions of heat transfer in convective boiling in a vertical tube (L1)
3. Derive and determine critical heat flux condition in two-phase forced convection boiling (L5)

UNIT-IV: **(10-Lectures)**

Saturated forced convection boiling: Saturated forced convection boiling in a circular tube – Two-phase forced convection region – Chen correlation for convection boiling heat transfer coefficient – Shah correlation – Fundamental limitations to flow boiling

Learning outcomes: At the end of this unit, the student will be able to

1. Solve for mass quality for saturated forced convection boiling in a circular tube (L4)
2. Evaluate convection boiling heat transfer coefficient by making use available correlations (L5)
3. List out Fundamental limitations to flow boiling (L1)

UNIT-V **(10-Lectures)**

Forced convection condensation: Convective condensation within a horizontal tube – Chato's correlation – Empirical equation by Akers et al. – Shah's empirical correlation

Learning outcomes: At the end of this unit, the student will be able to

1. Analyse convective condensation within a horizontal tube (L4)
2. Estimate the rate condensation by Chato's correlation (L5)
3. Applying Akers et al. and Shah's empirical correlation for convective condensation within a horizontal tube (L3)

TEXT BOOK:

1. J.G. Collier and J.R. Thome, *Convective Boiling and Condensation*, Third Revised Edition, Oxford University Press, 2002.

REFERENCE BOOK:

1. Van P. Carey, *Liquid Vapor Phase Change Phenomena: An Introduction to the Thermophysics of Vaporization and Condensation Processes in Heat Transfer Equipment*, Second Edition, CRC Press, 2007.