Ref. No PG/ME/T/128F/2019

M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAMINATION, 2019
M.E. NUCLEAR ENGINEERING FIRST YEAR SECOND SEMESTER EXAMINATION, 2019
(2nd Semester)

Two Phase Flow, Boiling and Condensation

Time: Three hours **Full Marks 100**

Use separate answerscript for each part

Part - I

Answer any TWO questions

All parts of the same question must be answered together.

Q:1(a) Derive Reynolds Transport Theorem for a control volume containing a single fluid. 20

(b) What is a material volume? What is the velocity of the control surface of a material control volume? 5

Q:2 Assuming the conservation equation for single phase flow and using the relation for mass conservation across an interface between two phases, derive the equation for conservation of mass for multi-fluid model. 25

Q:3 Starting from the basic conservation equations for a homogeneous steady one-dimensional two phase flow, show that the pressure gradient can be expressed as:

$$-\frac{dp}{dz}=\frac{\frac{2C_f}{D}G^2\left(v_l+xv_{12}\right)+G^2v_{12}\frac{dx}{dz}-G^2\left(v_l+xv_{12}\right)\frac{1}{A}\frac{dA}{dz}+\frac{gSin\theta}{v_l+xv_{12}}}{1+G^2\left[x\frac{dv_2}{dp}+(1-x)\frac{dv_1}{dp}\right]}$$ 25

Q:4(a) State the basic assumptions of separate cylinder model. Derive the separate cylinders model for turbulent flow, assuming a constant friction factor for both phases. 10

(b) What is flooding point? For a functional dependence of drift flux on void fraction of the form $j_{21}=\alpha(1-\alpha)^n v_\infty$, derive the expressions for j_1 and j_2 at the flooding point. 9

(c) Define the following terms: (a) mass fraction (b) drift flux (c) drift velocity 6

Part - II

Answer question no. 1 and any TWO questions from the rest.

1. Answer any three parts: 6X3=18

a) What do you mean by superheated liquid and supersaturated vapour? Explain the physical process with the help of TS diagram.

b) Show that for homogeneous nucleation, Gibbs free energy reaches its maximum when the molecular nuclei radius reaches r_{cr}, the symbol denote usual meaning. What is the expression of maximum value of free energy?

c) What do you mean by relaxation microlayer and evaporation microlayer? Explain with a neat sketch. Explain the differences between inertial and diffusion controlled growth of a bubble.

d) Express the scale of bubble departure diameter as a function of liquid and vapour density and surface tension co-efficient. Express the product of departure diameter and departure frequency as a function of thermodynamic parameters, and show that it is a constant for a particular fluid.

2. Develop with the help of scale analysis, the expression of diffusion controlled (thermal) growth of radius of a vapour bubble as a function of different thermo-fluid parameters and time. Draw the sketch of vapour bubble shape near surface and release pattern from a surface under nucleate boiling and critical heat flux condition. (16)

3. Develop Rohsenow's correlation for nucleate boiling with proper non-dimensionalization. (16)

4. Show with neat sketch from the surface the bubble growth rate, departure, surface temperature variation, waiting period, growth period and explain the bubble cycle. Why liquid superheat requirement is reduced for heterogeneous nucleation? (16)