INDIAN INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING
Mid Semester Examination
Multiphase Flow
Subject No: CH62021 No of Students: 32 Session: 2022-2023
Date of Examination: 22/09/2022 (FN)
This is an open book open notes examination

Time: 2 hours **Full marks – 50**

1. Water-kerosene flows through a vertical acrylic pipe of 0.0254 m and 1.5 m length at inlet velocities of 0.3 m/s of water velocity and 0.2 m/s of oil velocity.

Referring to Table 1 and Figs. 1 and 2, answer the following.

(a) Using a suitable analytical model, estimate the pressure drop and compare with the experimental value (Fig. 2a). Justify the choice of the analytical model. (5)

(b) State clearly all assumptions used in the analysis. (3)

(c) Discuss the reason(s) for mismatch. ((Hint: Fig. 2b may be helpful) (2)

(d) Discuss the sources of error in measuring the pressure drop during the aforementioned two-phase flow. (2)

(e) Estimate the actual slip between the phases. (3)

(f) Also estimate the theoretical and actual (i) momentum flux and (ii) kinetic energy of the liquid-liquid mixture. (5)

(g) Does the same model hold when the oil velocity is increased ten times keeping the water velocity constant. Derive the momentum balance equation under this condition. (5)

(h) Does the same model hold when the pipe is made horizontal and the same phase velocities (0.3 m/s of water velocity and 0.2 m/s of oil velocity) are maintained. With suitable assumptions, estimate the pressure drop and compare with the experimental value. (5)

A reactor containing a homogeneous gas-liquid mixture is emptied by a converging nozzle of 5 cm diameter and 5 cm length which is placed vertically at the reactor bottom. The flow rate measured at nozzle exit are 30 l/s of liquid and 5l/s of gas.

(a) Estimate the pressure drop at the nozzle. (5)

(b) Comment on the difference in pressure drop if the nozzle is placed horizontally on a side wall instead of the reactor bottom. (3)

(c) Suggest ways to reduce the pressure drop and the minimum pressure drop for horizontal placement of the nozzle. (2+5)

Air-water mixture flows in a 2.5 cm diameter 20 m long horizontal pipe. The superficial velocities are 1.2 m/s for water and 0.3 m/s for gas at atmospheric pressure and temperature. Calculate the pressure drop assuming no slip between the phases and negligible wall shear stresses. (5)

Table 1: Physical Properties of water and kerosene at 298K and 1 atm pressure

Fluid	Density kg/m^3	Viscosity kg/(m s)	Surface tension (fluid-PMMA)[a] N/m
Kerosene	787	0.00120	0.038
Water	1000	0.00084	0.016

Fig.1: Flow Regime Map for kerosene-water vertical flow in a pipe of diameter 2.54 cm

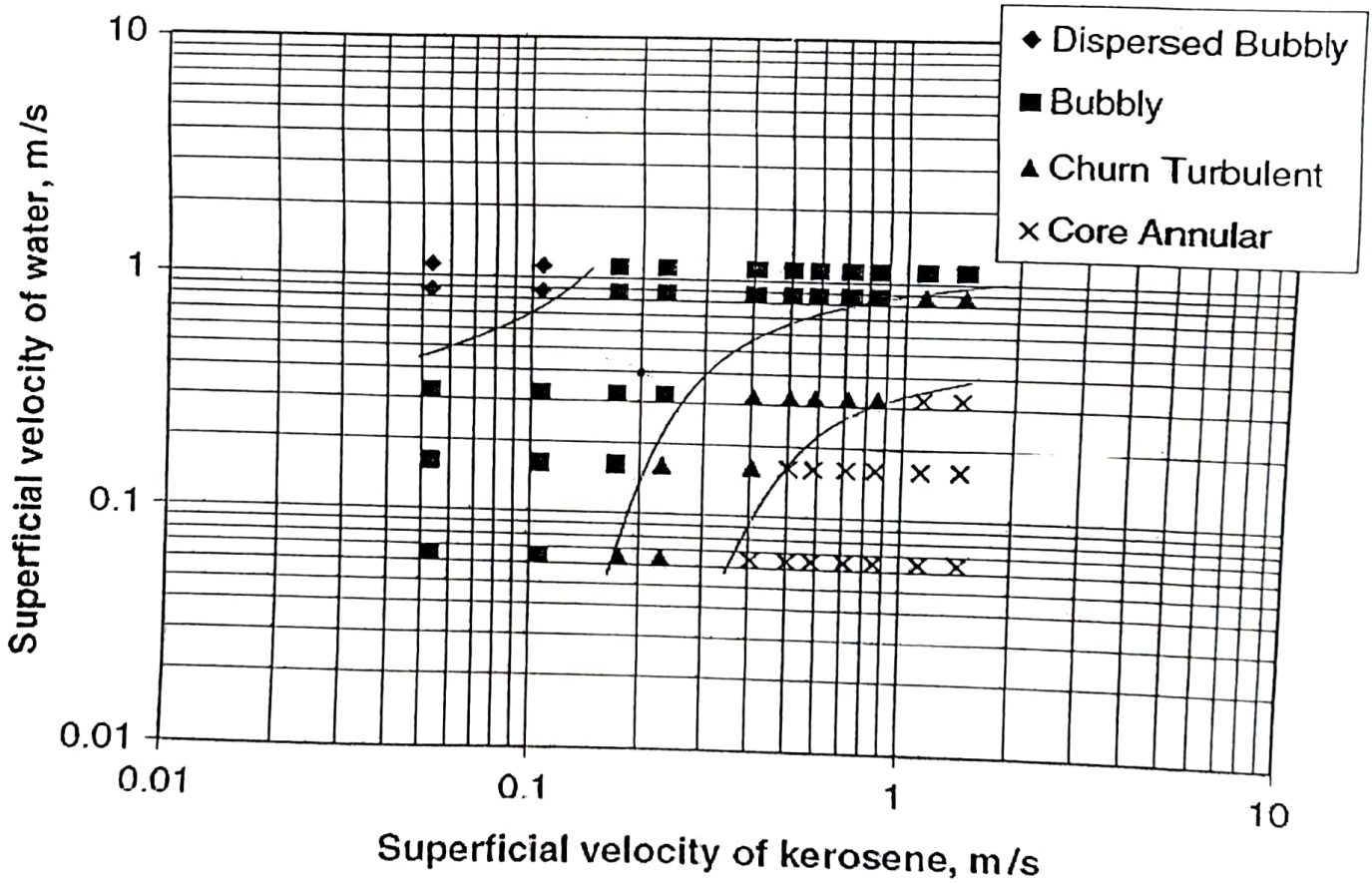
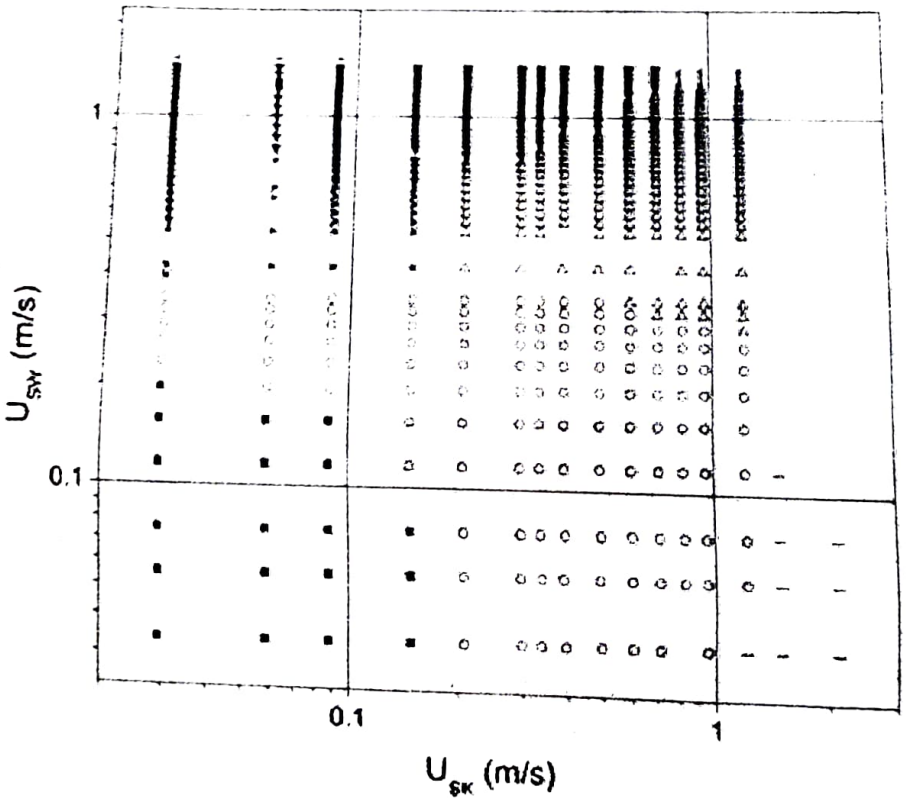


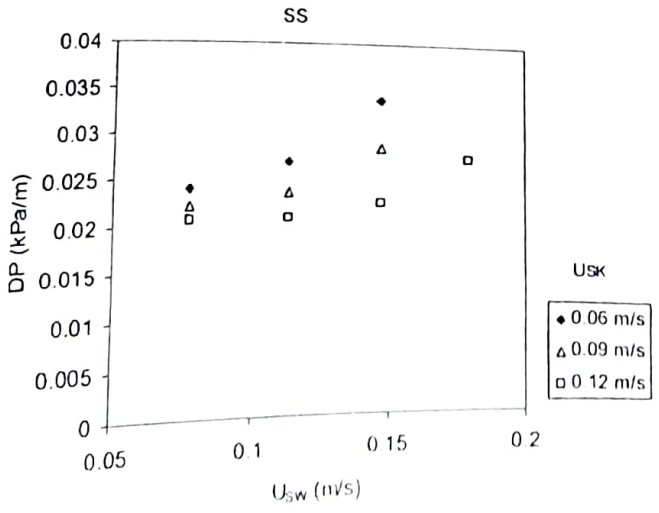
Fig.3: (a) Flow Regime Map for kerosene-water horizontal flow in a pipe of diameter 2.54 cm

■ – stratified smooth, ○ – stratified wavy, Δ– three-layer, ▽ – Dow&w, + – dispersed.

* – plug, – – O & W/O.



(b) Pressure gradient as function of water and kerosene velocity in smooth and wavy stratified flow



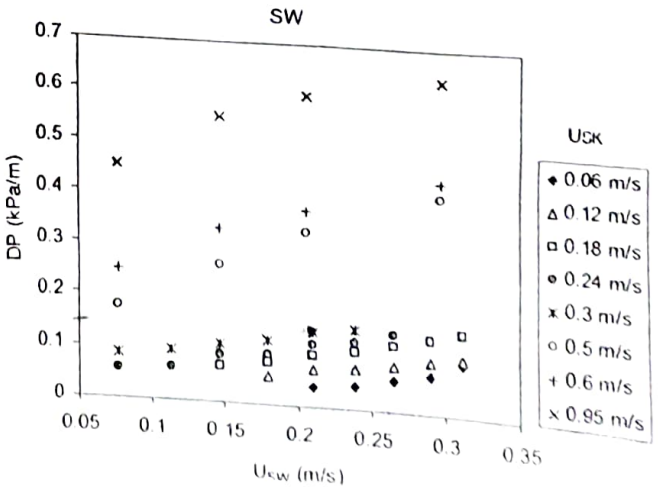


Fig.2: Plots of (a) pressure drop and (b) water holdup as function of oil inlet velocity for constant water velocity for kerosene-water vertical flow in a pipe of diameter 2.54 cm