S Y N O P S I S

The present work entitled "Simultaneous Gas-Liquid Fluidization of Solids" covers some of the momentum transfer aspects of multiphase fluid flow system. It includes the study of gas and liquid phase pressure drops, total power requirement and gas holdup in a three-phase gas-liquid-particle flow system. The parameters studied are gas and liquid velocities, bed height, particle size and particle density. Dimensionless correlations have been proposed for the total power requirement and holdup of gas. The thesis consists of three Chapters i.e. Introduction and Literature Survey, Experimental Setup and Procedure and Results and Discussion.

Chapter-I : Gas-liquid fluidization of solids is of very recent origin and is finding an increasing number of applications in all industries in general and petroleum industry in particular. An exhaustive literature survey reveals that a large number of studies have been made in bubble behavior, bed expansion, axial mixing, gas and liquid holdups and heat and mass transfer in such three-phase flow systems and that there is general agreement on many of these aspects. Some theoretical models have also been presented but they do not represent a true three-phase system in which liquid is in finite flow. Further, there is no generalized correlation available for any of the gas-liquid-particle operations. The bubbling-bed model, as developed by Kunni and Levenspiel, is limited in its application because of a number of simplifying assumptions. No work on pressure drop studies in a three-phase flow system has come to author's attention.

In the present study, attempt has been made to explain the three-phase flow phenomenon by visualizing it as a generalized form of two-phase flow i.e. considering the solid-liquid suspension as a pseudo-fluid, the gas constituting the second phase. On this consideration, a brief literature survey of two-phase flow has also been included.

Chapter-II : The experimental setup, standardisation and procedure have been discussed in detail. Air, water, and silica and limestone have been used as gas, liquid and solid phases respectively The parameters studied are gas and liquid mass velocities(G_G & G_L), static bed height (h), particle size (d_p) and solid density(ρ_s) in the following ranges:

Sl. No.	Parameter	Range of study
1	G_G	$0 - 22\times10^{-3}$ Kg/hr.cm^2
2	G_L	0 - 4.75 "
3	h	7.0 - 23.0 cm.
4	d_p	0.103 - 0.224 cm.
5	ρ_s	1.56 - 2.65 gm/cc.

Chapter-III : This chapter presents (i) pressure drop data for both gas and liquid phases in a three-phase system,

(ii) total power requirement data as on onset of fluidization and (iii) gas holdup data in a three-phase system.

Liquid-phase pressure drop in a three-phase flow system has been found to (i) decrease at first with increasing gas velocity and then to become constant, (ii) increase with increasing liquid velocity, (iii) increase with increasing static bed height and (iv) increase with increasing solid density.

The variation of liquid-phase pressure drop with respect to the various system parameters has been explained on the basis of considering the solid-liquid suspension as a pseudo-fluid with gas bubbling through it and thus extending the theoretical two-phase pressure drop equation, as developed by Nicklin, to the present case, This approach is found to offer a very satisfactory explaination, thus showing the validity of the extension.

Gas-phase pressure drop in a three-phase flow system is found to (i) decrease with increasing gas velocity, (ii) increase marginally with increasing liquid velocity, (iii) increase with increasing bed height and (iv) increase with increasing solid density. It is apparent that the gas-phase pressure drop depends, primarily, on the hydrostatic head of the solid-liquid suspension which must be overcome by the gas while being introduced and this forms the basis for the explaination of the variation of gas-phase pressure drop with respect to various parameters under study.

The total power requirement, under minimum fluidizing condition, is obtained for various combinations of gas and liquid flow rates (which are found to vary linearily) and is found to (i) decrease asymptotically with increasing G_G/G_L ratio, (ii) increase with increasing bed height, (iii) increase with increasing particle size and (iv) increase with increasing solid density. The experimental data show that the contribution of gas phase, towards the total power requirement, is very little(the maximum being only 5%). However, the introduction of gas phase considerably reduces the liquid flow rate required for the onset of fluidization, thereby reducing the total power requirement appreciably. A correlation is proposed relating the total power requirement with various system parameters and it is found to satisfactorily represent the experimental data :

$$\left[\frac{P_T}{v_G\, h^3\, \rho_s}\right] = 2.87 \times 10^{10} \left(\frac{v_G}{v_L}\right)^{-1.03} \left(\frac{d_p}{h}\right)^{2.75}$$

The gas holdup in a three-phase flow system is found to (i) increase almost linearily with increasing gas velocity, (ii)decrease marginally with increasing liquid velocity and (iii) decrease with increasing bed height. The following correlation is proposed relating the percentage gas holdup in a three-phase system with the system variables:

$$H_G = 1.909\, (v_G/v_L)^{1.12}\, (d_p/h)^{0.114}$$

The above correlation fits the experimental data very closely, with only ± 10% maximum deviation.