MEASUREMENT OF VOIDAGE/HOLDUP IN INDUSTRIAL FLOW SYSTEMS USING GAMMA RAY DENSITOMETRY

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1. INTRODUCTION

The industrial process systems involve flow of one or more than one phases. The distribution of holdup/voidage is one of the most important parameters which affects the process efficiency and product quality. Therefore, the knowledge of axial and radial distribution of the individual phases is required to evaluate mixing of the phases while designing and scaling up of industrial systems. Gamma ray densitometry technique is often used to measure holdup or voidage in two phase flow systems.

2. GAMMA RAY TRANSMISSION TECHNIQUE

The average voidage (ε) and holdup (H=1-ε) in a two phase system across the diameter or chord at an axial position of the system can be estimated by recording the intensity of the transmitted radiations with three conditions i.e. with air (empty system), with solids/liquid filled in the system and with two phase flow. Thus:

For fluidized bed $$\frac{\ln\left(\frac{I_{tp}}{I_s}\right)}{\ln\left(\frac{I_a}{I_s}\right)} = \frac{\varepsilon - \varepsilon_s}{1 - \varepsilon_s} \quad (1)$$

For bubble column $$\frac{ln\left(\frac{I_{tp}}{I_l}\right)}{\ln\left(\frac{I_a}{I_l}\right)} = \varepsilon \quad (2)$$

where I_a, I_s, I_l and I_{tp} are intensities of transmitted radiations with empty system (air), system full of solids, system full of liquid and with two phase flow, respectively. ε_s is the static void fraction in fluidized bed.

3. CASE STUDIES

3.1. Packed Fluidized Bed

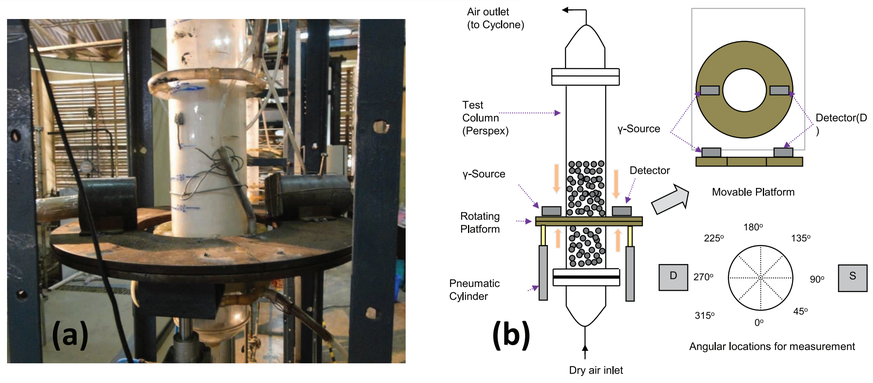


Fig.1. (a).Photograph of packed fluidized bed and (b) experimental setup

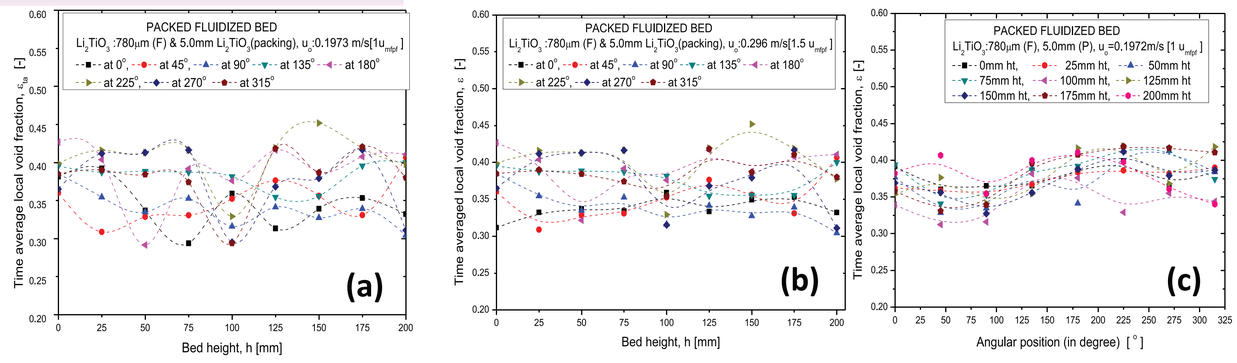
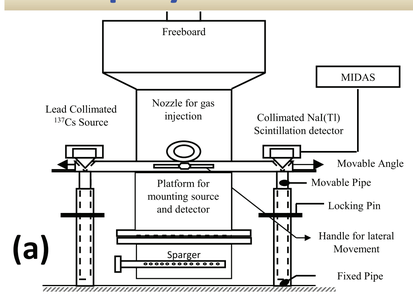


Fig.2. Representative holdup profiles measured in packed fluidized bed

Void fraction remains constant at different axial and angular positions in packed fluidized bed, it also remains constant at higher μ_{mf} Packing pebbles in packed fluidized bed prevent the coalescence of bubbles. As a result the void fraction is uniformly distributed throughout the bed

3.2. Spray Fluidized Bed



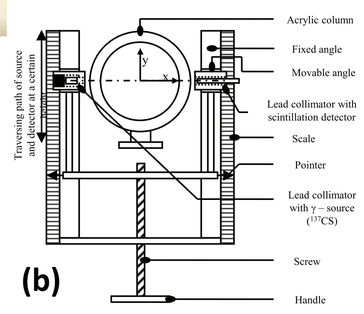


Fig.3. Schematic diagram of spray fluidized bed (a)Side view (b) Top view

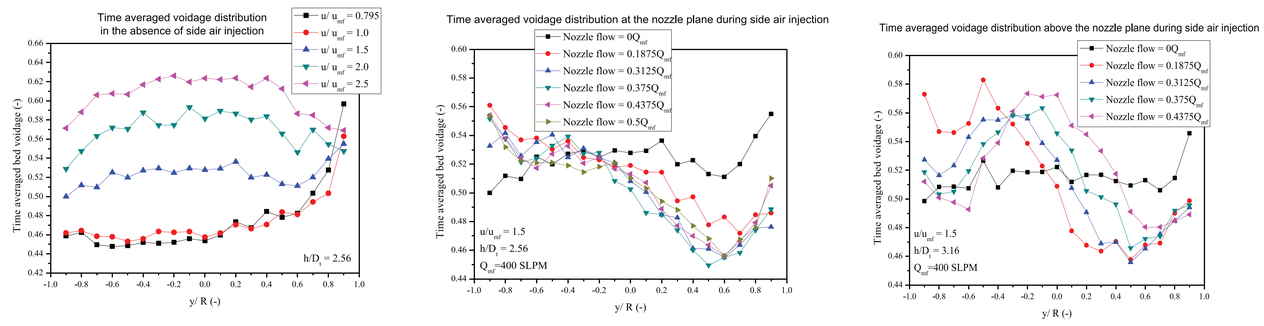


Fig.4. Representative holdup profiles measured in spray fluidized bed

The void fraction measurements at the nozzle plane and above the nozzle plane clearly show that a fraction of the injected gas passes along the nozzle wall and the rest of the air flows through the bed as bubbles. Also the fluidizing agent uses the jet void as shortcut and forms a compacted region opposite to the nozzle wall.

3.3. Bubble Column with Internals

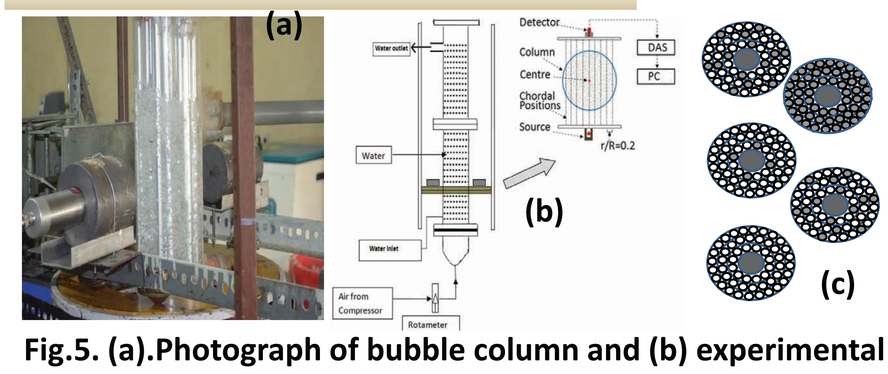


Fig.5. (a).Photograph of bubble column and (b) experimental setup (c) configuration of internals

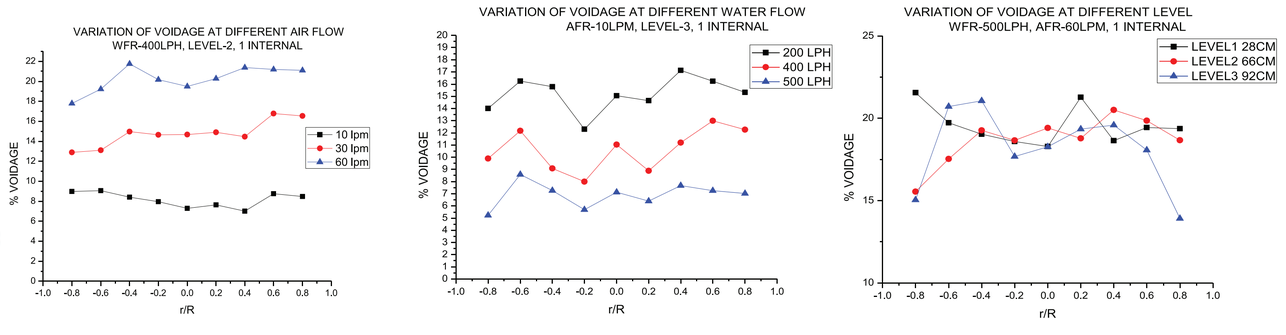


Fig.6. Representative holdup profiles measured in bubble column with internals

It was observed that at a particular level and at constant water flow rate voidage increases with increase in air flow rate and at a particular level and at constant air flow rate voidage decreases with increase in water flow rate. Mixing of two phases is not uniform at different levels.

4. CONCLUSIONS

Gamma ray transmission technique was successfully used to measure the holdup/voidage profiles in different process system. The holdup/voidage study helped to understand the flow dynamics and gas-solid interaction in the fluidized bed, gas-liquid interaction in bubble column and helped to optimize operating conditions.

References

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2. Sandip Bhowmick, V. K. Sharma, J. S. Samantray, H. J. Pant, K. T. Shenoy, A. Dash, S. B. Roy, Experimental Investigation on Interaction of Side Gas Injection with Gas Fluidized Bed Using Gamma Ray Transmission Technique, Industrial & Engineering Chemistry Research, 2015.