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Fibre Optic Probe for Measurement of Local Hydrodynamic Parameters of Trickle Bed Reactor

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Abstract – Trickle bed reactors are widely used in chemical industries. Trickle bed reactor implies a reactor in which a liquid phase and a gas phase flow counter currently or co-currently downward or upward through a fixed bed of catalyst particles while reaction takes place. These reactors are widely used in chemical industries like petrochemicals, pharmaceuticals etc. A lot of research has been done to measure their average hydrodynamic parameters but there is very less development in the field of measurement of local hydrodynamic parameters, which is very important to understand what is really happening inside the reactor and to design it more efficiently. Investigations are aimed at developing an optical fibre probe setup which may measure the local hydrodynamic parameters of these reactors.

Keywords- Trichel bed reactor, Optical fiber probe, Hydrodynamic parameters, gas hold up, bubble frequency

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I. INTRODUCTION

A light reflection probe detects the light reflected at probe tip or in phase around the probe tip. Optical fibre probe is made from optical fibre, a part of cladding is peeled off and fibre is bent to make a U shaped tip probe. This tip is inserted into the reactor to measure hydrodynamic parameters. From one side of fibre light is made to enter. It is then totally internally reflected multiple times, until it reaches the probe tip. From tip light is reflected back or is refracted on the basis whether gas or liquid respectively is present around the tip. Then the reflected light again undergoes through multiple TIR and is then received at the other end of the fibre.

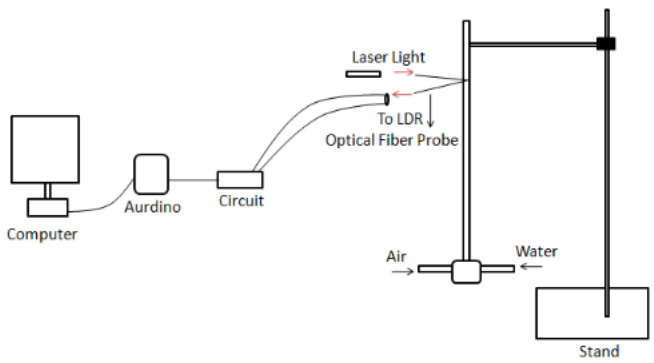

Fig. 1: Line Diagram of Setup for Analysis of Optical Fibre Probe

The experimental setup was made with a 1 meter long and 4.5 mm internal diameter capillary, and water & air inlets were provided at the bottom. The setup was operated in co-current up-flow and continuous mode, using air as gas phase and water as liquid phase. Water and air together entered the capillary at the bottom and were discharged to drain from top which is open to atmosphere. Figure 1 shows the line diagram for the Experimental Set up constructed for investigation.

II. MEASUREMENTS

For measuring the hydrodynamics of the system, optical probe technique is adopted. Two probes were inserted into the capillary at a distance of 4.7 cm from each other. One end of fibre probe is attached to laser and other end to LDR which is connected to the electronic unit.

Graphs obtained were saved in computer for analysis. Camera was used for video recording the experiments.

Fig. 2: picture showing slug flow regime in capillary at a liquid glow rate of 2LPH and gas flow rate of 0.5 LPH

III. RESULTS

Many readings were taken for different air and water flow rates and video were also made for the same experiment simultaneously. Both were compared and it was seen that the peak was obtained at the same time when bubbles cross the probe and depths were obtained when liquid flows through the probe. Local velocity, gas holdup, bubble frequency etc. were calculated with the use of those graphs. So it can be concluded that optical fibre probe works efficiently for the given experimental conditions. Figure 3 shows the graphs obtained for 2.5 LPH Liquid flow rate and 20 LPH air flow rate.

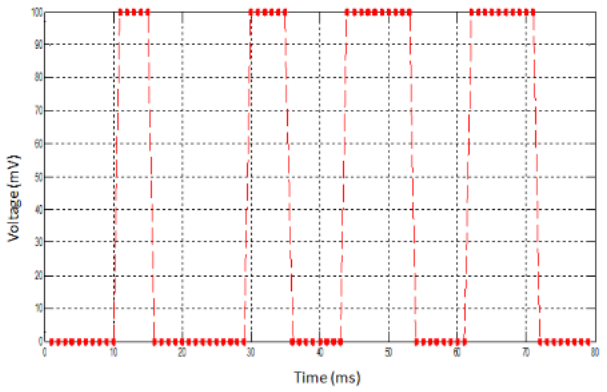

Fig. 3: Graph obtained between voltage signal and time for 2.5 LPH liquid flow rate and 20 LPH air flow rate

IV. CONCLUSION

We saw that there is a difference in voltage signal when probe faces bubbles and when it faces liquid. Hence this probe has been positively used to detect slug bubbles in capillary setup and calculate various hydrodynamic parameters like bubble velocity, bubble frequency and gas hold up. When probe was incorporated in trickle bed reactor it also showed difference in voltage signal but was not able to capture them efficiently so no germane inference could be made. An optical fibre probe with more sophisticated electronic unit may have the potential to measure local hydrodynamic parameters of trickle bed reactor and hence it offers scope for future work.

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