STUDIES ON TRICKLE BED REACTORS

By

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CERTIFICATE

This is to certify that this thesis entitled **Studies on Trickle Bed Reactors** being submitted by **Anil Kumar Saroha** to the Indian Institute of Technology, Delhi for the award of the degree of Doctor of Philosophy is a record of bonafide research work carried out by him. Anil Kumar Saroha has worked under my supervision and has fulfilled the requirement for the submission of the thesis.

The results contained in this thesis have not been submitted in part or in full, to any other university or Institute for the award of any degree or diploma.

KNigam

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ABSTRACT

Trickle bed reactor implies a reactor in which a liquid phase and a gas phase flow concurrently downward through a fixed bed of catalyst particles while reaction takes place. The major processes carried out in trickle bed reactors are hydrotreating, hydrocracking, hydrodesulphurisation, hydrodenitrogenation, hydrodewaxing, hydrodemetallisation and hydrofinishing. Trickle bed reactors also find applications in chemical and biochemical industries.

An exhaustive literature survey on the hydrodynamic parameters of trickle bed reactors was carried out. The major hydrodynamic parameter covered were flow regimes, two-phase pressure drop, liquid saturation, liquid distribution, heat transfer, mass transfer and wetting efficiency. It can be concluded from literature review that most of the literature on trickle bed reactors corresponds to the experiments performed at atmospheric pressure. As the trickle bed reactors are operated at a pressure of 25-40 MPa, the correlations proposed by various investigators for atmospheric pressure cannot be used in the design of trickle bed reactors.

Experiments should be performed with such gas-liquid systems whose physical properties match with that of the reaction condition in an industrial trickle bed reactor. The packing should be porous in nature instead of glass beads or Raschig rings. Most of the experiments have been performed at laboratory scale reactors (< 20 cm ID). Efforts should be made to perform experiments in a pilot scale reactor. As the industrial trickle bed reactors are normally operated under adiabatic

conditions, efforts should be made to operate the pilot scale reactors adiabatically because temperature influences the conversion and selectivity.

Liquid distribution studies were carried out in a 15.2 cm (ID) glass column packed with 1.5 mm diameter commercial alumina extrudates. Experimental data on liquid distribution was obtained with water, kerosene, ethylene glycol and water doped with surfactant as liquid phase and air as gas phase. The effect of liquid and gas flow rates on wall flow was studied. The influence of liquid surface tension and density was also investigated. Increase in liquid and gas flow rate was found to reduce the liquid flow in outermost annulus. Wall flow was found to decrease with decrease in liquid surface tension. It was further noticed that decrease in liquid density improves liquid distribution. The model for liquid distribution proposed by Herskowitz and Smith (AIChEJ, 24, 442, 1978) has been modified to incorporate the effect of particle orientation. Model parameters have been correlated with liquid and gas flow rates as well as liquid surface tension.

The residence time distribution (RTD) for liquid phase in a trickle bed reactor has been experimentally studied for air-water system. It was noticed from the literature that most of the experimental studies on liquid phase axial dispersion were carried out using small diameter columns (< 15 cm) and also diameter of column to particle ratio less than 25. It was also observed that most of the experiments have been performed using nonporous packings. Therefore to obtain reliable data, experiments were performed in a 15.2 cm diameter column using commercial alumina extrudates with diameter of column to particle ratio equal to 75 to eliminate the radial flow differences. Congored dye was used as a tracer and the concentration of the tracer was analysed continuously using a liquid spectrophotometer. The axial dispersion model was used to compute axial dispersion coefficient.

The liquid axial dispersion coefficient was computed in terms of Bodenstein number. No significant effect of gas phase was observed on Bodenstein number. The experimental values of Bodenstein number are lower as compared to the correlations reported in the literature. The probable reason for this discrepancy can be the nature of packing used in this study. It may be noted that all the studies reported in the literature were performed using nonporous packings while in the present study porous alumina extrudates were used. It can be concluded from the experimental results that the Bodenstein number is about two times lower for porous packings as compared to nonporous packings.

The residence time distribution information was used to compute the total liquid holdup. The total liquid holdup was found to increase with increase in liquid flow rate and decrease with increase in gas flow rate. The total liquid holdup obtained using pulse tracer technique was found to be lower as compared to the liquid holdup determined by weighing method. A correlation has been proposed for estimating total liquid holdup.

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