

188a Effect of Flow Maldistribution on Multiphase Monolith Reactor Performance

Shaibal Roy and Muthanna Al-Dahhan

Solid catalyzed gas-liquid reactions have long been an important part of the Chemical Process Industries. Trickle beds, slurry, slurry bubble column etc. are typical examples of conventional reactors in which such multiphase reactions are carried out. In the last couple of decades, researchers have looked to alternative configurations to overcome some of the shortcomings of the existing conventional reactors. Monolith structured packing reactor has been proposed as one of the new configurations for multiphase catalyzed reactors (Boger et al, 2003). Even though significant progress has been made in the field of gas-liquid catalytic monolith reactor, there are still challenging issues associated with these investigations, most importantly the flow distribution across monoliths. Most researchers have assumed completely uniform gas and liquid distribution at the top of the monolith. However, experimental evidence to support such claims is rare. On the contrary, several researchers have shown (Mewes et al., 1999; Gladden et al., 2003; Heibel et al., 2003) that depending on the type of liquid distributor and gas and liquid superficial velocities, there could be significant maldistribution of phases leading to underutilization of catalytic channels. Therefore, to extract maximum productivity from a catalytic monolith reactor, proper investigation of flow distribution, and the factors affecting the distribution, is essential. Such study will tell us the optimum flow conditions and the distributor type which will maximize the reactor productivity. The present study investigates the factors affecting flow distribution across a 400 cpsi monolith having three different solid fractions, operating in gas-liquid cocurrent downflow mode. Specifically, a computed tomograph is used to determine the liquid saturation in each monolith channel at a range of gas and liquid superficial velocities within the slug flow regime. Gas and liquid superficial velocities range from 10 to 50 cm/s and 2.5 to 50 cm/s respectively. Three different liquid distributors, viz. Nozzle, showerhead and foam are evaluated for their effectiveness in achieving uniform distribution across the monolith. For each liquid velocities, an optimum distributor height from the monolith top is determined which gives closest to uniform phase distribution. In all measurements, the uniformity of phase distributor is measured using a newly developed statistical method and expressed as uniformity factor (Shaibal et al., 2004). The results show that within the range of gas and liquid superficial velocities investigated, there exists a window of operating conditions (intermediate gas and liquid velocities) which corresponds to a close to uniform phase distribution. Within this window of flow conditions, a liquid saturation correlation based on drift-flux model with the distribution parameter proposed by Ishii (1977) fitted well with the experimental values of liquid saturation.

Keywords: Monolith, Flow distribution, Liquid saturation, Computed tomography

Reference

Boger T., AK Heibel, CM Sorensen, Monolithic Catalyst for the Chemical Industry, Ind. Engg. Chem. Res., (2004)

Heibel AK, FJ Vergeldf, H van As, F Kapteijn, J Moulijn, T. Boger, Gas and liquid distribution in the monolith film flow reactor, AIChE J. 2003;, 49(12): 3007-3017

Ishii M., One-dimensional drift-flux model and constitutive equations for relative motions between phases in various two phase flow regimes, 1977; ANL Report ANL-77-47

Mewes D, T Loser and M Millies, Modelling of two-phase flow in packings and monoliths. Chemical Engineering Science. 1999; 54(21): 4729-4747

Gladden LF, MHM Lim, MD Mantle, AJ Sederman & H Stitt, MRI visualisation of two-phase flow in structured supports and trickle-bed reactors. *Catalysis Today*, 2003; 79-80: 203-210.

Roy S, A Kemoun, MH Al-Dahhan, MP Dudukovic, TB Skourlis, & FM Dautzenberg, Countercurrent flow distribution in structured packing via computed tomography. *Chemical Engineering and Processing.*, 44, 59-69, 2004