LOADING METHODOLOGIES AND IMPACT ON PACKING CONFIGURATIONS

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Abstract

Packing algorithm for catalyst particles has been developed using force-displacement models. Structures for spherical and cylindrical catalyst packing are simulated and compared with experimental values. Impact of loading methods on packing configurations is elucidated. The reactor wall affects the porosity variation in packed beds. In addition the cylindrical packing seems to undergo orientation ordering which modify the flow pattern. Impact of loading methodologies on evolution of radial porosity features is evaluated using these algorithms. These investigations help in developing tools to manipulate the heterogeneities in packed beds to mitigate maldistribution and enhance reactor performance

Keywords

Packing, cylinders, catalyst, packed bed reactors.

Introduction

Multiphase reactors with solid catalysts are the most prevalent class of reactors in industry. With simultaneous interplay of heat, mass and fluid flow coupled with reaction, these reactors make many of the otherwise process economically and technically feasible. The solid packing in these reactors has multifold importance on the overall behavior of the reactor. The contact patterns among the different phases, access to catalyst surface, pressure drop and heat removal in the reactor and overall conversion are strongly influenced by the catalyst packing are crucial in these reactors. Some aspects that seem to be significantly affected by particle stacking are that of liquid spreading, liquid maldistribution and pressure drop (Mansour Bazmi, Hashemabadi, & Bayat(2013),M. Bazmi, Hashemabadi, & Bayat(2013),M. Bazmi, Hashemabadi, & Bayat(2012)). Specifically in the case of cylindrical particles the orientation of particles results in different flow patterns and conversions (Dixon(2014)). In this study, an attempt has been made to develop packing structure for the non-trivial yet industrially relevant case of cylindrical extrudates packing elements.

Mathematical Model

The model studied by Marek (2013) has been used in this investigation to analyze cylinder packing. The model works on the principle of contact detection, followed by calculation of force and moment (in case of cylinders) and resultant displacement over a finite interval of time. Contact detection is trivial for spheres, however the scenario of cylinders is complex Discrete Shape Representation (Kodam et al. (2010)) is used as a viable methodology to calculate cylinder overlap.

This procedure is repeated until the particle reaches mechanical equilibrium. In order to ensure the particle has reached equilibrium another iteration of gravity driven motion is performed. In case the particle is destabilized the calculations are repeated, however if particle stabilizes, the particle is assumed to achieve final stability Simulations were performed for three different loading methodologies

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(Uniform, Sock and Wall loading) frequently practiced in industry.

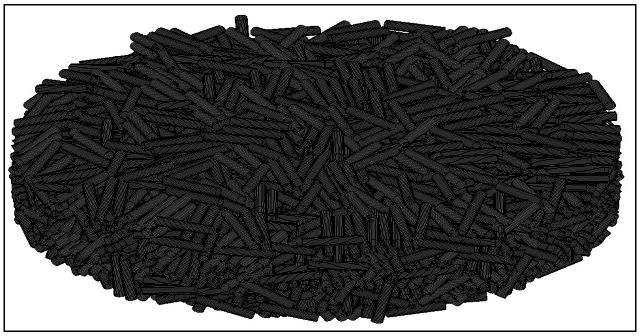

Figure 1. Schematic of extrudate packing

Results

Figure 1 presents a typical bed structure generated in this study. Two important aspects that have been looked at in these simulations are that of wall ordering and radial porosity variation.

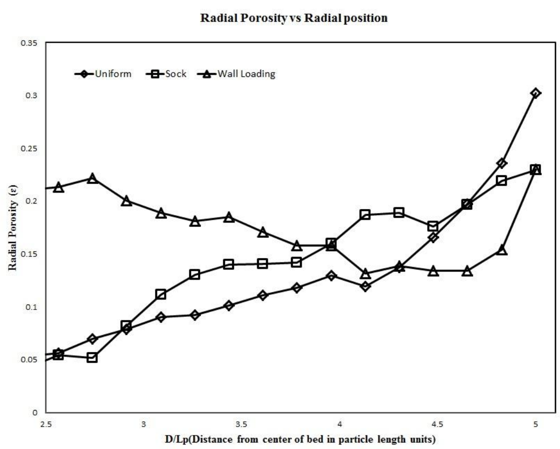

Figure 2. Radial porosity across the bed section

The radial porosity gradients tend to create preferential wall flow patterns which lead to maldistribution and under utilisation of the reactor. By varying the loading methodologies, much more flatter porosity profiles can be generated resulting in better irrigation densities for the bed

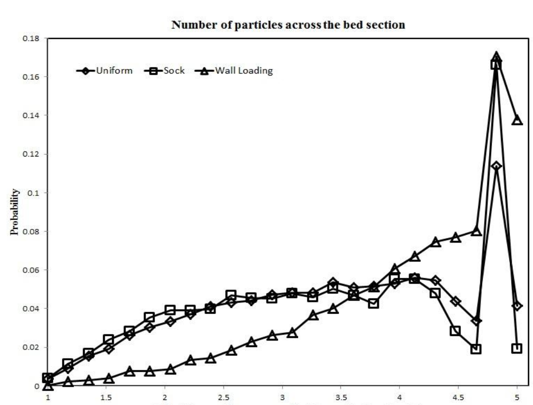

Figure 3.Ordering of particles in adjacency of wall

Cylinder orientation around wall affects the flow patterns and the catalytic activity due to the difference in the surface area exposed to the fluid flow. Wall loading and Sock loading prefer to align the particles horizontally along the wall and induce a patterning compared to random orientation of Uniform loading.

Conclusions and Future Work

In this work an attempt has been made to understand the impact of loading methodologies on particle packing in fixed beds. Loading methodologies tend to produce different porosity profiles and orientation ordering in cylindrical particles and hence impact the overall ordering. These packing structures can be used for understanding flow evolution and heat transfer in packed beds.The effect of bed diameter and particle size distribution on packing structure will also be taken up in future.

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