Does shape matter? FEMDEM estimations of strength and post failure behaviour of catalyst supports

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ABSTRACT

The catalysts typically employed for fixed-bed reactors contain an active metal component supported on porous materials with a high surface area, most commonly alumina (aluminium oxide, Al_2O_3). To maximise the available surface area and increase heat transfer, these supports can be shaped as cylindrical pellets, balls or more complex configurations. In conventional reforming processes, reaction temperatures in the 700-900 °C range are required to react with most of the hydrocarbon gas. For this reason the bundles of steel tubes are suspended in a heated chamber, typically at a temperature of 1,000 °C.

A better understanding of fracture propagation in packed structures of ceramic bodies is crucial to the development of new strategies to reduce the accumulation of catalyst fragments and to extend the lifetime of reactors, and further innovations in fixed-bed reactor technology.

In this work the effects of the catalyst support shapes on their final strength and fragmentation behaviour are investigated through controlled experiments and numerical simulations. Uniaxial compression tests and high-speed video recordings are employed to estimate the strength and fragment size distributions respectively. The combined finite-discrete element method (FEM-DEM) implemented in Solidity is employed to simulate the effects of geometrical features and loading orientation on the pre- and post-failure behaviour of catalyst supports.

REFERENCES

[1] Xiang J., Latham J.P. and Farsi A. *Algorithms and capabilities of Solidity to simulate interactions and packing of complex shapes.* 7th International Conference on Discrete Element Methods (2016).

[2] Farsi A., Xiang J., Latham J.P., Carlsson M., Stitt E.H. and Marigo M. *Simulation and characterisation of packed columns for cylindrical catalyst supports and other complex-shaped bodies.* 7th International Conference on Discrete Element Methods (2016).

[3] Farsi A., Xiang J., Latham J.P., Pullen A.D., Carlsson M., Stitt E.H. and Marigo M. *An application of the finite-discrete element method in the simulation of ceramic breakage: Methodology for a validation study for alumina specimens.* 4th International Conference on Particle-based Methods (2015).