Hydrodynamic and heat transfer characterization in a packed bed reactors with low tube to particle diameter ratio

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The adequate modeling of industrial packed bed catalytic reactors with low tube to particle diameter ratio (PBR-LTP) requires a reliable characterization of both kinetics and the transport phenomena [1, 2]. Although in literature there are several contributions trying to describe the behavior of PBR-LTP, where highly exothermic reactions occur, to this day, there is not a general model able to describe their industrial performance. Besides, due to the today need developing new industrial processes with low environmental and economic impact in the production of chemical intermediaries, namely phthalic anhydride [1], ethylene oxide or ethylene [3], industry and academy have focused their effort trying to develop a generalized model able to describe multi-tubular PBR-LTP. In this sense, this contribution is aimed at identifying, based on an exhaustive literature survey, main experimental and theoretical uncertainties when describing heat transfer in PBR-LTP, which includes the hydrodynamics description, and hence at proposing a reliable methodology to properly characterize heat transfer mechanisms in these systems. Several issues that question the reliability of published heat transfer studies are elucidated herein. These issues are analyzed from experimental and theoretical perspectives. A proposal to overcome heat transfer uncertainties is also analyzed in this contribution. Some results are presented next. Figure 1 shows the prediction of several heat transfer approaches to describe two radial temperature profiles at two axial positions in a PBR-LTP, this approaches consider a plug flow or an axial velocity profile in the axial convective term of the heat balance, as well as the effect of the radial velocity. Figure 2 shows the dynamic temperature profile of a pseudo-homogeneous and pseudo-heterogeneous model for a PBR-LTP. These figures elucidate the lack of heat transfer approaches describing radial temperature profiles and transitory temperature profiles.

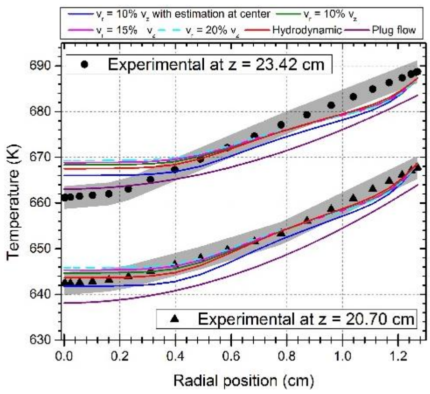

Figure 1. Approaches to describe radial temperature profiles of a PBR-LTP at two axial positions.

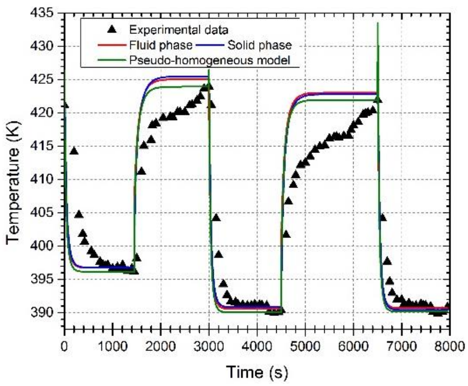

Figure 2. Dynamic temperature profile with a pseudo-homogeneous and pseudo-heterogeneous model.

References
[1] Castillo-Araiza, C.O. and López-Isunza, F., Ind. Eng. Chem. Res., 49, (2010), 6845-6853.
[2] G. F. Froment, Ind. & Eng. Chem., 59 (1967) 18-27.
[3] G. Che-Galicia, et al., Chem. Eng. J., 280 (2015) 682-694.

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