

Novel Joule-heated Reactor based on Radial Current and Flow for the Intensification of Endothermic Catalytic Processes

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Abstract

Electrification of Steam Methane Reforming (eSMR) is a promising route towards the decarbonization of H₂ production. In this work we address a major topical challenge of SMR, i.e., tuning the local heat supply to the varying heat demand of the endothermic reaction. To this scope, we propose a novel eSMR reactor configuration based on centrifugal gas flow across an open-cell foam directly Joule-heated by radial electric current and packed with catalyst particles (EMERALD concept) [1]. Comparative simulations were carried out for EMERALD packed foam reactors, employing the hybrid heterogeneous approach outlined in [2]. According to a hierarchical approach, the 3D CFD simulations were used to derive correlations and parameters for 1D and 2D porous media models [3].

Figure 1 shows simulation results for a Joule heated SiSiC foam packed with Rh-based catalyst particles ($d_p = 1$ mm), operated at inlet temperature = 773 K, outlet pressure = 7 bar, fed with H₂O:CH₄ = 2.5:1, GHSV = 20 NI/h/gcat, reactor volume = 21.4 L, with power input = 234 kW. The EMERALD configuration essentially eliminates the cold spot in the reactor entry region thanks to a specific power input (solid black line) which is maximum at the entrance of the catalytic bed and decreases with $1/r^2$ (at constant electrical resistivity), thus closely matching the profile of reaction heat demand.

We will report on the experimental investigation of a lab-scale prototype currently ongoing at Politecnico's facilities (Fig. 2).

Acknowledgments. The authors acknowledge Air Liquide for their support of this research.

References

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- [3] Micale, D.; Ferroni, C.; Uglietti, R.; Bracconi, M.; Maestri, M.; *Chem. Ing. Tech.* 2022, 94, 634-651.

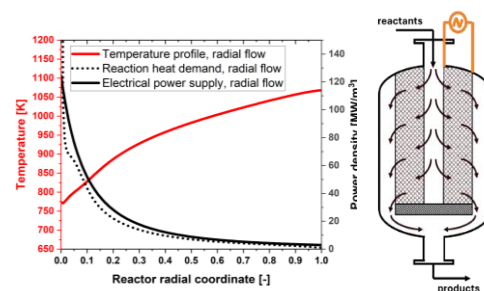


Figure 1. Simulation results for eSMR in the EMERALD reactor.

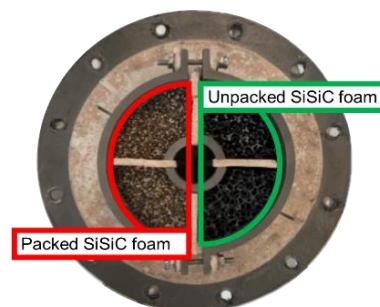


Figure 2. Lab-scale EMERALD reactor.