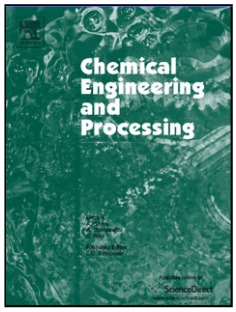

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CFD simulation of single-phase heat transfer in a rotor-stator spinning disc reactor

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Abstract

A computational fluid dynamics (CFD) study on hydrodynamics and heat transfer in a rotor-stator spinning disc reactor (RSSDR), an inventive reactor technology engineered within the frame of process intensification, was performed with OpenFOAM®. This allows the investigation of locally resolved temperature profiles and heat transfer coefficients in the reactor gap, which is experimentally difficult for RSSDRs with small dimensions, while keeping computational costs low. The retrieved radial and tangential velocity and temperature profiles are in agreement with literature. Local stator-side heat transfer coefficients were determined, which increase with higher disc speeds and with increasing throughputs. Area-averaged heat transfer coefficients across the reactor gap were calculated and validated against experimental results performed on the setup simulated in this study; the numerical and experimental data are in qualitative agreement. This study presents the possibility to characterize an RSSDR in terms of hydrodynamics and heat transfer properties by means of a two-dimensional axisymmetric geometry and Reynolds-averaged Navier-Stokes (RANS) turbulence modeling in OpenFOAM®. Expensive measurements, which are difficult to perform particularly for RSSDRs with small dimensions, could thus be avoided, simulating industrial applications at the conditions of interest and designing the RSSDR setup accordingly.

Keywords: Rotor-stator spinning disc reactor, heat transfer, local temperature distribution, computational fluid dynamics, process intensification.

Abbreviations: CFD, computational fluid dynamics; LES, large eddy simulation; PI, process intensification; RANS, Reynolds-averaged Navier-Stokes; RSM, Reynolds stress model; RSSDR, rotor-stator spinning disc reactor; SDR, spinning disc reactor; SIMPLE, semi-implicit method for pressure-linked equations; 2.5D, two-dimensional axisymmetric