Stator heat transfer in a multistage rotor-stator spinning disc reactor

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Abstract title	STATOR HEAT TRANSFER IN A MULTISTAGE ROTOR-STATOR SPINNING DISC REACTOR
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Background and aims

Previous research in our laboratory showed that high gas-liquid and liquid-solid mass transfer rates can be achieved in the rotor-stator spinning disc reactor (SDR) [1,2]. Further research in the possibilities for scaling up the SDR has shown the potential of the multistage rotor-stator spinning disc reactor (MSDR) mainly for mass transfer limited and highly exothermic multiphase reactions[3,4]. To investigate the potential of the MSDR for highly exothermic multiphase reactions, the present work describes the fluid-stator heat transfer in the MSDR for single and multiphase flows.

Experimental approach

The MSDR setup was described in detail in literature[4]. Hot fluid (liquid and gas-liquid) was fed at the top to the rotor side of the MSDR. Cold fluid (liquid) was fed countercurrent to the hot fluid, at the bottom of the reactor to the internal channels of the stator. Fluid temperatures were measured directly at the two in- and outlets of the reactor as well as at each stage. Heat transfer characteristics were determined for a range of fluid velocities and temperatures, gas-liquid ratios and rotational velocities.

Results

Measurements of single phase (liquid) heat transfer in the MSDR showed a strong increase of fluid-stator heat transfer with rotational velocity. Dimensionless heat transfer coefficients increased from $Nu_s = 600$ at $Re_\theta = 0$ to $Nu_s = 2000$ at $Re_\theta = 1.5*10^5$ with a throughflow of $2.8*10^5$. Extrapolation to zero throughflow yielded Nusselt numbers closely resembling values in literature[5]. The single phase heat transfer coefficient is expected to increase further at higher rotational velocities, but the overall heat transfer coefficient in the current experimental setup is limited due to poor heat transfer in the stator cooling channels.

The addition of gas to the rotor side of the MSDR (up to 50% by volume) resulted in a decrease of the heat transfer coefficient of up to 30% compared to the single phase flow when no rotation was present. This was attributed to the lower thermal conductivity of gas compared to liquid. It was found that at higher rotational velocities the detrimental effect of the gas phase on heat transfer towards the stator decreased. At approximately 150 rad s^{-1} heat transfer towards the stator was again no longer limiting. This was explained by the low gas holdup encountered in the MSDR[1].

Conclusions

The MSDR was evaluated for performing highly exothermic reactions. It was found that for single phase reactions the heat transfer in the stator cooling channels will be limiting even at low rotational velocities; a better thermal design can greatly increase the performance. For gas-liquid flow at the rotor side it was found that rotation enhances the heat transfer by decreasing the gas holdup as expected.

1. Meeuwse *et al.*, *CES* **65** 466 (2010).

2. Meeuwse *et al.*, *I&ECR* **49** 10751 (2010).

3. Meeuwse *et al.*, *CEP:PI* **50** 1095 (2011).

4. Meeuwse *et al.*, *AIChE Journal* **58**, 247 (2012).

5. Howey *et al.*, *IJHMT* **53**, 491 (2010).

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