Numerical analysis was carried for novel configuration of high temperature PFHE. The current study has hot channel (helium), cold channel (SO₂, SO₃, O₂ and water vapor) and separating solid (SiC). Rectangular, triangular, bolt type and ripsaw fin designs were modeled. Recirculation were formed at the end of each fins. Pressure drop and avg. Nusselt number for square and triangular fins are 15.12 Pa, 18.54 Pa and 3.490, 3.00. Adding more fins increases surface area density which in turn increases heat transfer rate.

Results and discussions

Horseshoe vortices were formed which were looped around the cylinder and then gradually trails off as the fluid reaches the outlet. Pressure drop and avg. Nusselt number for the bolt-type fins are 31.54 Pa, 22.22 Pa and 3.10, 2.88.

Bolt-type fins

Recirculation were formed at the end of each fins. Pressure drop and avg. Nusselt number for square and triangular fins are 15.12 Pa, 18.54 Pa and 3.490, 3.00. Adding more fins increases surface area density which in turn increases heat transfer rate.

Future work

Analytical studies are being done for all the fin configurations. Structural modeling and chemical reactions have to be done in order to find the best fin design of plate-fin heat exchanger.

References


Introduction

Square and triangular fins

No recirculation formed in between the fins. Highest heat transfer and lowest pressure drop was obtained for the ripsaw fins. The pressure drop and avg. Nusselt number for the ripsaw fin with 0.5 mm thickness is 16.38 Pa and 4.215. Parametric study was carried out for the selected ripsaw fin design. They are done to find the effects of friction factor and average Nusselt number for different Reynolds number.

Eyelid type and Ripsaw fins

Parametric studies

Meshing and validation

Meshing was done in Ansys Workbench. Selected number of nodes and faces for ripsaw fin design were 532,599 and 1,496,152. The heat exchanger dimensions were taken from Ponyavin et al. and they are in the order of few millimeters. The mass flow rate for the cold flow was 3.148×10⁻⁶ kg/s and the hot flow was 1.409×10⁻⁶ kg/s for a single channel. Heat transfer and friction factor results for rectangular and ripsaw fin designs were validated with the correlations obtained from Manson.

Geometry of various fin designs

Nine different fin designs with single-banking configuration were modeled. The current study has hot channel (helium), cold channel (SO₂, SO₃, O₂ and water vapor) and separating solid (SiC). Ripsaw fin design with thickness of 0.05 mm gives maximum heat transfer with less pressure drop and friction factor.

Meshing and validation

Meshing was done in Ansys Workbench. Selected number of nodes and faces for ripsaw fin design were 532,599 and 1,496,152. The heat exchanger dimensions were taken from Ponyavin et al. and they are in the order of few millimeters. The mass flow rate for the cold flow was 3.148×10⁻⁶ kg/s and the hot flow was 1.409×10⁻⁶ kg/s for a single channel. Heat transfer and friction factor results for rectangular and ripsaw fin designs were validated with the correlations obtained from Manson.

Results and discussions