CFD study on heat transfer and pressure drop characteristics of offset strip-fin heat exchangers in helium systems

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Background
Plate-fin heat exchanger is a kind of the compact heat exchangers, which has high coefficient of heat transfer and large specific surface. The offset strip fins are widely used in the large scale cryogenic helium plants to meet the demands for saving energy and resources. In dynamic simulation of the large scale helium cryogenic systems, the j and f factors are needed parameters. However, the current available correlations were obtained on the occasion that air was taken as heat transfer medium. Moreover, the correlations in the open literatures are quite different even with same Re and geometries of fins. Therefore, it's necessary to derive the suitable correlations in helium systems.

Objectives
- To obtain the suitable correlations of j and f factors used in helium offset strip – fin heat exchangers in low temperature.
- To study the inner flow pattern of the offset strip – fin heat exchangers

Methods
Usually, the fin channel is assumed to be rectangular, and the fin offset is uniform and equal to half-fin spacing.

In order to ignore the entrance effect, the extension section is established at the inlet and outlet of the fluid domain. Upstream section locates at 1.5 times hydraulic diameter from first fin in the flow direction while the downstream section sets at 5 times hydraulic diameter from the last fin.

Results

The pressure drop of model is tend to constant when the grid number is more than 800000. Hence, this grid number was chosen to calculate the j and f factors.

Conclusion
- The correlations for j and f factors of helium offset strip-fin heat exchanger had been developed by the multiple regression analysis, which can predict 94.5\% of the f data and 92.7\% of the j data for laminar region, and 95.4\% of the f data and 90.9\% of the j data for the turbulent regime within \pm 20\% derivation.
- The simulation results denoted that extraction section was applicable in solving the heat transfer and fluid flow problems to ignore the entrance effect.
- The simulation results will provide a selection in the design and dynamic simulation of the offset strip fin heat exchangers in helium systems.

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The inner flow analysis of the model

One of the advantages of the numerical method is that it can be used to observe the flow pattern in every part of the model.

The contour of velocity didn't show the periodicity for the first eight fins because of the entrance effect. After the 8th fins, the flow field features get steady.

The top view and axonometric drawing of computation domain

Comparison between the regression data and the CFD results in laminar and turbulent region

Comparison of correlation for f and j by correlations with CFD results in laminar region

Comparison of correlation for f and j by correlations with CFD results in turbulent region

Flow velocity contours when Re=462

Flow velocity contours when Re=4560

Flow velocity contours when Re=2000