MIGRATE2017:153702

ADVANCED CFD METHODOLOGY TO SIMULATE HIGH TEMPERATURE MICRO HEAT EXCHANGERS.

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KEY WORDS

Conjugate heat transfer, Micro channels, Counter flow.

ABSTRACT

The objective of this research is to predict a micro heat exchanger performance from a detailed modelling of microchannels and a new methodology to assess the full heat exchanger characteristics based on reduced order modelling. The heat exchanger is made as a pile of counter flow flow passages with optimised thickness separated by thin foils. The flow passages are delimited by frames with integrated collectors. Geometries of both frames are identical, and they are positioned on top of each other by mirroring. A metallic wire mesh is inserted in the flow passages to provide the required thickness and stiffness for the microchannels. This also helps in enhancing the efficiency of the heat exchanger. Due to the complexity of the geometry and intricate channels, it is difficult to numerically simulate the entire heat exchanger. Appropriate CFD hypotheses are required to reduce the very high computational cost which would result from a full heat exchanger model.

The reduced model consists of collectors and microchannels, modelled through a porous medium approximation [1]. The reduce model approximation based on the Darcy Forchheimer law [2] gives the pressure losses depending on the mass flow. Temperature drop in the microchannels is 700-850 K. Pressure and temperature drop across the microchannel of the reduced model is reproduced by the porous medium approximation and source term implementation. The Darcy- Forchheimer law is modified (to calculate the porous medium coefficients) [3] to account for the temperature evolution in the heat exchanger. Several computations of the microchannel using 3D CFD-CHT (Conjugate Heat Transfer) modelling are performed at various inlet stream velocities. The resulting Pressure drop-velocity relation (from CHT analysis of microchannels) is used to calculate the porous medium parameters. Porous medium parameters, inertial and viscous coefficients [4] were calculated using three different approaches. They have been implemented and verified. The best-revised methodology allows to obtain pressure losses with less than two percent error with respect to the 3D CFD-CHT modelling. Counter-flow microchannel arrangement (**Figure 1, a**), computational CHT domain (**Figure 1, b**) together with reduced model (**Figure 1, c**), is shown in **Figure 1**.

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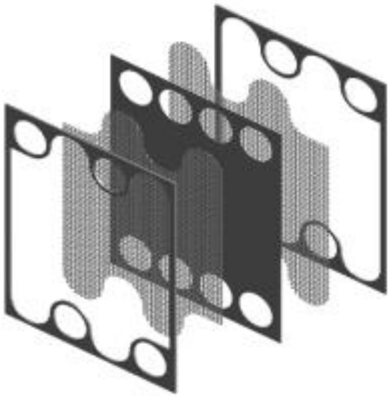
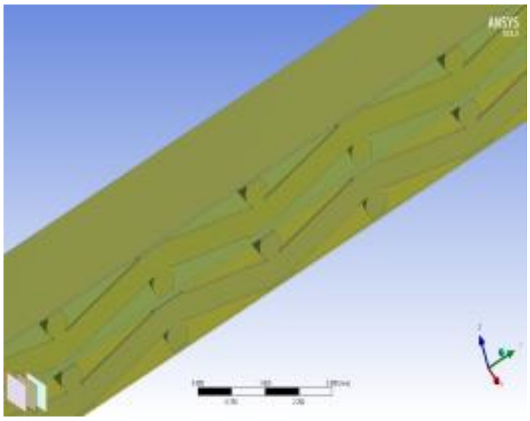
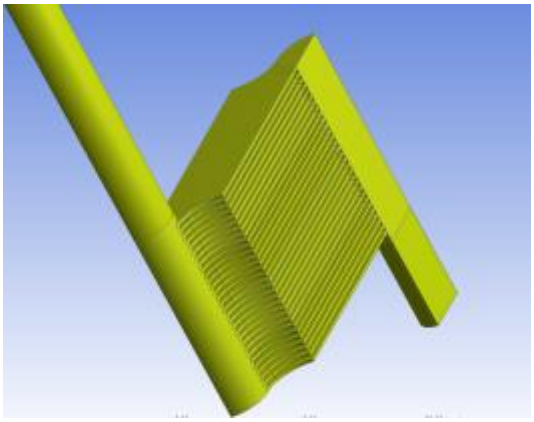


a: Counter flow heat exchanger arrangement



b: Conjugate Heat Transfer computational model



c: Computational domain for collectors with micro channels.

Figure 1

A parametric study was carried out considering the effect of the wire mesh geometry, foil thickness and microchannel length. Reynolds number based on inlet is between 30-300 (for micro-channels), 2000-30000 (for secondary collectors) and even higher for Primary collectors. Microchannel porosity (75%) can enhance localised turbulence at smaller Reynolds numbers. Since the Knudsen number is low, thermal creep or rarefaction effects are negligible. An optimum microchannel mass flow is found to ensure the highest thermal efficiency and seems to be quite independent of the microchannel parameters. It is a function of localized turbulence [5] produced near the net intersections. This is due to the high wall normal fluctuations created by net intersections. Higher order turbulence model, (Reynolds stress model) was used to investigate the wired net intersection effect on turbulence for various mass flows.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 643095.

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