Heat Transfer in Crossflow Heat Exchangers for Microreactors

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Introduction: Microreactors with integral heat exchangers are used in the production of new and exotic chemicals. We sought improvements in the heat transfer coefficient in a cross-flow heat exchanger for use with microreactors. Both material and structural changes would contribute to the solution.

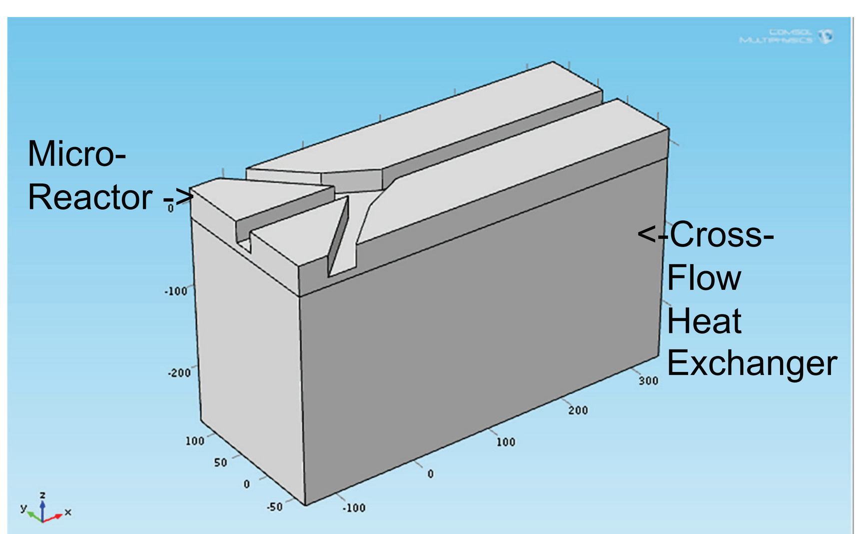

Figure 1. Microreactor System

Use of COMSOL Multiphysics: This derivation of the Cross-Flow Heat Exchanger model[1] from the COMSOL Models Library modifies the substrate geometry by adding two additional layers and uses the material copper in certain regions instead of stainless steel to improve heat transfer.

The conjugate heat transfer calculations in the Heat Transfer physics interface are used to calculate heat transfer in both liquids and solids with both conduction and convection heat transfer effects as the liquid coolant flows through the bi-metallic channels in the substrate. See Figure 2.

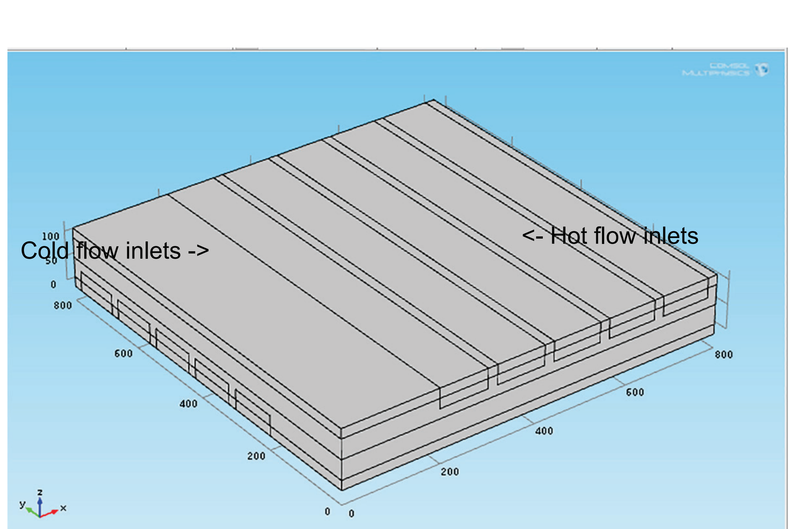

Figure 2. Cross-flow Heat Exchanger

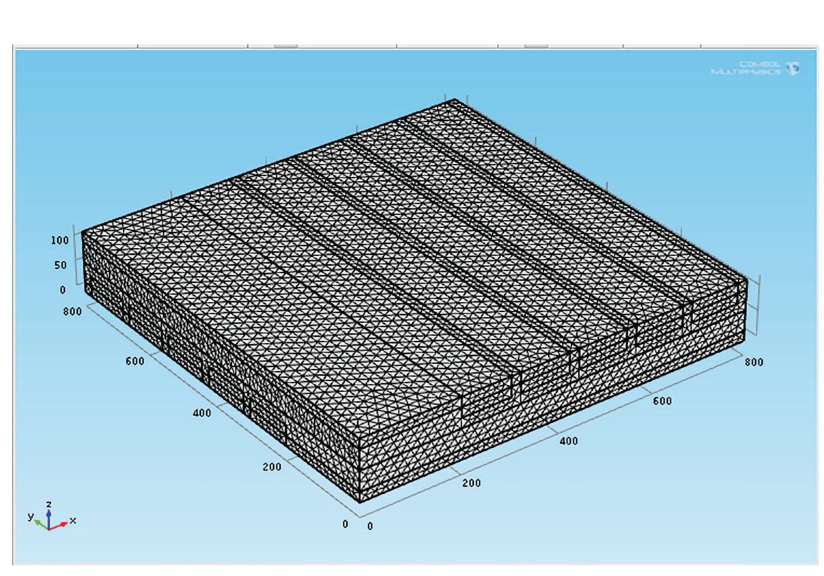

Figure 3. Meshed Cross-flow Heat Exchanger

This model employs a free tetrahedral mesh with custom parameters. See Figure 3.

Results: The incorporation of additional layers of copper in the center of the cross-flow heat exchanger geometry increased the heat transfer coefficient by a factor of approximately 26. Table 1 compares the heat transfer value for the all-stainless steel version to that of the stainless steel-copper version.

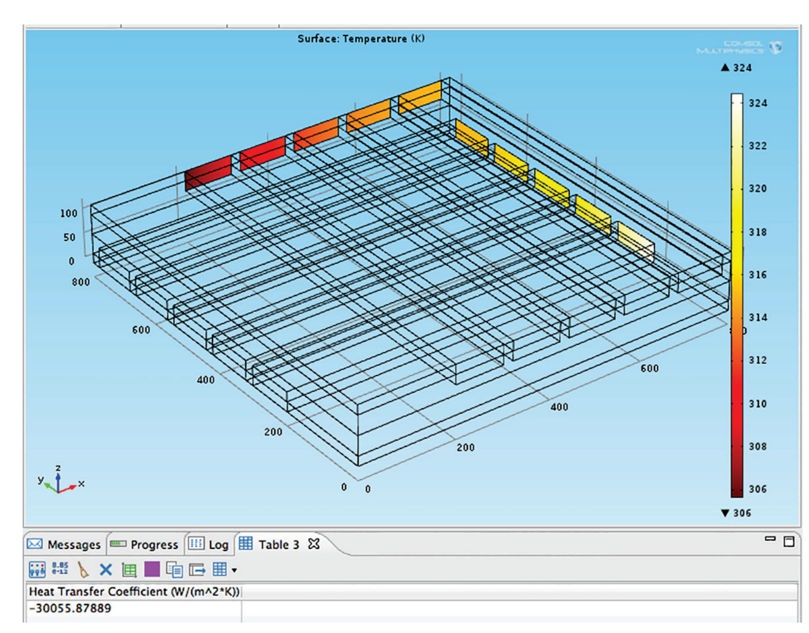

Figure 4. Outlet temperatures

Layers	Materials	H.T. Coeff.
2	Stainless Steel (SS)	1560 W/($m^2 \cdot$K) [1]
4	SS-Cu-Cu-SS	30055 W/($m^2 \cdot$K)

Table 1. Heat Transfer Coefficients

Figure 4 shows the temperature of the outlets of the modeled cross-flow heat exchanger and the calculated heat transfer coefficient (~ 30,056 W/m^2 K) for this structure.

Conclusions: The rate of heat transfer in a cross-flow heat exchanger is significantly increased through structural and materials design modifications.

Reference:

1. COMSOL, crossflow_heat_exchanger, COMSOL Model Library, COMSOL 4.4 (Build: 145), COMSOL Heat Transfer Module, Conjugate Heat Transfer