Numerical Analysis of Conjugate Heat Transfer in a Combustion Chamber and Firetubes

K. R. Anderson[1], C. Collizi[2]

[1]California State Polytechnic University, Pomona, CA, USA
[2]Cryoquip, Inc., Murrieta, CA, USA

Abstract

This paper presents results of an industry motivated problem to understand the conjugate heat transfer in an industrial heat exchanger. This paper will present the use of COMSOL for the numerical analysis of conjugate heat transfer in a combustion chamber and fire-tubes. The COMSOL Heat Transfer and CFD modules are used in the analysis. The heat transfer module is used to model the conjugate (conduction + convection) heat transfer set up by the gas flow which is modeled with the CFD module. Turbulent flow is modeling using the SST k-omega turbulence closure model. The analysis is used to quantity the heat transfer performance in a combustion chamber / fire-tube heat exchanger boiler head assembly. The main findings for the heat transfer coefficients (HTC) of the system are as follows: chamber 45 W/m^2-K, fire-tube 62.45 W/m^2-K, system average 56.73 W/m^2-K. The HTC values found by COMSOL analysis are used to update legacy hand-calculation based approximations of the HTC values. The model is also used to quantify the temperature distribution of the fire-tubes. Data for the distribution of temperature with length as a function of flow rate is presented. Plots of velocity contours and streamlines are used to illustrate and understand the flow path in the fire-tube manifold assembly.