ME 477: Finite Element Analysis
Fall 2007

ANSYS Assignment #4: Transient Thermal Analysis of a Heat Exchanger

The heat exchanger shown below is used to cool a motor. The coolant coming from the motor (hot fluid) runs through the block near a cold fluid coming from a separate reservoir. The base of the heat exchanger is mounted on an insulated surface (no heat transfer occurs across the base). The heat exchanger also utilizes fins along its top surface to increase heat transfer to the surrounding air through convection.

As shown in the figure below, the heat exchanger block is 54 mm wide by 80 mm high, and is sufficiently long that it can be analyzed using a 2D thermal analysis; i.e., heat flow in the third direction (into the paper) can be neglected. The five fins on the top surface are 6 mm thick, with 6 mm spacing between fins, rounded on the inner and outer edges with a 3 mm radius. The fins are 20 mm long. Both fluid channels have a diameter of 24 mm and are centered horizontally in the block.

The air temperature surrounding the heat exchanger is 300 K, and the convective heat transfer (film) coefficient can be assumed to be h = 400 W/m^2-K. This convection acts on all external surfaces except for the base, which is insulated. The temperature of the hot fluid is T_{hot} = 600 K, and the temperature of the cold fluid is T_{cold} = 285 K. The convective heat transfer coefficient of both fluids is h = 5000 W/m^2-K.

The heat exchanger is made of an aluminum alloy with the following thermal properties (density, ρ = 2702 kg/m^3):

Temperature (K)	200	300	400	600
Thermal Conductivity, k (W/m-K)	237	237	240	231
Specific Heat, c (J/kg-K)	798	903	949	1033

Using ANSYS, perform a transient thermal analysis of the heat exchanger using 2D, 8 node thermal solid (quadrilateral) elements (Plane 77). Assume an initial temperature for the heat exchanger of 300 K, and perform the analysis over a time period of at least 2 minutes. Assume the thermal loads (convections) are applied suddenly (stepped). Determine the temperature distribution in the exchanger after 2 minutes, and generate temperature vs. time plots for the hottest and coolest nodes in the heat exchanger, as well as the node at the top of the center fin. Determine the approximate length of time for the hottest node to reach 440 K. Based on your analysis, does it appear that the temperature of the heat exchanger has reached approximately steady-state conditions after 2 minutes?

Submit a *one-page typed summary* of your analysis, listing the results specified above. Also list the nonlinear solution parameters used in the analysis (i.e.; time step size, and max and min values if automatic time stepping was used, etc.). In addition, include the following plots: an element plot, a nodal temperature plot after 2 minutes, and a temperature vs. time plot for the nodes listed above.