ANSYS - Heat Conduction in a Cylinder

Heat Conduction in a Cylinder: Tips

Problem Specification

4. **MATLAB and ANSYS analysis of axisymmetric heat flow**

Consider axisymmetric radial heat flow by conduction through a homogenous hollow cylinder of inner radius R_i and outer radius R_o. If the cylinder is sufficiently long the end effects can be neglected. The governing equation is:

$$-\frac{\mathrm{d}}{\mathrm{d}r}\left(\kappa A \frac{\mathrm{d}T}{\mathrm{d}r}\right) = AQ \text{ for } R_i < r < R_o$$

where κ is the thermal conductivity, $A = 2\pi r L$ is the surface area at each radial location, L is the cylinder length, Q is the heat generation per unit volume, r is the radial coordinate, and T is the temperature. Heat flow q is

$$q = -\kappa A \frac{\mathrm{d}T}{\mathrm{d}r}.$$

(a) Using the following set of values, solve this problem in both MATLAB using `OneDBVP.m` and in ANSYS. Compare your results, being sure to make a note of what element types you're using, etc. $R_i = 2$ in, $R_o = 4$ in, $\kappa = 0.04$ BTU/ft $\cdot$ hr$\cdot$°F, $L = 10$ ft, $Q = 0$, $T(r = R_i) = 400$°F, $T(r = R_o) = 80$°F. You can also compare your results to the analytical solution, which in this case is

$$T(r) = T(R_i) - (T(R_i) - T(R_o))\frac{\ln r/R_i}{\ln R_o/R_i}.$$

(b) Solve the problem again using the same geometry and conductivity, but with $Q = 200\ \mathrm{BTU/hr/ft^3}$ and the boundary conditions of an insulated inner radius (no flux) and fixed temperature at the outer radius $T(R_o) = 80$°F. Again compare MATLAB and ANSYS. Be sure to comment on how you know your solution is converged.

(c) Solve the problem a third time, now with $Q = 0$ and a "point source" (such as due to an embedded conducting layer) at $r = 2.5$ in that adds 500 BTU/hr of energy to the system. Use the same boundary conditions as in part (b). Describe your input and compare your results between MATLAB and ANSYS.

Explanation of Axisymmetric Assumption

Governing Equation and Boundary Conditions

Tips for Part B and Part C

Visualizing the Equivalent 3D Solution

One can visualize the 2D axisymmetric solution in 3D by revolving the 2D solution about the axis. This is not required in the above problem statement but is useful to build physical intuition about axisymmetric models. To learn how to revolve the 2D solution about the axis, go to the bottom of this page and review the **last** video entitled "Stepped Shaft in ANSYS, Axisymmetric Visualization."