Radiation Between Surfaces - Exercises

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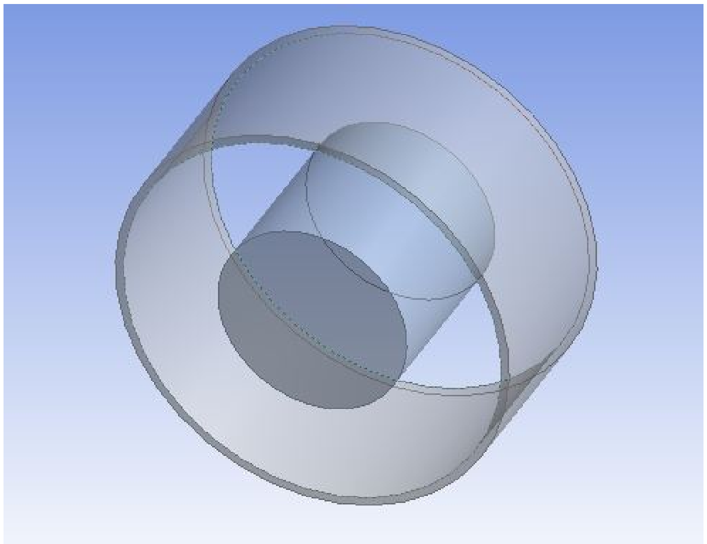
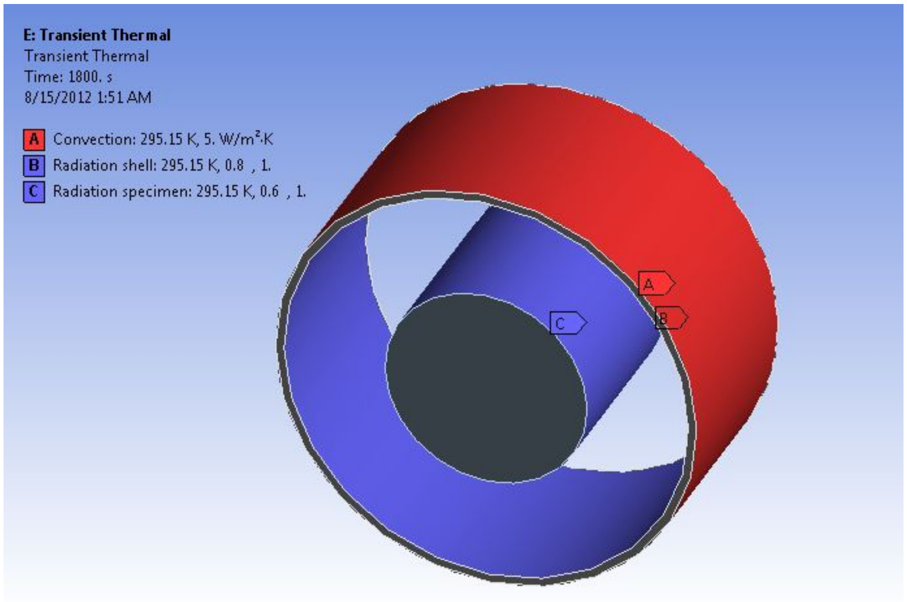
Exercise

Problem Statement

Consider a pair of concentric cylinders with a ***height*** of ***24 mm***. The ***smaller cylinder*** has a radius of ***12 mm***. The ***inner*** and ***outer*** radius of the ***larger, hollow cylinder*** is ***24 mm*** and ***25 mm***, respectively. The same boundary condition and the initial condition from the shell and specimen tutorial will be used: ***Convection*** on the outer surface of the larger, hollow cylinder, and ***two radiation boundary conditions*** for each emitting surface. The larger, hollow cylinder will be set to ***22 degress Celsius*** and the smaller cylinder will be set to ***-273.15 degrees Celsius***.





Analytic Solution

Assume only the inner surface of the larger, hollow cylinder and the cylindrical surface of the smaller cylinder are emitting radiation. Also assume the surfaces are gray and diffuse. The net radiation of an emitting surface of this concentric cylinder, two-surface enclosure is give below:

$$F_{12} = 1$$

$$q_{12} = \frac{\sigma A_1 (T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1-\varepsilon_2}{\varepsilon_2}\left(\frac{r_1}{r_2}\right)}$$

In this convention, the ***subscript "1"*** denotes the smaller cylinder and the ***subscript "2"*** denotes the larger, hollow cylinder. Since this is a two-surface enclosure problem, we can expect the ***view factor*** for each surface to be 1. All the radiation emitted by one surface is intercepted by the other surface. The notation of the above equation is the net radiation of the smaller cylinder.

The analytic solution shows the net radiation of the smaller cylinder is ***-0.428 watts***.

ANSYS result

Solve this problem with the same procedure for the shell and specimen tutorial. First solve the ***steady state*** model and transfer the data to ***transient analysis*** to complete the simulation. Make sure you use the same step end time and the same boundary and initial conditions.

From the tabular data, the net radiation of the smaller cylinder is ***-0.423 watts*** at the step end time. ANSYS result shows a ***1.4%*** deviation from the analytic solution. Hence we can verify that the view factor and radiation heat transfer are computed correctly in this set up. This also verifies the validity of the shell and specimen model.

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