Appendix 3.5.2, Excerpted from ALGOR Non-Linear Thermal Transient Heat Transfer Analysis Manual, *Emulation of body-to-body radiation as temperature dependent conduction*

In some cases, body-to-body radiation can be emulated using temperature dependent conduction as shown in the figure below:

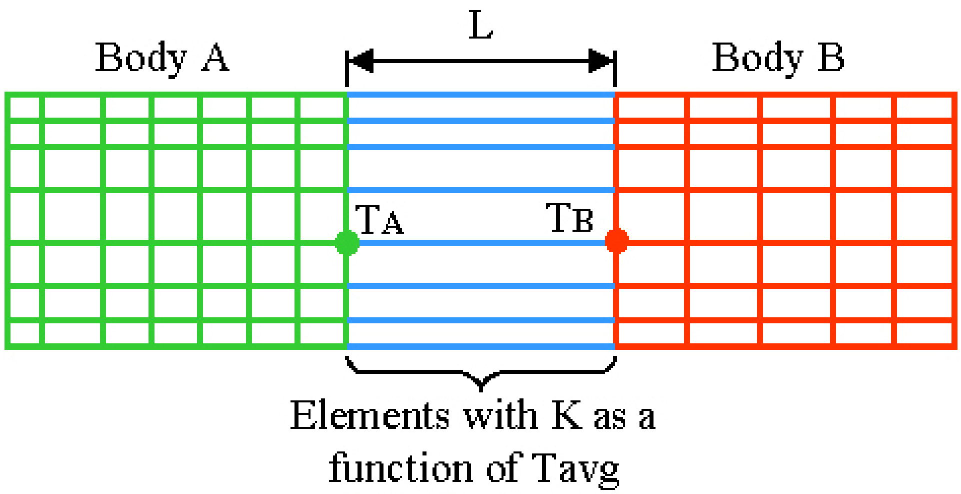

Figure 2: Body to Body Radiation

The requirements for this approximation to be accurate are as follows:

1. The view factor between the bodies must be close to 1.
2. The heat flux out of the system is negligible; that is, there is no radiation to the environment.
3. The surface area of each body is equal.
4. The expected temperatures of the surfaces are approximately known either from hand calculations, experimentation or previous analysis (multiple iterations).

The heat exchanged between two bodies which see each other and nothing else can be written based on the "surface resistance" and "space resistance" of the bodies as

$$q = \frac{A\sigma\left(T_A^4 - T_B^4\right)}{\frac{1-\varepsilon_A}{\varepsilon_A} + \frac{1}{VF_{AB}} + \frac{1-\varepsilon_B}{\varepsilon_B}}$$

Where T_A and T_B are the temperatures of surfaces A and B (in absolute temperatures), ε_A and ε_B are the emissivities of surfaces A and B, and VF_{AB} is the view factor between the two surfaces.

The heat flow due to conduction between the two bodies is

$$q = kA\frac{\Delta T}{L}$$

Since the heat flow due to radiation must equal the heat flow by conduction, equating the above two equations and expanding $T_A^4 - T_B^4$ as follows

$$T_A^4 - T_B^4 = \left(T_A^2 + T_B^2\right)\left(T_A^2 - T_B^2\right) = \left(T_A^2 + T_B^2\right)\left(T_A + T_B\right)\left(T_A - T_B\right)$$

leads to the solution

$$K = \frac{L\sigma\left(T_A^2 + T_B^2\right)\left(T_A + T_B\right)}{\frac{1-\varepsilon_A}{\varepsilon_A} + \frac{1}{VF_{AB}} + \frac{1-\varepsilon_B}{\varepsilon_B}}$$

using absolute temperatures.

Letting $T_{average} = (T_A+T_B)/2$, then $T^2_{average}$ is approximately $(T^2_A+T^2_B)/4$.

Using this substitution, and assuming the emissivities are 1 and the view factor is 1, this is further simplified to:

$$K \cong L\sigma(8)(T_{average})^3$$

Since the radiant heat transfer and conduction through the air occur in parallel the conduction coefficient is added to the psuedo radiant coefficient for input into the problem.

One layer of elements is constructed in a new part between the two bodies. The material model is set to orthotropic so that the material properties are temperature dependent. The conductivity is calculated at estimated surface temperatures T_A and T_B (in absolute temperature) using the above equation. The calculated conductivity is entered in the material properties at a temperature of $T_{average}=0.5(T_A+T_B)$. Additional data points are entered by evaluating $T_{average}$ and K at other values of T_A and T_B. A range of temperatures $T_{average}$ is included in the material properties so that the calculated temperature is not outside of the range of material properties.