EXAMPLE 3.11-1: Startup of a Finned Cylinder

The engine cylinder on a small air-cooled engine is made of cast aluminum with external fins, as shown in Figure 1.

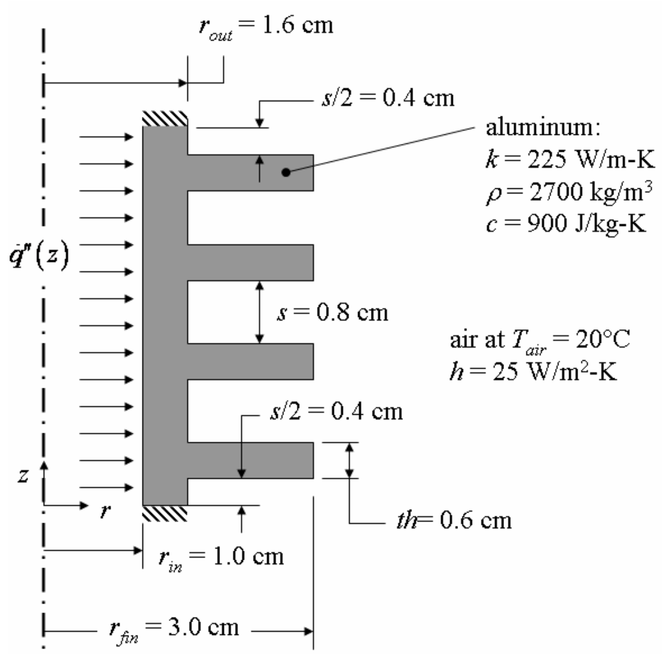

Figure 1: Case aluminum, finned engine cylinder.

The emission characteristics of the engine depend strongly on the inner wall temperature and therefore it is important to understand how the wall temperature changes during startup so that the fuel delivery can be adjusted, if necessary, in order to meet emission regulations. The inner and outer radii of the cylinder are r_{in} = 1.0 cm and r_{out}= 1.6 cm, respectively. The total length of the cylinder is 5.6 cm; the length is divided into the 4 equally spaced fins. The thickness of each fin is th = 0.6 cm and the fins are separated by s = 0.8 cm. The outer radius of the fins are r_{fin} = 3.0 cm. The engine cylinder and fins are composed of aluminum with conductivity k = 225 W/m-K, ρ = 2700 kg/m^3, and c = 900 J/kg-K. The outer surface of the cylinder and the fins is surrounded by ambient air at T_{air}= 20°C and h = 25 W/m-K. The top and bottom surfaces are adiabatic and the inner surface is exposed to a spatially varying heat flux due to the motion of the piston and the physics of the combustion process; the heat flux depends on z, the distance from the bottom of the cylinder, according to:

$$\dot{q}'' = 20000\ [\text{W/m}^3]\, z \tag{1}$$

At time t=0 the aluminum is at a uniform initial temperature of T_{in} = 20°C and the heat flux is applied.

Develop a finite element model using FEHT that predicts the inner temperature of the cylinder as a function of time.