6.7 A heavy-walled steel nozzle shown in Fig. 12.18 is used in our hybrid rocket research. Assuming a 15 second test firing, we like to know if the throat will survive. We estimate an average h_g of 10,000 w/m^{2}k and for steel, we have k = 60.5 w/mk, $\alpha = 17.7\times10^{-6}$ m^2/s. The test will be conducted at P_c = 300 psi with an oxidizer of 85% aqueous solution of H_2O_2 and HTPB as fuel at a mixture ratio of 7.0. Plot the temperature profile at the throat through the thickness of the part at t = 2, 5, 10, and 15 seconds. Clearly state all assumptions in your analysis. Will the steel melt? (melt temp is 2550°F)

(3) From NASA code at throat $T_t = 2502.4\,K$ $\quad K = 60.5\ W/mK$

$\gamma = 1.1509$ $\quad \alpha = 17.7\times10^{-6}\ m^2/s$

$P_r = .6652$ $\quad h = 10\,000\ W/m^2$

$T_i = 298.15\,K$

$$T_r = \left(1 + \frac{\gamma-1}{2} P_r^{1/3} \overset{1}{\cancel{M}}{}^2\right) T_t = 2667.2\ K$$

$$\frac{T(x,t)-T_i}{T_r - T_i} = \operatorname{erfc}\frac{x}{2\sqrt{\alpha t}} - \exp\left[\frac{hx}{K} + \frac{h^2 \alpha t}{K^2}\right] \operatorname{erfc}\left[\frac{x}{2\sqrt{\alpha t}} + \frac{h\sqrt{\alpha t}}{K}\right]$$

looking at the graph, the steel will melt.