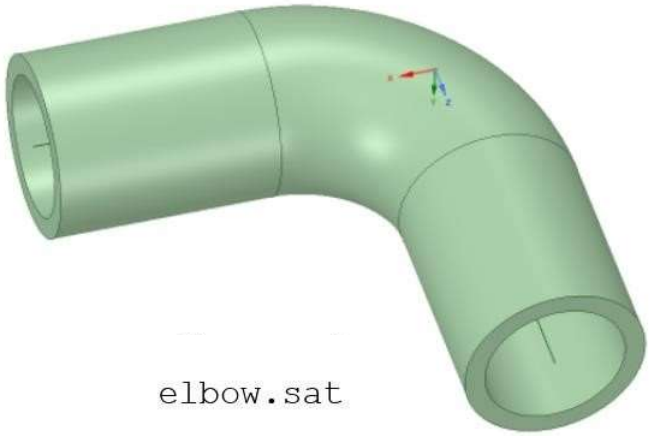
Assignment 2 - Steady State and Transient Analyses of an Elbow Pipe

Figure 1 shows a cast iron elbow pipe with a 90-degree bend. Inside and outside diameters are 70 mm and 90 mm, and its thermal properties are indicated in the figure.



Thermal Conductivity	
T (C)	K (W/m-C)
20	51.6
100	50.8
200	49.8
300	48.8
400	47.8
500	46.8

Density: 7200 kg/m^3
Specific Heat = 447 J/kg-C

Figure 1

A) The Steady State Problem (30 points)

The pipe is carrying steam at 150 C and is to be wrapped with insulation (K = 0.2 W/m-C). Computationally determine the "critical radius" of the insulation to the nearest integer mm and its maximum outside temperature to the nearest integer degree. The inside convection coefficient is 20 W/m^2-C, the outside convection coefficient is 3.7 W/m^2-C, and the outside temperature is 20 C. Assume the pipe ends are adiabatic.

B) The Transient Problem (70 points)

For the transient problem, model the pipe wrapped with 15-mm thick insulation; that is, the outside radius of the insulation is 60 mm. The entire structure is initially and uniformly at 20 C. The inside surface of the pipe is subjected to a step-applied convection shock of fast moving steam at 150 C and a convection coefficient of 50 W/m^2-C. The outside convection coefficient is 3.7 W/m^2-C, and the maximum outside temperature is 20 C. Assume the pipe ends are adiabatic. The density and specific heat properties for the insulation are 2500 kg/m^3 and 840 J/kg-C, respectfully.

- To the neared integer, what is the maximum temperature on the outside of the insulation at 10 minutes.
- To the nearest integer minute, how long does it take this analysis to reach steady state conditions? For that purpose, assume steady state is achieved when the maximum outside surface temperature of the insulation reaches 95% of its steady state value.

Notes and Additional Guidance:

1) Write a summary report (no more than 5 pages in Word docx/pdf format, including a title page), showing your results, assumptions, analysis approach, and conclusions. You may attach extra graphical result displays to the report's appendix (optional).

2) Accurate, convergence results in terms of your mesh and time step selections are expected.

3) In view of 2) it is strongly recommended that you use either constant time steps (Auto Time Stepping = Off) or semi-automatic control (Auto Time Stepping = On) in which you select the initial, minimum, and maximum times steps for transient analysis.

4) You may use symmetry – however it's not mandatory