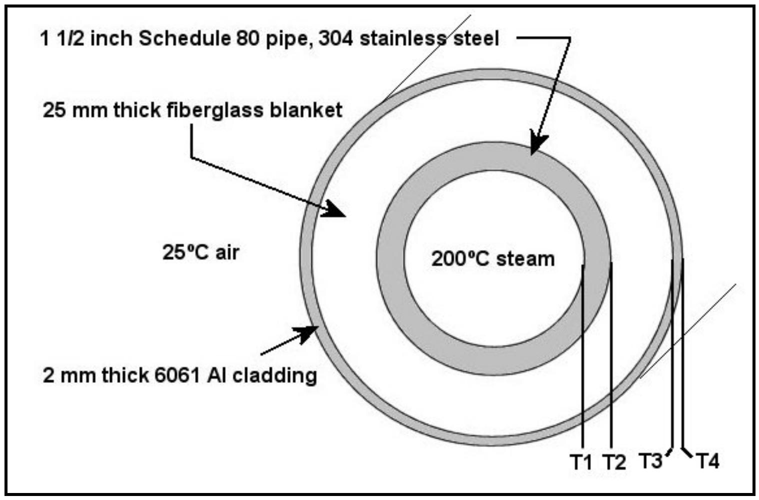
ES 3073 **Exam I** **July 8, 2004**

Open Books and Notes

I. 50 points

A 1 ½ inch Schedule 80 steel pipe (see Hagen, pg 671) is made of AISI 304 stainless steel. It has a 25 mm thick blanket of fiberglass insulation around it, and the whole assembly is clad with a 2 mm thick 6061 aluminum sheet metal. Condensing steam maintains the inside temperature of the pipe at T1 = 200°C. Air at 25°C surrounds the outside.



A. 20 points
Assuming the outside of the aluminum cladding is at T4 = 25°C, calculate Q, the rate of heat loss, from a 1 meter length of pipe (with insulation and cladding).

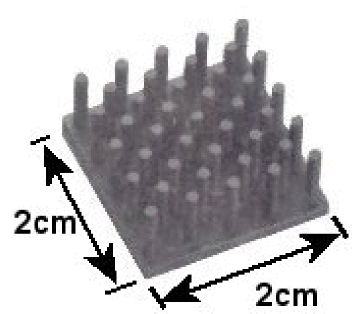
B. 20 points
Calculate T2, the outside temperature of the Schedule 80 stainless steel pipe, for the case where T1 = 200ºC and T4 = 25°C.

C. 10 points
Assuming the heat transfer coefficient on the outside is 10 W/(m^2-K), calculate Q, the rate of heat loss, from a 1 meter length of pipe for T1 = 200ºC and a surrounding air temperature of 25°C.

You may neglect contact resistances for all calculations.

II. 50 points

An integrated circuit 2cm x 2cm has a small copper heat sink of the same base dimension attached to it. The heat sink has 41 copper pin fins, each 1.5 mm in diameter and 5 mm long equally spaced around the heat sink similar to that given at the right. The outside air temperature is 50ºC, the base of the heat sink is maintained at 125ºC, and the heat transfer coefficient is 18 W/(m^2-K).



A. 25 points
What is the efficiency of any single pin?

B. 25 points
What is the total heat transfer from the device with 41 pins?