Brian Jin
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Thermal Systems Case Study Answers

a) **Why should the plate require time to heat up?**

The aluminum plate requires time to heat up because it requires a certain amount of energy to be input before it increases in temperature and we are providing energy to the resistive heater at a limited rate. The quantity that relates the heat input per unit mass to the temperature of the aluminum plate is the specific heat constant of aluminum. Additionally, the plate requires time to heat up because it is losing energy via free convection and radiation.

b) **Would you expect the temperature of the top of the plate (exposed to ambient air) and the bottom of the plate (attached to the heater) to be at the same temperature? If they are different, express the difference in terms of some material property of the plate.**

The temperature of the top of the plate (exposed to ambient air) and the bottom of the plate (attached to the heater) will not be at the same temperature. They are different temperatures because of the thermal conduction resistance, which is a material property of the plate.

c) **In the ideal system, if the heater is left on continuously, would the temperature of the plate rise to infinity? If not, what would cause it to stop?**

If the heater is left on continuously, the temperature of the plate would not rise to infinity. This is because as the temperature of the plate increases the rate of heat loss approaches the rate of heat addition to the plate. At a certain temperature the rate of heat addition will equal the rate of heat dissipation and the plate will not increase in temperature since the net heat flow will be zero.

d) **Assuming that the equivalent circuit for the heater is simply a resistor and the power is applied from a D.C. power supply, what is the value of the heat flux (in Watts) in terms of the applied voltage to the heater?**

The value of the heat flux of the heater, assuming that the equivalent circuit for the heater is a resistor with D.C. power applied, is the voltage from the D.C. power supply squared divided by the resistance of the heater. Note this is the equation for D.C. power (in Watts)

$$P = \frac{{V_{DC}}^2}{R}$$

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e) **Assuming that the equivalent circuit for the heater is simply a resistor and the power is applied from the A.C. power line, what is the value of the heat flux (in Watts) in terms of the applied voltage to the heater?**

The value of the heat flux of the heater, assuming that the equivalent circuit for the heater is a resistor with A.C. power applied, is the root mean square current from the A.C. power supply squared times by the resistance of the heater. Note this is the equation for A.C power (in Watts).

f) **Give 2 applications of temperature control in commercial (home or personal) products.**

Two applications of temperature control are a thermostat which can regulate the temperature of a home or office space and control of the temperature of a slow cooker, which has a temperature setpoint and turns on and off a resistive heater.

g) **Give 2 applications of temperature control in business products or machines (i.e. commercial products used by businesses).**

Two applications for temperature control in business are refrigeration units for storing pharmaceutical drugs and computer fans which are used to cool the CPU when it overheats.

h) **Give 2 applications of temperature control in industrial (factory) processes.**

Two applications of temperature control in industrial processes are die-casting machines, which require the temperature of molten metal to be maintained at a certain level and injection molding machines, which regulates the temperature of the melted plastic in the barrel.

i) **A potential problem is that the heater can burn out. Describe in words how you might program the microcomputer to detect this problem and declare a fault.**

The microcomputer can be programmed to detect if the heater has burned out by setting a pin high when the heater control is active which turns on an indicator LED. If this indicator LED specifies that the control is active yet the temperature of the plate has decreased for a predetermined threshold of time then this signifies that the heater has burned out.

j) **Another potential problem is that the temperature sensor can burn out at some fixed value. Describe in words how you might program the microcomputer to detect this problem and declare a fault.**

The microcomputer can be programmed to detect if the temperature sensor has burned out by monitoring the fluctuations of the temperature sensor and if the value of the sensor does not change from a fixed value after a predetermined threshold of time when fan or plate temperature controls are active then this is indicative of a burned out temperature sensor.