MCL 141 Thermal Science for Manufacturing
Minor Test - 1

Max. Marks: 30
Duration: 1 hour

September 1, 2017

1. Consider a cylindrical rod of 150 mm length and 15 mm diameter initially. It is subjected to tension by anchoring its one end and pulling its other end applying an external force F. It can be assumed that the volume of the rod is constant during deformation, meaning that an increase in length results in a decrease in its cross-sectional area. The stress-strain relation for the material of the rod can be written as $\sigma = 200\varepsilon^{0.25}$ MPa. Use the basic definitions of stress $\sigma = F/A$ where A is the area of cross section at any instant when the force is acting, and strain $d\varepsilon = dL/L$ where L is the length at the same instant.

   (a) Deduce the expression for the final strain ε_f when the rod increases in length by 20% of its initial length, and find the value of ε_f using the above data. (4)

   (b) From the basic definition of work for such an object, deduce the expression for work done on unit volume of the rod in terms of stress σ and strain ε. Hence compute the total work done by the external force and work done per unit volume of the rod. (6)

2. An electric geyser containing 5 kg of water is supplied with electric power of 1 kW for 5 minutes. The heating coil can be taken to be at the same temperature as the water in the geyser before and after the process. Water is heated from an initial temperature of 15°C. Energy contained in the coil and water could be given by 400 T and 4200 T Joules, where T is the temperature of the coil / water in kelvin. No water flows into or out of the geyser during this process. The walls of the geyser can be assumed to be a massless interface between the water and the surroundings. 10% of the electrical energy supplied to the geyser is lost in the form of heat to the surroundings across the walls of the geyser. Surrounding temperature is 15°C.

   (a) Compute the increase in temperature at the end of heating by choosing an appropriate object. Describe your approach, using a sketch, clearly identifying the components of the object, in/out flows of heat / work and change in energy corresponding to each. (7)

   (b) Is the object identified by you undergoing a reversible or an irreversible process? If reversible, clearly give the assumptions involved and if irreversible, clearly indicate whether the irreversibilities are internal or external to the object and also give the causes of irreversibility? (3)

   (c) Compute the change in entropy of the coil, water and the surroundings. In case there are entropy generation(s) in the process, identify them and compute them. For these calculations, you may assume that the wall of the geyser is at the mean temperature of water during heat transfer. (10)

Energy contained in coil = 400 T
~~Conde~~
water = 4200T per kg } in kg