National Institute of Technology, Srinagar
Department of Mechanical Engineering
Assignment-III

Subject: Basic Mechanical Engineering (MEL 100) **Submission Date: 31-05-2020**

Second Law of Thermodynamics

1) Heat is transferred to a heat engine from a furnace at a rate of 90 MW. If the rate of waste heat rejection to a nearby river is 55 MW. Determine the net power output and the thermal efficiency of this heat engine.

2) An inverter claims to have designed a heat engine which absorbs 1 kJ of energy as heat at 727°C and delivers 0.6 kJ of work when the ambient temperature is 27°C. Would you agree with this claim?

3) A reversible heat engine delivers 0.65 kW power and rejects energy at the rate of 0.4 kJ/s to a reservoir at 27°C. Determine the efficiency of the engine and the temperature at which energy is absorbed by the engine.

4) A reversible heat engine has an efficiency of 0.6 when it absorbs 400 kJ of energy as heat from a reservoir at 537°C. Calculate the sink temperature and the energy rejected as heat to the sink.

5) It is proposed to design a cold storage for maintaining certain vegetables under frozen conditions at -20°C. The ambient temperature in summer is 37°C and the estimated energy transfer as heat into cold storage through the doors, walls and roof is 3 kJ/s. Determine the minimum power required to operate a refrigeration plant for maintaining the cold storage and maximum possible COP of the refrigerator.

6) The normal boiling point of liquid helium is 4.2 K and the enthalpy of vaporization at this temperature is 83.3 J/mol. It is required to produce liquid helium from saturated vapor at 4.2 K at the rate of 1 mol /sec when the ambient atmospheric temperature is 37°C. Calculate the maximum possible COP of a refrigerator can have at these conditions and the minimum power consumption of the refrigerator.

7) An electric storage battery which can exchange heat only with a constant temperature atmosphere goes through a complete cycle of two processes. In process 1–2, 2.8 kWh of electrical work flow into the battery while 732 kJ of heat flow out to the atmosphere. During process 2–1, 2.4 kWh of work flow out of the battery.
   (a) Find the heat transfer in process 2–1.
   (b) If the process 1–2 has occurred as above, does the first law or the second law limit the maximum possible work of process 2–1? What is the maximum possible work?
   (c) If the maximum possible work were obtained in process 2–1, what will be the heat transfer in the process?

8) A refrigeration plant for a food store operates as a reversed Carnot heat engine cycle. The store is to be maintained at a temperature of – 5°C and the heat transfer from the store to the cycle is at

the rate of 5 kW. If heat is transferred from the cycle to the atmosphere at a temperature of 25°C, calculate the power required to drive the plant.

9) A heat engine operates between the maximum and minimum temperatures of 671°C and 60°C respectively, with an efficiency of 50% of the appropriate Carnot efficiency. It drives a heat pump which uses river water at 4.4°C to heat a block of flats in which the temperature is to be maintained at 21.1°C. Assuming that a temperature difference of 11.1°C exists between the working fluid and the river water, on the one hand, and the required room temperature on the other, and assuming the heat pump to operate on the reversed Carnot cycle, but with a COP of 50% of the ideal COP, find the heat input to the engine per unit heat output from the heat pump. Why is direct heating thermodynamically more wasteful?

10) It takes 10 kW to keep the interior of a certain house at 20°C when the outside temperature is 0°C. This heat flow is usually obtained directly by burning gas or oil. Calculate the power required if the 10 kW heat flow were supplied by operating a reversible engine with the house as the upper reservoir and the outside surroundings as the lower reservoir, so that the power were used only to perform work needed to operate the engine.

NOTE:

- **Duplication of assignment is not allowed. If found then student will be awarded zero mark.**
- **After the start of institute, students have to submit hard copy of the all the assignments**
- Students have to submit this assignment on or before 31-05-2020 to their class instructor on their email ID/Class Room ID.

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