Thermodynamics
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Lecture 68
Tutorial problems (2 numbers)

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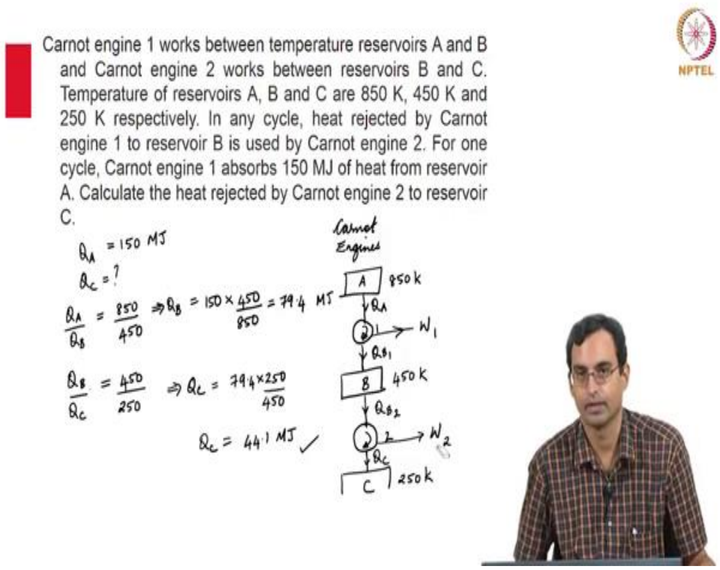

Figure 1.

Solution of the problem in Fig. 1:

$T_A = 850\ K, T_B = 450\ K, T_C = 250\ K, Q_A = 150\ MJ$

The schematic showing the engines and the temperature reservoirs is drawn in Fig. 1.

In any cycle, heat rejected by the Carnot's engine 1 equals the heat received by the Carnot's engine 2.

Since these are Carnot's engines,

$\frac{Q_A}{Q_B} = \frac{T_A}{T_B} = \frac{850}{450} \rightarrow Q_B = 79.4\ MJ$ (Q_A and Q_B are the magnitudes of the heat transfers)

Similarly, $\frac{Q_B}{Q_C} = \frac{T_B}{T_C} = \frac{450}{250} \rightarrow Q_C = 44.1\ MJ$

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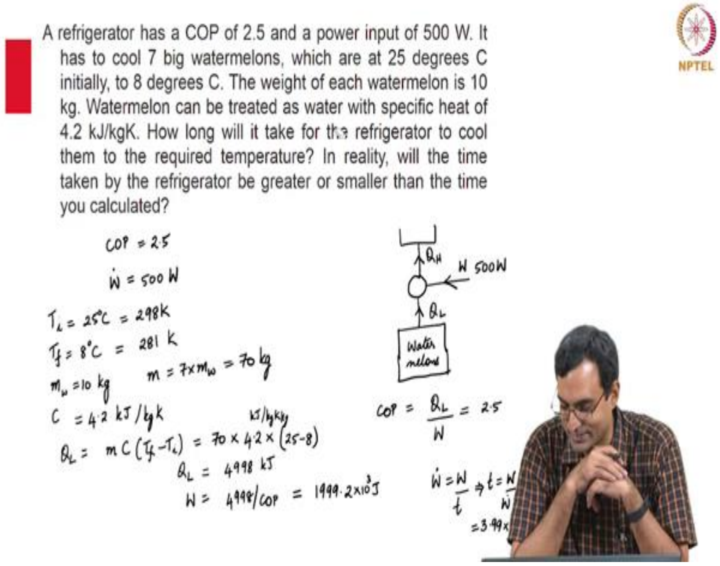

Figure 2.

Solution of the problem in Fig. 2:

$$COP = 2.5, \dot{W} = 500\ W, T_i = 25\ ℃ = 298\ K, T_f = 8\ ℃ = 281\ K, m_W = 10\ kg, m = 7 \times m_W$$
$$= 70\ kg, C = 4.2 \frac{kJ}{kg \cdot K}$$

We are going to assume that the temperature of this refrigerator is the temperature of the watermelons. We are cooling only the watermelons and not the insides of the refrigerator or there is nothing else in the refrigerator other than the watermelons.

The schematic of the refrigerator is drawn in Fig. 2.

The magnitude of heat needed to be removed from the watermelons,

$Q_L = mC\Delta T = 70 \times 4.2 \times (25 - 8) = 4998\ kJ$

Now, $COP = \frac{Q_L}{W} \ \rightarrow \ W = 1999.2\ kJ$

Now, $\dot{W} = \frac{W}{t} \ \rightarrow \ t = \frac{W}{\dot{W}} = 3.99 \times 10^3\ s = 1.1\ h$

If the fridge was at the temperature of the watermelons initially, it is going to take longer than the time calculated above because there is some air around the watermelons which is also getting cooled along with the watermelons. Also, there are always heat losses as the insulation of the fridge is not perfect/ideal which also leads to consumption of more time for cooling.

However, if the fridge is already very cold, it might take less time to cool watermelons than what we calculated.