Thermodynamics of Energy Conversion and Storage

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EXERCISES 13

1) Calculate the theoretical COP for a heat pump in Switzerland if the water temperature for heating in the house is 50°C and the outside temperature is 10°C, 0°C and -10°C.

$COP = T_1/DT$ = 323.15K/40K = 8
= 323.15K/50K = 6.4
= 323.15K/60K = 5.4

2) Calculate the heating power for a building with a heat pump as a function of temperature and surface area.

$P_{loss} = A \cdot \Delta T \cdot 1\ W \cdot m^{-2} \cdot K^{-1}$
$COP = T_1/\Delta T$
$P_{loss}/COP = P_{el} = A \cdot \Delta T^2 \cdot T_1^{-1} \cdot 1\ W \cdot m^{-2} \cdot K^{-1}$

3) Calculate the efficiency of a thermoelectric element with Z·T = 1 working between 100°C (1000°C) and 20°C. .

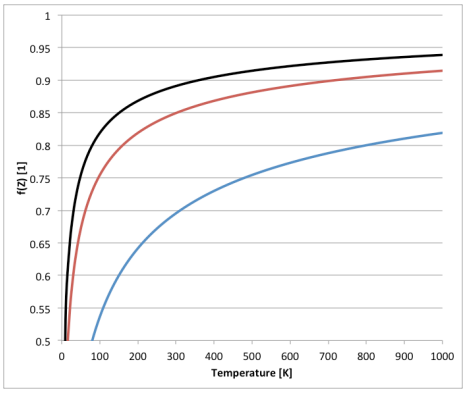
$$\eta_{max} = \frac{P}{\dot{Q}_h} = \frac{\Delta T}{T_h} \cdot \frac{\sqrt{1+Z \cdot T}-1}{\sqrt{1+Z \cdot T}+1}$$

η = $\Delta T \cdot T_1^{-1}$·(sqrt(1+373)-1)/(sqrt(1+373)+1) = 0.90·0.21 = 19%
η = $\Delta T \cdot T_1^{-1}$·(sqrt(1+1273)-1)/(sqrt(1+1273)+1) = 0.97·0.76 = 75%

4) Calculate the effect of increasing ZT on the efficiency.

$$F(Z) = \frac{\sqrt{1+Z \cdot T}-1}{\sqrt{1+Z \cdot T}+1}$$

Z = 0.1 blue, Z = 0.5 red, Z = 1 black



5) Explain the function of cooling power of a Peltier element vs. the current. .

With increasing current the heat transported increases linearly and the Joules heat produced increases. Therefore, the cooling power goes through a maximum as a function of the current.