CANKAYA UNIVERSITY
FACULTY OF ENGINEERING AND ARCHITECTURE
MECHANICAL ENGINEERING DEPARTMENT

ME 211 THERMODYNAMICS I
Fall 2015

CHAPTER 5 EXAMPLES
SOLUTIONS

11)A refrigeration cycle rejects Q_H =540 kJ per cycle to a hot reservoir at T_H =500 K, while receiving Q_C= 400 kJ per cycle from a cold reservoir at temperature T_C. For 20 cycles of operation, determine (a) the net work input, in kJ, and (b) the minimum theoretical temperature T_C, in K.

2) a) $W_{cycle} = Q_H - Q_C$ per cycle

for 20 cycles

$W_{cycle} = (Q_H - Q_C)\left(\frac{kJ}{cycle}\right)(20\ cycle)$

$= (540-400)(20) = 2800\ kJ$

b) for minumum temperature cycle be reversible, so

$\beta = \frac{T_C}{T_H - T_C}$

and also

$\beta = \frac{Q_C}{Q_H - Q_C} = \frac{400}{540-400} = \frac{400}{140}$

so $\frac{T_C}{500 - T_C} = \frac{400}{140}$

$\Rightarrow T_C = 370\ K$

12) Two reversible refrigeration cycles operate in series. The first cycle receives energy by heat transfer from a cold reservoir at 310 K and rejects energy by heat transfer to a reservoir at an intermediate temperature T greater than 310 K. The second cycle receives energy by heat transfer from the reservoir at temperature T and rejects energy by heat transfer to a higher-temperature reservoir at 850 K. If the refrigeration cycles have the same coefficient of performance, determine (a) T, in K, and (b) the value of each coefficient of performance.

Solution:

(a) Write the expression for coefficient of performance (β_1) for the first reversible refrigeration cycle as follows:

$$\beta_1 = \frac{T_c}{T - T_c}$$

Here, T_C is the temperature of cold reservoir.

Similarly, write the expression for coefficient of performance (β_2) for the second reversible refrigeration cycle as follows:

$$\beta_2 = \frac{T}{T_H - T}$$

Here, T_H is the temperature of hot reservoir.

It is given that $\beta_1 = \beta_2$, therefore,

$$\frac{T_c}{T - T_c} = \frac{T}{T_H - T}$$

$$T_c\left(T_H - T\right) = T\left(T - T_c\right)$$

$$T_C T_H - T_C T = T^2 - T_c T$$

$$T = \sqrt{T_C T_H}$$

Substitute 310 K for T_C and 850 K for T_H.

$$T = \sqrt{(310\text{ K})(850\text{ K})}$$

$$= 513.3\text{ K}$$

Thus, the value of T is $\boxed{513.3\text{ K}}$.

(b) Substitute 310 K for T_C and 513.3 K for T in the following expression of β_1:

$$\beta_1 = \frac{T_c}{T - T_c}$$
$$= \frac{310\ \text{K}}{513.3\ \text{K} - 310\ \text{K}}$$
$$= 1.52$$

Coefficient of performance for each refrigeration cycle is same. Thus, the coefficient of performance of each cycle is $\boxed{1.52}$.