**Ex.** A simple refrigeration cycle operates between −10 $^{o}$C and 40 $^{o}$C in evaporator and condenser respectively. If R−134a flows in the system at a rate of 0.025 kg/s. Find the COP of the cycle in three modes of operation:

a) Ideal operation.

b) Real operation taking the compressor isentropic efficiency to be 88%.

c) Same as in (b) with a pressure drop in condenser to be 5% of its inlet pressure.

**sol.**

**a) Ideal mode**

at $T_1$ = 10 $^{o}$C from sat. tables of R−134a $h_1$ = 392.9 kJ/kg , $s_1$ = 1.7341 kJ/(kg $^{o}$C)=$s_{2s}$

at $T_{2,\,sat}$ = 40 $^{o}$C from sat tables $P_2$ = 1017 kPa

from superheated tables at 1000 kPa and $s_{2s}$ = 1.7341 kJ/(kg $^{o}$C) , $h_2$ = 425.7 kJ/kg

at $T_3$ = 40 $^{o}$C from sat tables , $h_3 = h_4$ = 256.6 kJ/kg

COP = $(h_4-h_1)/(h_{2s}-h_1)$ = (256.6−392.9)/(425.7−392.9) COP=4.15 (Ideal operation)

**b) Real operation (compressor irreversibility only)**

$\eta_c = (h_{2s}-h_1)/(h_2-h_1)$ 0.88 = (425.7–392.9)/($h_2$–392.9) $h_2$ = 430.1 kJ/kg

COP = $(h_{4s}-h_1)/(h_2-h_1)$=(256.6−392.9)/(430.1−392.9) COP=3.56 (Real operation)

**c) Real operation ((compressor irreversibility and pressure drop in condenser)**

the new pressure in condenser is found as follows:

$P_3 = P_2-0.05\times P_2 = P_2 \times 0.95 = 1000 \times 0.95 = 950$ kPa

at 950 kPa from sat tables , $h_3 = h_4$ = 253.6 kJ/kg

COP = $(h_4-h_1)/(h_2-h_1)$=(253.6−392.9)/(430.1−392.9) COP=3.64 (Real operation)