5.6 Refrigeration and heat pumps

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS vapor-compression cycle • compressor • coefficient of performance

Objective

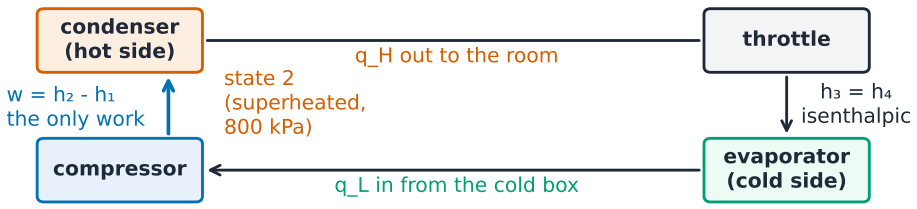
Read the reversed cycle: refrigeration effect and COP from the ports, the heat-pump identity, and the reversed-Carnot ceiling in absolute temperatures.

1 Key knowledge and worked examples

■ Benefit over cost

$\mathrm{COP}_R = q_L/w_{in}$, $\mathrm{COP}_{HP} = q_H/w_{in} = \mathrm{COP}_R + 1$; throttle keeps h; ceiling COP $\le T_{cold}/(T_{hot} - T_{cold})$.

the reversed machine: one work input



COP_R = q_L / w = 3.99 · COP_HP = q_H / w = 4.99 = COP_R + 1

*The compressor is the only work input

■ Worked example. The R-134a machine

$q_L = 394.6 - 241.8 = 152.8$, $w_{in} = 432.9 - 394.6 = 38.3$: $\mathrm{COP}_R = \mathbf{3.99}$ ✓ against the ceiling $263.2/41.3 = 6.37$.

2 Practice

A vapor-compression machine runs on a refrigerant with $h_1 = 240.0$ kJ/kg (evaporator exit), $h_2 = 290.0$ kJ/kg (compressor exit, superheated), $h_3 = h_4 = 100.0$ kJ/kg (condenser exit, throttle keeps h). The cold space sits at $-5\,^\circ$C and the condenser surroundings at $30\,^\circ$C.

2.1 With $h_1 = 240.0$ (evaporator exit), $h_2 = 290.0$ (compressor exit) and $h_3 = h_4 = 100.0$ kJ/kg: the refrigeration effect, the compressor work (one decimal each, kJ/kg) and the COP of refrigeration (two decimals). [4]

2.2 For the machine of 2.1: the heating effect (one decimal, kJ/kg) and the COP as a heat pump (two decimals), showing the identity between the two COPs. [4]

2.3 The reversed-Carnot ceiling between the cold space at $-5\,^\circ$C (268.2 K) and the condenser surroundings at $30\,^\circ$C (303.2 K) (two decimals), and one sentence on whether the machine of 2.1 is viable. [3]

2.4 One sentence each: why does the cycle use a throttle instead of a turbine, and why must the ceiling use absolute temperatures? [3]