Refrigeration Cycle Analysis

Introduction

Consider a vapor-compression refrigeration cycle with R134a as the working fluid, with

- an evaporator exit temperature of -15°C
- compressor exit temperature and pressure of 85°C and 1.3 MPa

What is the

- heat transfer in the evaporator and condenser,
- isentropic efficiency of the compressor,
- and the coefficient of performance?

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> with(ThermophysicalData):
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State 1

Inlet to compressor, sat vapor at -10°C

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> h_1 := Property(enthalpy, temperature = -15 degC, Q = 1, R134a)
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$$3.896 \times 10^5 \ \frac{J}{kg} \tag{2.1}$$

```
> s_1 := Property(entropy, temperature = -15 degC, Q = 1, R134a)
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$$1.737 \times 10^3 \ \frac{J}{kg\,K} \tag{2.2}$$

State 2

Actual compressor exit

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> h_2AC := Property(enthalpy, pressure = 1.3 MPa, temperature = 85 degC, R134a)
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$$4.635 \times 10^5 \ \frac{J}{kg} \tag{3.1}$$

State 3

Exit condenser saturated liquid at 1MPa

> $h_3 := \text{Property}(\text{enthalpy}, \text{pressure} = 1.3\ \text{MPa}, \text{Q} = 0, \text{R134a})$

$$2.708 \times 10^5\ \frac{\text{J}}{\text{kg}} \tag{4.1}$$

State 4

Exit valve

> $h_4 := h_3$

$$2.708 \times 10^5\ \frac{\text{J}}{\text{kg}} \tag{5.1}$$

Evaporator

Heat transfer in the evaporator is

> $\text{q} := h_1 - h_4$

$$1.188 \times 10^5\ \frac{\text{J}}{\text{kg}} \tag{6.1}$$

Ideal Compressor

> $T_{2s} := \text{Property}(\text{temperature}, \text{pressure} = 1.3\ \text{MPa}, \text{entropy} = s_1, \text{R134a})$

$$330.68\ \text{K} \tag{7.1}$$

> $h_{2s} := \text{Property}(\text{enthalpy}, \text{pressure} = 1.3\ \text{MPa}, \text{entropy} = s_1, \text{R134a})$

$$4.329 \times 10^5\ \frac{\text{J}}{\text{kg}} \tag{7.2}$$

Work done by ideal compressor

> $w_{cs} := h_{2s} - h_1$

$$4.328 \times 10^4\ \frac{\text{J}}{\text{kg}} \tag{7.3}$$

Actual Compressor

> $w_c := h_{2AC} - h_1$

$$7.384 \times 10^4\ \frac{\text{J}}{\text{kg}} \tag{8.1}$$

Coefficient of performance

> $\text{COP} := \frac{\text{q}}{w_c}$

$$COP := 1.609475082 \tag{8.2}$$

Isentropic efficiency of compressor

> $\eta c := \frac{w_{cs}}{w_c}$

$$\eta c := 0.5861669410 \tag{8.3}$$

Condenser

Heat transfer in the condenser

> $qH := h_{2AC} - h_3$

$$1.927 \times 10^5 \ \frac{J}{kg} \tag{9.1}$$

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