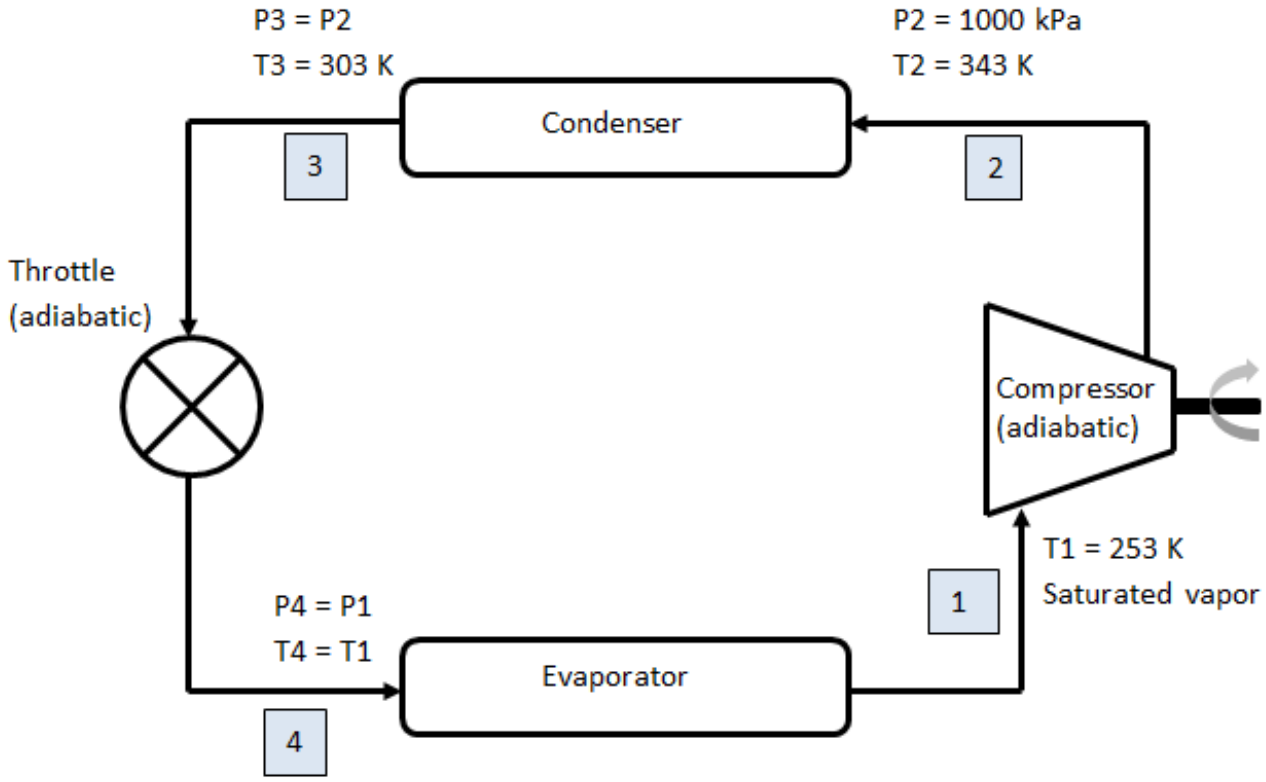
Analysis of a Vapor-Compression Refrigeration Cycle

Introduction

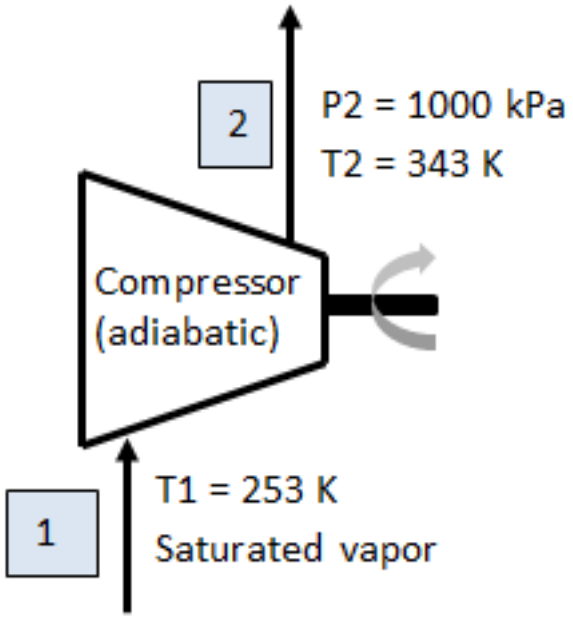
This application analyzes the following refrigeration cycle, and calculates the coefficient of performance.



Additionally, the thermodynamic cycle will be plotted on a pressure-enthalpy-temperature chart.

```
> restart
> with(ThermophysicalData):
  with(Units[Standard]):
  with(plots):
```

Compressor



Enthalpies at points 1 and 2

> P2 := $1000 \cdot 10^3$ Pa :

> h1 := Property(enthalpy, temperature = 253 K, Q = 1, R134a);

$$386.462 \ \frac{kJ}{kg} \qquad \textbf{(2.1)}$$

> h2 := Property(enthalpy, temperature = 343 K, pressure = P2, R134a);

$$451.844 \ \frac{kJ}{kg} \qquad \textbf{(2.2)}$$

The work done by the compressor (w)

> workCompressor := h1 − h2

$$-65.383 \ \frac{kJ}{kg} \qquad \textbf{(2.3)}$$

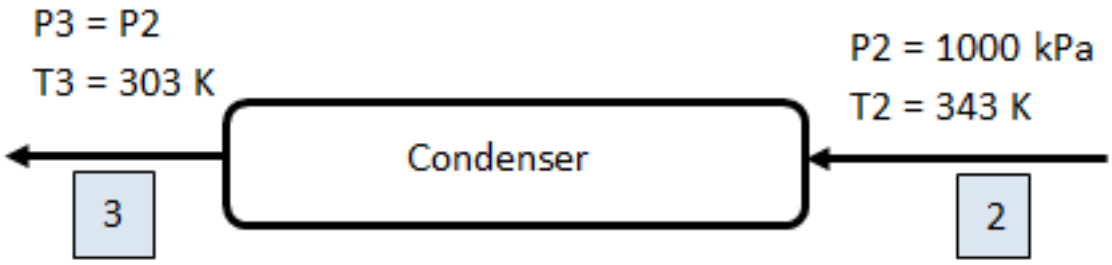
Pressure at point 1

> P1 := Property(P, temperature = 253 K, Q = 1, R134a)

$$131.877 \text{ kPa} \qquad \textbf{(2.4)}$$

Condenser

For the condenser, w = 0, Î”KE = 0 and Î”PE = 0. Hence q = Î”h



Enthalpy at point 3

> h3 := Property(enthalpy, temperature = 303 K, pressure = P2, R134a)

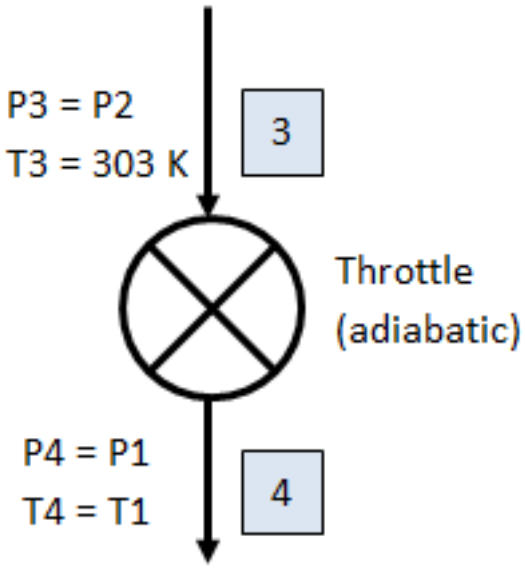
$$241.500\ \frac{kJ}{kg} \quad \textbf{(3.1)}$$

> h3 — h2

$$-210.345\ \frac{kJ}{kg} \quad \textbf{(3.2)}$$

Throttle

For the throttle, q = 0, w = 0, Î”KE = 0 and Î”PE = 0. Hence Î”h = 0



Enthalpy at point 4

> h4 := h3

$$241.500\ \frac{kJ}{kg} \quad \textbf{(4.1)}$$

Saturation pressure of R134a at 253 K

> P4 := P1

(4.2)

131.877 kPa **(4.2)**

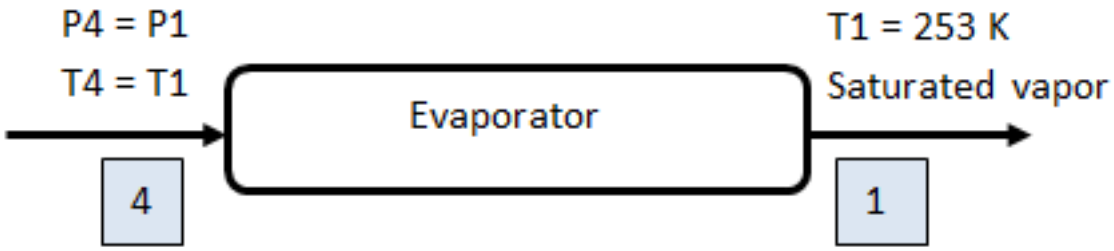
Quality at P = press4 and H = h4

```
> Property( Q, pressure = P4, H = h4, R134a )
```

.319 **(4.3)**

Evaporator

For the evaporator, w = 0, Î”KE = 0 and Î”PE = 0. Hence q = Î”h



Heat extracted by evaporator

```
> heatEvaporator := h4 — h1
```

$$-144.962\ \frac{kJ}{kg} \quad \textbf{(5.1)}$$

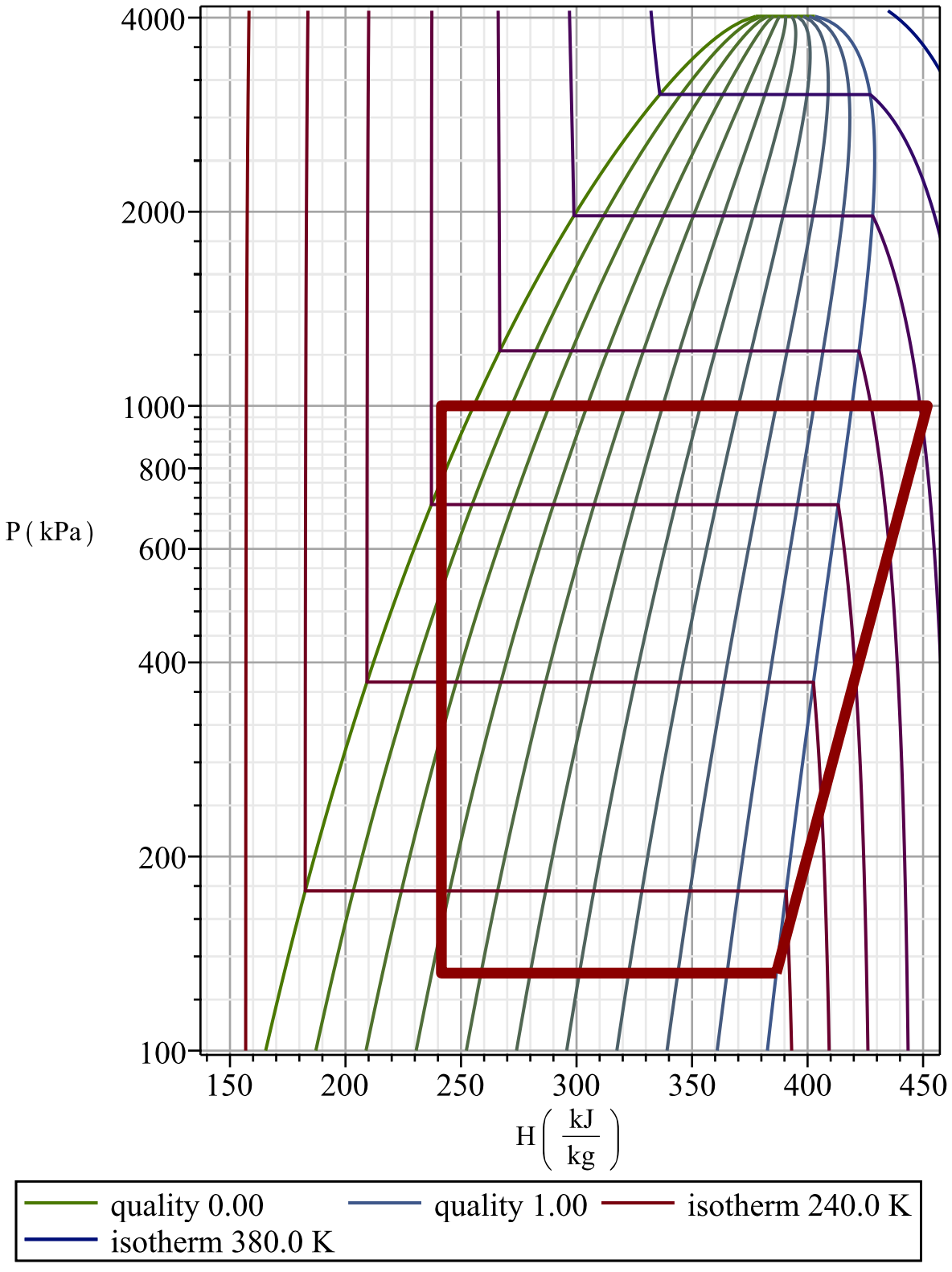
Coefficient of Performance

```
> heatEvaporator / workCompressor
```

2.217 **(6.1)**

Plot the Refrigeration Cycle on a P-h-T Chart

```
> phtChart := PHTChart( R134a, 100 kPa ..4100 kPa ) :
> pts := convert~( [ ( [h1, P1] ), [h2, P2], [h3, P2], [h3, P4], [h1, P1] ], unit_free ) :
> cycle := pointplot( 0.001·~pts, connect = true, color = "DarkRed", thickness = 5 ) :
> display( phtChart, cycle )
```


4000
2000
1000
800
600
400
200
100
P (kPa)
150
200
250
300
350
400
450
H (kJ / kg)
quality 0.00
quality 1.00
isotherm 240.0 K
isotherm 380.0 K

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