Emma Harshberger, elh 254
ENGRD 2210: Thermodynamics
Device: Refrigerator (Vapor-Compression Refrigeration Cycle)

ENGRD 2210 Portfolio Assignment

Device Overview:

A household refrigerator uses a vapor-compression refrigeration cycle to remove heat from the inside of the refrigerator and reject it to its surroundings. It operates continuously and relies on a circulating refrigerant that repeatedly undergoes evaporation, compression, condensation, and expansion. This is executed with four components: a compressor, condenser, throttling device and evaporator. We can typically model these cycles with steady state operation, one-dimensional flow, and negligible changes in potential and kinetic energy.

From State 1 to State 2:

Work is input by the compressor to compress a low-pressure refrigeration vapor to a high pressure and high temperature in order to allow the temperature of the refrigerant to surpass that of the hot reservoir (surrounding air). This is what allows heat to be rejected to the surroundings.

From State 2 to State 3:

The now high pressure, high temperature refrigerant vapor enters the condenser and heat is rejected to the surroundings. As the heat is removed, the refrigerant condenses into a high-pressure liquid.

From State 3 to State 4:

The high-pressure liquid passes through the throttling device, and the pressure and temperature drop significantly.

From State 4 to State 1:

The now low temperature and low pressure fluid enters the evaporator, and heat is absorbed from inside of the refrigerator. This is how the interior of a refrigerator is cooled.

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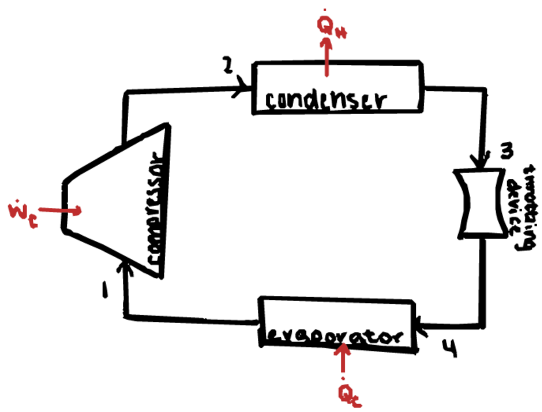

Mass Balance Calculations:
This system can be modeled as a steady state system.

$$\frac{d\dot{m}}{dt} = \dot{m}_{in} - \dot{m}_{out}$$

$$\frac{d\dot{m}}{dt} = 0 \text{ (steady state)}$$

$$\dot{m}_{in} = \dot{m}_{out} = \dot{m}$$

Energy Balance Calculations:
This system can be modeled as steady state, adiabatic, with negligible changes in potential and kinetic energy.

$$\overset{\text{steady state}}{\cancel{\frac{dE}{dt}}} = \overset{\text{adiabatic}}{\cancel{\dot{Q}}} - \dot{W} + \dot{m}(h_i + \overset{\text{negligible}}{\cancel{KE_i}} + \overset{\text{negligible}}{\cancel{PE_i}}) - \dot{m}_{out}(h_{out} + \overset{\text{negligible}}{\cancel{KE_{out}}} + \overset{\text{negligible}}{\cancel{PE_{out}}})$$

$$\dot{W} = \dot{m}(h_i - h_o)$$

Potential Modifications:
If insulation is improved the rate of heat leaking into the cold interior from the surroundings is reduced. Meaning the evaporator has to remove less heat, therefore the required work input by the compressor is reduced as well and ultimately increasing the device's coefficient of performance.

$$COP = \frac{\dot{Q}_c}{\dot{W}_c}$$