

Vapor-Compression Refrigeration Lab

Brandon Lim
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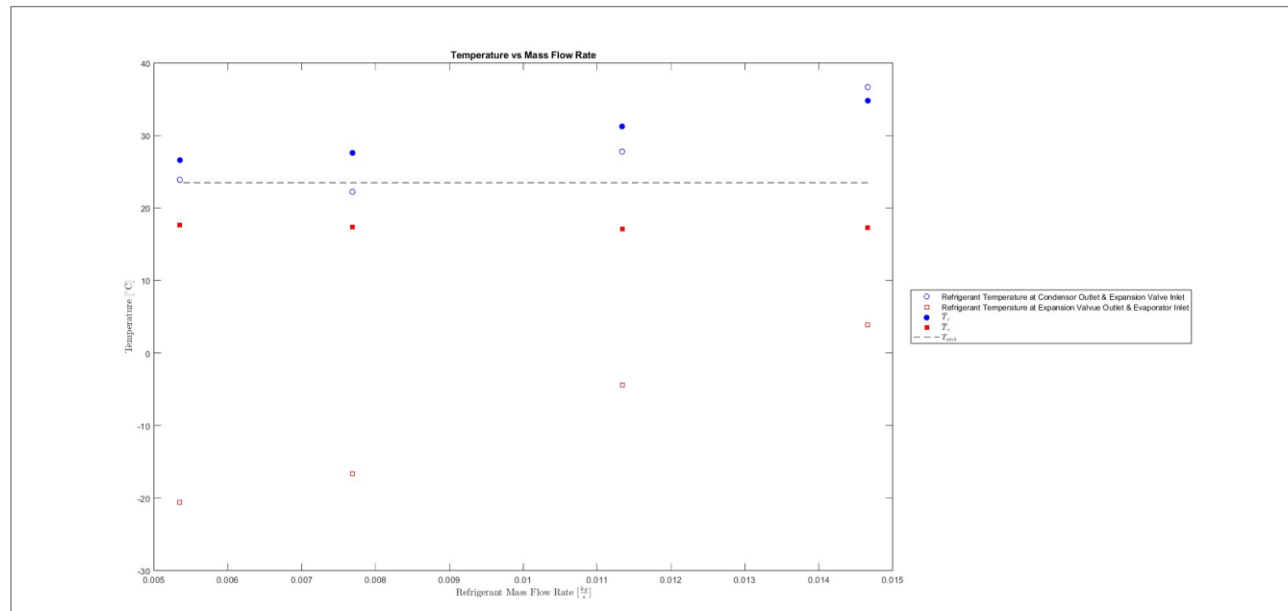


Figure 1a. Refrigerant cycle state temperatures in Celsius on the y-axis versus refrigerant mass flow rate in kilograms per second on the x-axis. The solid blue circles represent average air temperature exiting the evaporator, the solid red squares represent average air temperature exiting the condenser, the open blue circles represent the refrigerant temperature at the condenser outlet & expansion valve inlet, the open red squares represent the refrigerant temperature at the expansion valve outlet & evaporator inlet, and the dashed black line represents the ambient temperature.

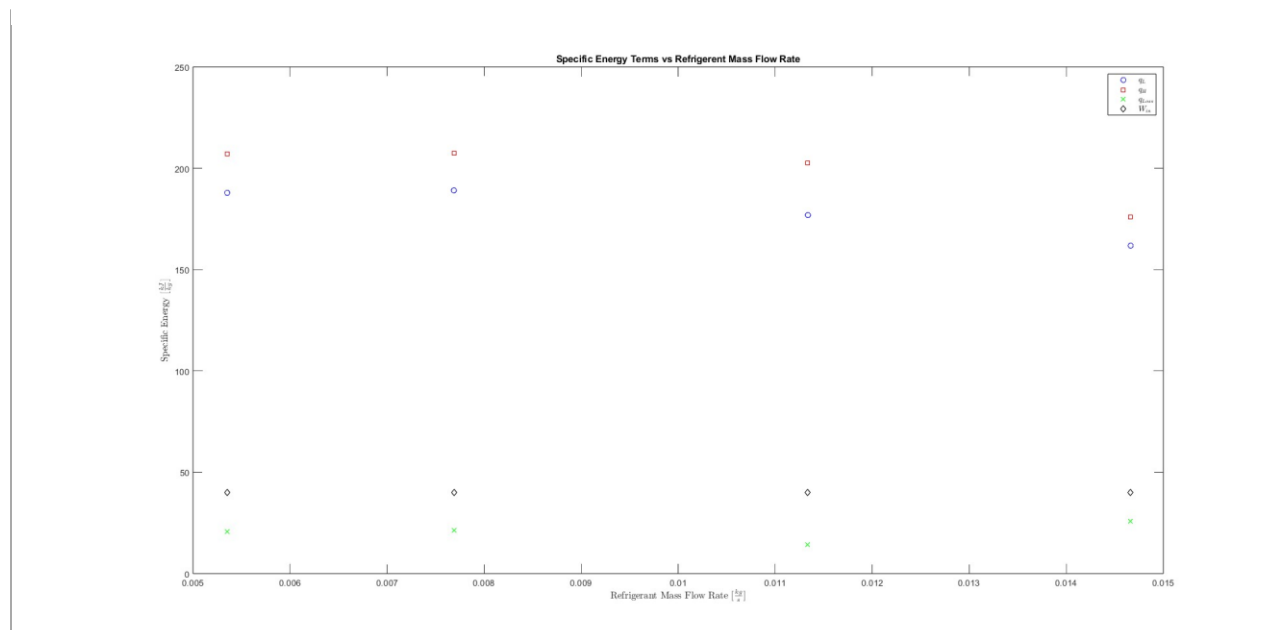


Figure 1b. Specific energy terms in kilojoules per kilogram on the y-axis versus refrigerant mass flow rate in kilograms per second on the x-axis. The red square markers represent the heat per unit mass rejected from the refrigerant in the condenser, the blue circles represent the heat per unit mass transferred to the refrigerant in the evaporator, the green x's represent heat loss to the surroundings per unit mass, and the black diamonds represent the work to the refrigerant per unit mass.

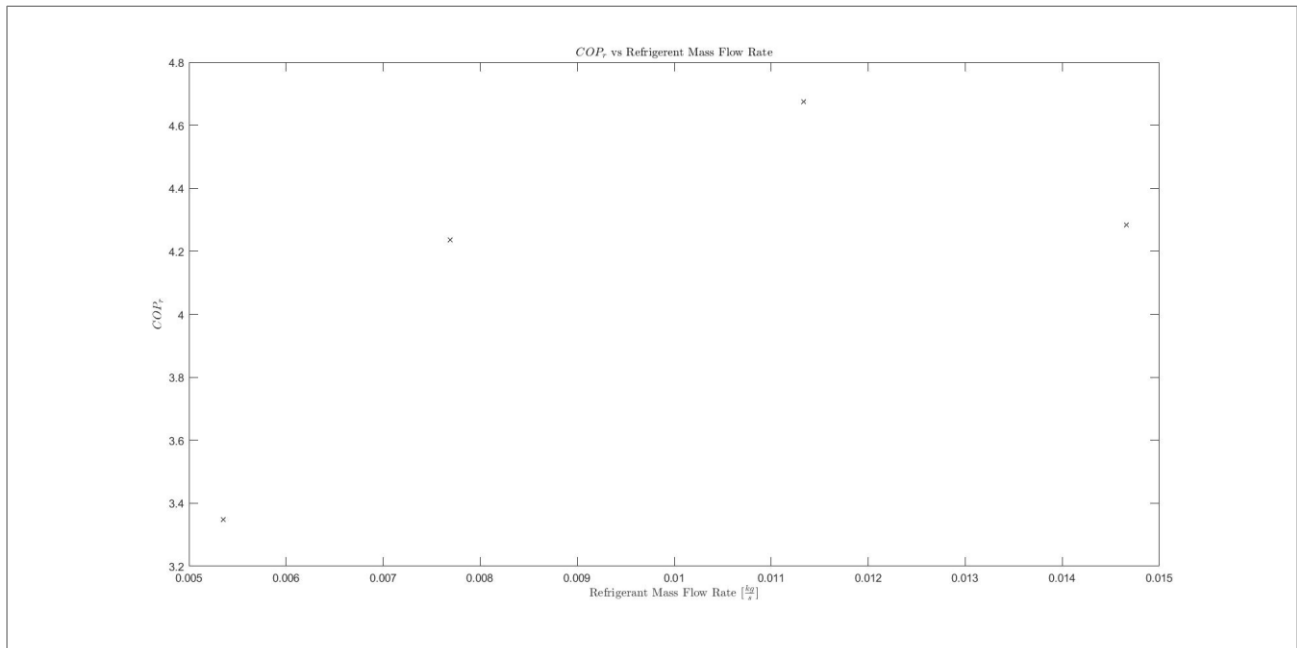


Figure 1c. Coefficient of performance on the y-axis versus refrigerant mass flow rate in kilograms per second on the x-axis.

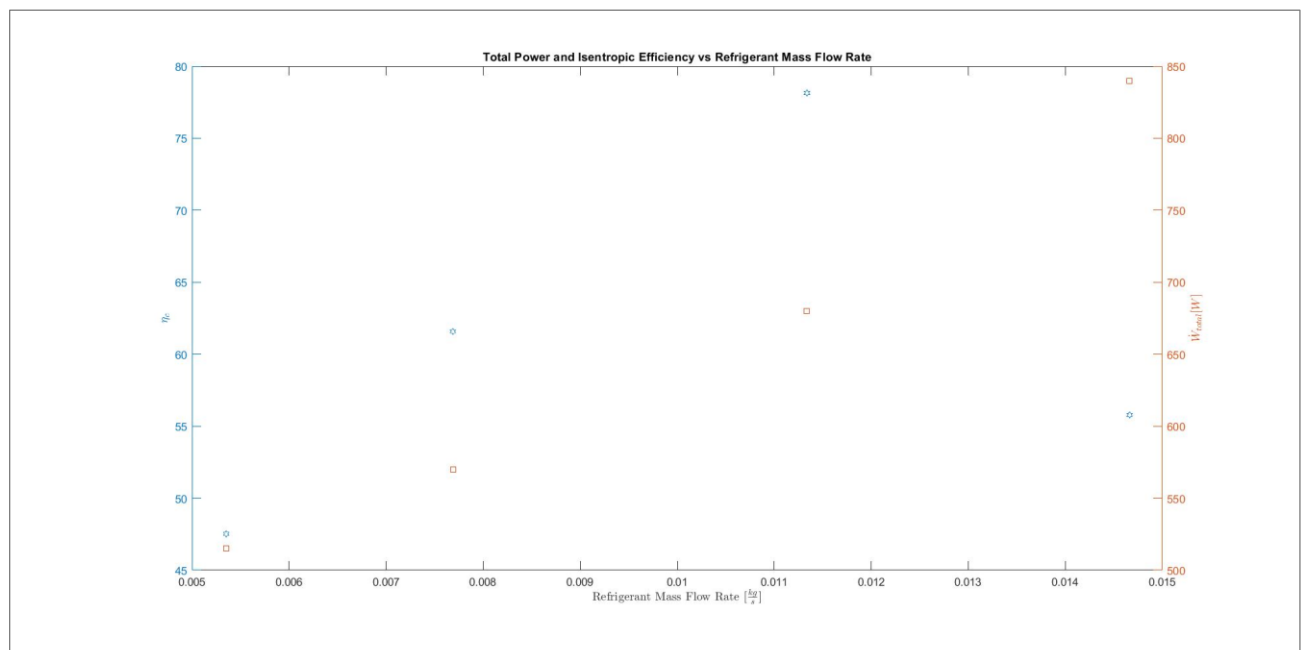


Figure 1d. Total power in watts and isentropic efficiency in percentage on the y-axes versus refrigerant mass flow rate in kilograms per second on the x-axis. The left y-axis and the blue hexagons represent the isentropic efficiency of the refrigerant cycle. The right y-axis and the orange squares represent the total power of the refrigerant cycle.

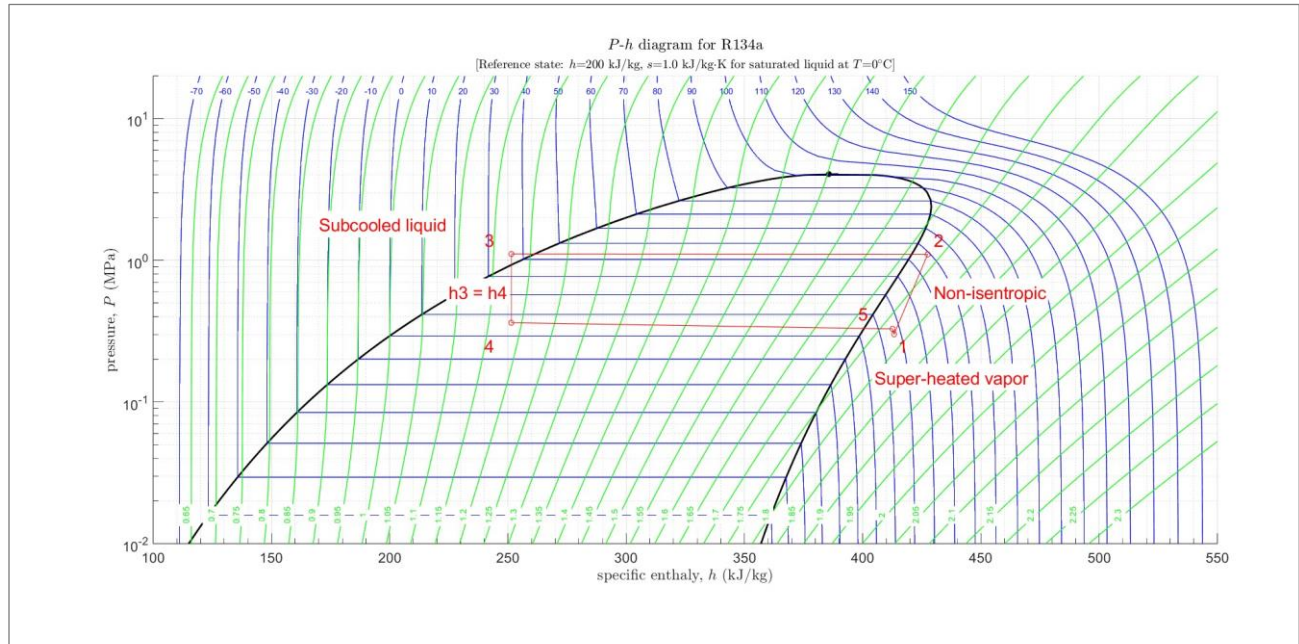


Figure 1e. P-h diagram for R134a with experimental refrigeration cycle process for the highest refrigerant mass flow rate of 0.0147 kilograms per second. The red circles represent state points that are annotated with their state numbers. The experimental process states are connected by red process path lines. At states 1, 2 and 5, the refrigerant is in a super-heated vapor state. At state 3 the refrigerant is a subcooled liquid. At state 4, the refrigerant is in a saturated liquid-vapor mixture.

Short-Answer Questions

2a. List and explain the observed differences in the P - h diagrams between an ideal cycle (as depicted in Figure 2 of the Handout) and that obtained from your actual measurements. [4–6 sentences]

The ideal cycle as depicted in figure 2 follows the same general process path and state location as the actual cycle as depicted in figure 1e shown above. A major difference between the two are the slight differences in state locations. In the actual cycle, the first state is in the superheated vapor region and the third state is in the subcooled liquid region. In the ideal cycle, the first state is on the saturated vapor line and the third state is on the saturated liquid line. Another major difference between the ideal cycle and the actual cycle is the existence of the fifth state in the actual cycle. This is because the ideal cycle does not assume a pressure loss in the tubing hardware.

2b. Based on your results and your engineering judgment, at what flow rate should the refrigerator be run. Justify your answer. [3–4 sentences]

Based on the results and my engineering judgment of the refrigeration cycle, the refrigerator should be run at a flow rate of 0.15 gpm. At this flow rate, the refrigerator coefficient of performance is at its maximum. This flow rate also creates the best isentropic efficiency in the refrigeration cycle.

2c. Perform a brief literature search of vapor-compression refrigeration systems to determine how one can improve the coefficient of performance of an actual system. Describe at least one means of increasing COP_R and explain how it works in terms of the equation: $COP_R = q_L / w_{in}$. Include one or more references from your literature search. [3–6 sentences]

A flash chamber added before the evaporator can improve the coefficient of performance of a vapor-compression refrigeration system. A flash chamber before the evaporator processes unwanted vapor that are generated by the expansion valve. These unwanted vapors are not conducive to absorbing latent heat. This effects the coefficient of performance equation by effecting the q_L term. With less unwanted vapors from the flash chamber, refrigerant entering the evaporator can absorb more heat per unit mass increasing q_L . This in turn increases the coefficient of performance.

Reference:

<https://allaboutrefrigeration.blogspot.com/2019/01/methods-for-improvement-in-vapour.html>