TFES Lab (ME EN 4650)
Vapor-Compression Refrigeration Cycle

Required Figures

Captions

A meaningful and comprehensive caption must accompany all figures. The caption is placed *below* the figure and includes the label Figure 1x., where x denotes the letter a–e according to the plot order listed below. Use the following guidelines when writing figure captions:

→ Ideally, the figure caption should provide a "standalone" description of the plot, and contain enough information that the reader can understand what is being shown without having to refer back to the main text of the document (report, memo, etc.).

→ The caption should start with a statement of the quantities plotted on both axes. Typically the axis labels will utilize mathematical symbols (with appropriate units) for the quantities being plotted; however, in the caption, these quantities are described in words.

→ Include relevant contextual information about the plot. For example, for the wake profile, you should state the x/D location and Re_D value at which the measurements were taken. Additionally, you should state that the measurements are for the case of flow around a two-dimensional circular cylinder. Finally, adding some text about the measurement technique used to obtain the data would be appropriate.

→ When your plot includes errorbars, it is helpful to provide information in the caption about the errorbars. For example, you should include the fact that the errorbars represent a 95% confidence interval.

→ When comparing with published data, provide a reference for the publication.

→ If in doubt about what information to include in the caption, one should err on the side of providing more information, rather than less.

Plots

1a. On a single figure, plot the ambient air temperature (T_{amb}), refrigerant temperature at the condenser outlet & expansion valve inlet (T_3), refrigerant temperature at the expansion valve outlet & evaporator inlet (T_4), air temperature exiting the condenser ($\overline{T_e}$), and air temperature exiting the evaporator ($\overline{T_c}$) as functions of refrigerant mass flow rate, $\dot{m}$. Plot temperatures on the y-axis in units of °C, and mass flow rate on the x-axis in units of kg/s. Plot the refrigerant temperatures using *open* markers, the ambient air temperature as a black dashed line, and the other air temperatures using *solid* markers. Use the following marker/line styles for each data set: ○ T_3; □ T_4; ● $\overline{T_c}$; ■ $\overline{T_e}$; - - T_{amb}. Be sure to include a legend. Do NOT connect the data points with lines.

1b. On a single figure, plot the specific energy terms (q_L, q_H, q_{loss} and w_{in}) as a function of refrigerant mass flow rate, $\dot{m}$. Plot the specific energy terms on the y-axis in units of kJ/kg, and refrigerant mass flow rate on the x-axis in units of kg/s. Use the following marker/line styles for each data set: ○ q_L; □ q_H; × q_{loss}; ◇ w_{in}. Be sure to include a legend. Do NOT connect the data points with lines.

1c. Plot the coefficient of performance of the refrigerator COP_R (on the y-axis) as a function of refrigerant mass flow rate $\dot{m}$ (on the x-axis in units of kg/s). Use a marker for your data. Do NOT connect the data points with a line.

1d. On a single figure, plot both the isentropic efficiency of the compressor η_c and the total electrical power supplied $\dot{W}_{\text{total}}$ (in units of W) versus refrigerant mass flow rate $\dot{m}$ (in units of kg/s). To do this, create two different y-axes: one on the left side (for η_c) and another on the right side (for $\dot{W}_{\text{total}}$). Plot $\dot{m}$ on the x-axis. Use different marker styles for η_c and $\dot{W}_{\text{total}}$. Do NOT connect the data points with a line. Be sure to include a legend. [See the "Help Notes" on CANVAS for creating this type of plot.]

1e. For the highest refrigerant mass flow rate, plot the **actual** cycle processes on a P-h diagram for R134a. To do this, open the provided Matlab figure of the P-h diagram for R134a (see Appendix IV). Draw points on the P-h diagram that represent the five state points of the actual processes, as determined from your analysis. Be careful to notice that the units on the provided P-h diagram is MPa for pressure and kJ/kg for specific enthalpy. Label each of your state points on the diagram. Finally, draw lines connecting the state points representing the process paths. Use a red color for your points and process path lines. Note, the enthalpy **reference state** for the P-h diagram provided is such that h=200 kJ/kg and s=1.0 kJ/kg·K for saturated liquid at T=0°C. Therefore it is important that you use this same reference state when evaluating the enthalpy for each state point.

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]

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

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: $\text{COP}_\text{R} = \frac{q_L}{w_{\text{in}}}$. Include one or more references from your literature search. [3–6 sentences]