TFES Lab (ME EN 4650)
Cooling Tower Lab Assignment

Required Figures

A meaningful and comprehensive figure caption must accompany all figures. The figure caption must include the following label: Figure 1X. where X denotes the letter a – f according to the order listed below. For the first few labs, a Word template will be provided that illustrates how to write appropriate figure captions.

1a. On a single figure, plot water temperature (T_w) and wet bulb temperature (T_{wb}), for the case of $\dot{m}_{w_{\text{in}}} \approx 30$ g/s, as a function of cooling tower height (z) at the 5 positions: A=0 cm, F=24.8 cm, G=48.3 cm, H=71.8 cm, B=100 cm. Plot height on the x-axis in units of m, and temperature on the y-axis in units of °C. Use the following marker styles: ■ (red) T_w; ● (blue) T_{wb}. Do NOT connect the markers with a line. Include a legend. On the same figure, draw the Range (R) and Approach (A) using vertical lines with double arrows; and, label the two lines as R and A appropriately. Draw these lines in Matlab or using other software.

1b. Plot cooling tower efficiency (η) in terms of a percentage on the y-axis as a function of water inlet flow rate ($\dot{m}_{w_{\text{in}}}$) in units of g/s on the x-axis.

1c. On a single figure, plot specific humidity (ω) as a function of cooling tower height (z) at the 5 positions: A=0 cm, F=24.8 cm, G=48.3 cm, H=71.8 cm, B=100 cm. Plot height on the x-axis in units of m, and humidity on the y-axis in units of kg/kg of dry air. Use the following marker styles for the different water inlet flow rates: ◇ (green) $\dot{m}_{w_{\text{in}}} \approx 20$ g/s; ○ (blue) $\dot{m}_{w_{\text{in}}} \approx 30$ g/s; □ (red) $\dot{m}_{w_{\text{in}}} \approx 40$ g/s. Do NOT connect the markers with a line. Include a legend that lists the actual water inlet mass flow rate in g/s for each linestyle.

1d. On a single figure, plot the dry bulb air temperature (T_{db}) as a function of cooling tower height (z) at the 5 positions: A=0 cm, F=24.8 cm, G=48.3 cm, H=71.8 cm, B=100 cm. Plot height on the x-axis in units of m, and dry bulb air temperature on the y-axis in units of °C. Use the same marker styles and legend as in plot 1c.

1e. Plot the ratio of the water outlet mass flow rate to water inlet mass flow rate ($\dot{m}_{w_{\text{out}}}/\dot{m}_{w_{\text{in}}}$) on the y-axis as a function of inlet water temperature ($T_{w_{\text{in}}}$) in units of °C on the x-axis.

1f. On a single figure, plot the heat transfer rates ($\dot{Q}_a$ and $\dot{Q}_{\text{amb}}$) in units of kW on the y-axis as a function of inlet water temperature ($T_{w_{\text{in}}}$) in units of °C on the x-axis. Use a different marker style for $\dot{Q}_a$ and $\dot{Q}_{\text{amb}}$. Include a legend.

Short-Answer Questions

Your responses to the questions below must be typed and organized in the order listed below with the correct numbering scheme. Responses must be concise, clear, and written in complete sentences with correct grammar/sentence structure. Points will be deducted for poor writing. In all cases, your responses must reflect the results you obtained from your plots, unless you explain otherwise.

2a. Briefly describe what happens to the dry bulb temperature and the specific humidity of the air-water vapor mixture passing through the tower from point A (air inlet, water outlet) to point B (air outlet, water inlet). Explain the reason for these observations. Your response should consider the effect of evaporation. [4–6 sentences]

2b. What percentage of the inlet water is evaporated? State how this percentage changes as the inlet water temperature increases. Provide a physical explanation for the observed trend. [2–4 sentences]

2c. Based on your analysis of the data, what is the makeup water flow rate required (in g/s) for this facility? Your answer should be an average over the three experiments. State how close this average value is (in terms of a percentage) to what you observed during the experiments. [2 sentences]

2d. State the maximum efficiency achieved (in %) over the measurement range investigated in the lab. Describe how efficiency varies with inlet water flow rate. [2 sentences]