Cooling Tower Lab

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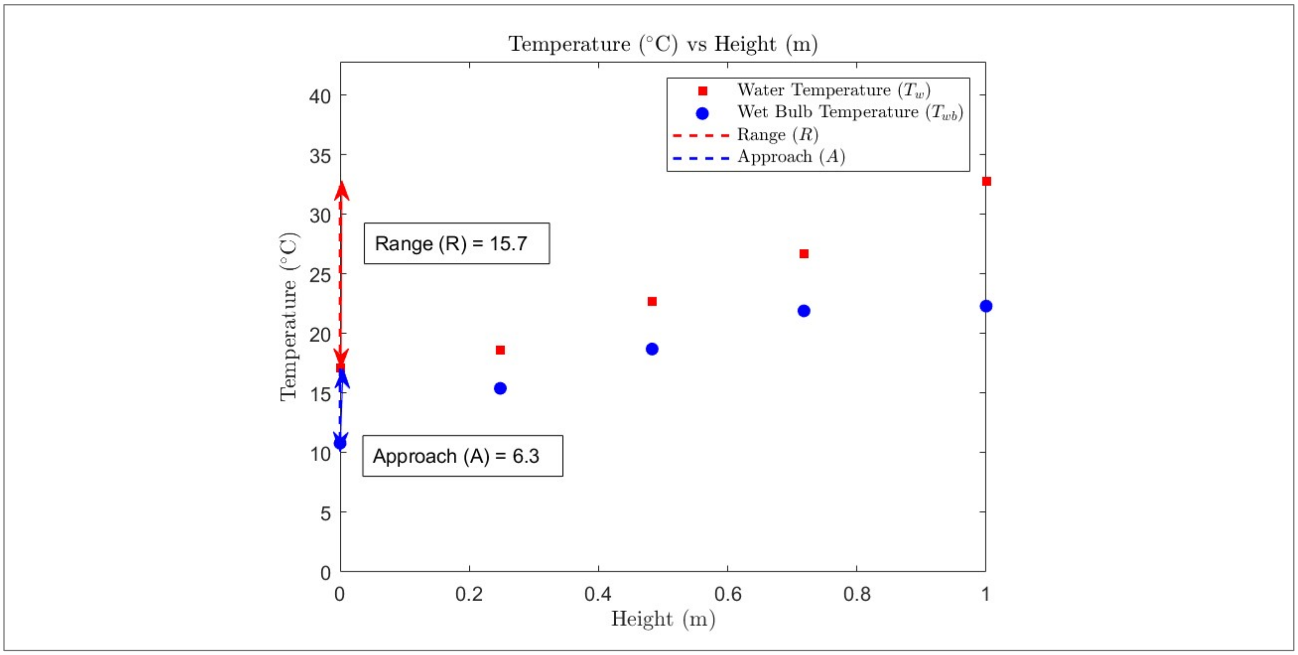

Figure 1a. Water temperature and wet bulb temperature of the air as a function of height along the cooling tower for the case of an inlet water flow rate of 30 gm/s. The Range and Approach are denoted by the vertical lines labeled “Range (R)” and “Approach (A)”, respectively.

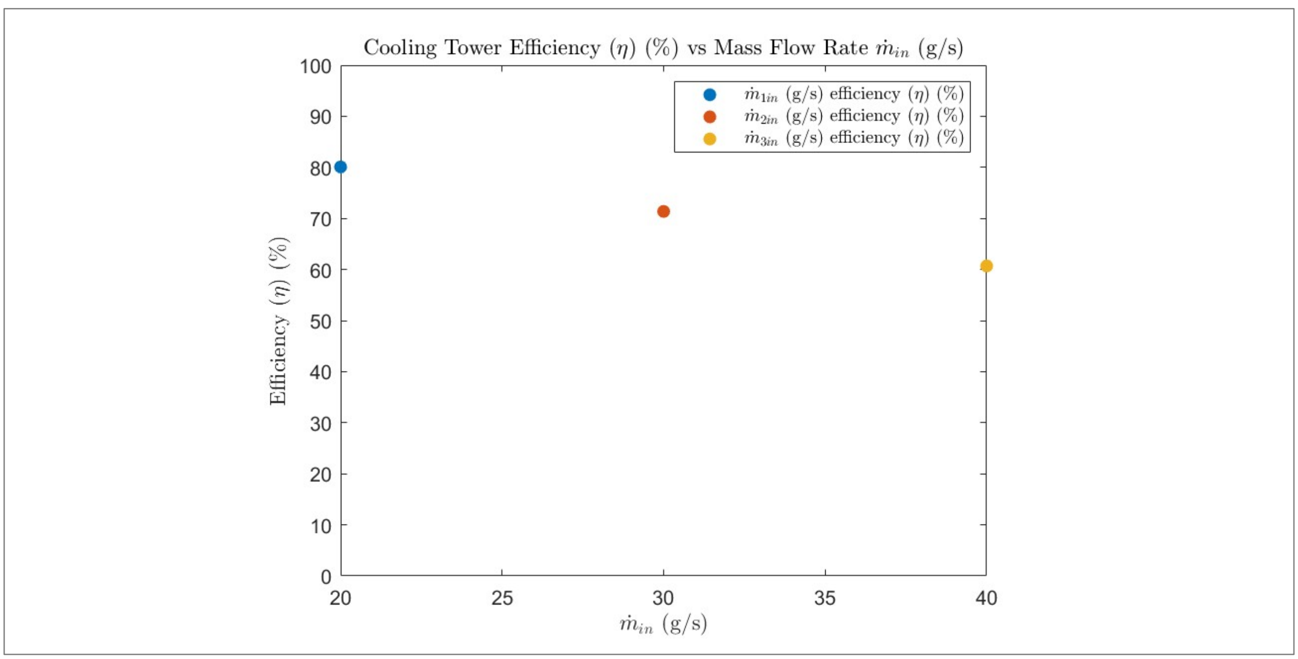

Figure 1b. Cooling tower efficiency as a function of water inlet flow rate.

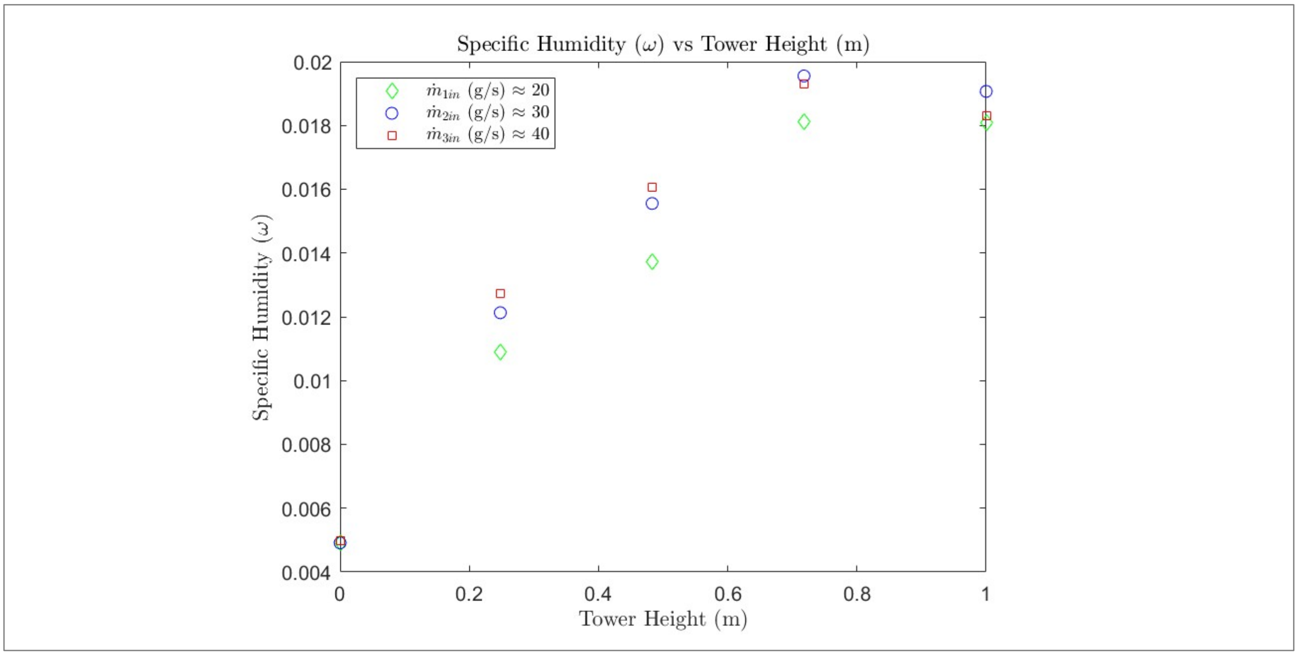

Figure 1c. Specific humidity as a function of height along the cooling tower. The results for three different water inlet flow rates are shown.

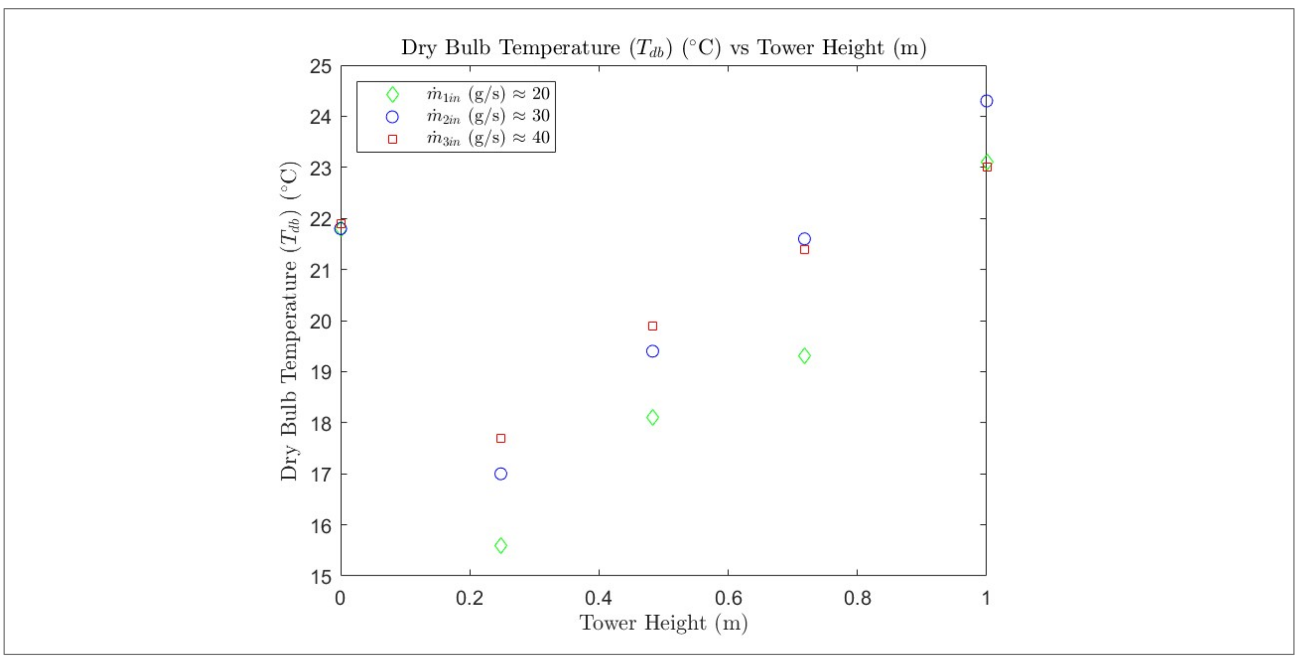

Figure 1d. Dry bulb temperature as a function of height along the cooling tower. The results for three different water inlet flow rates are shown.

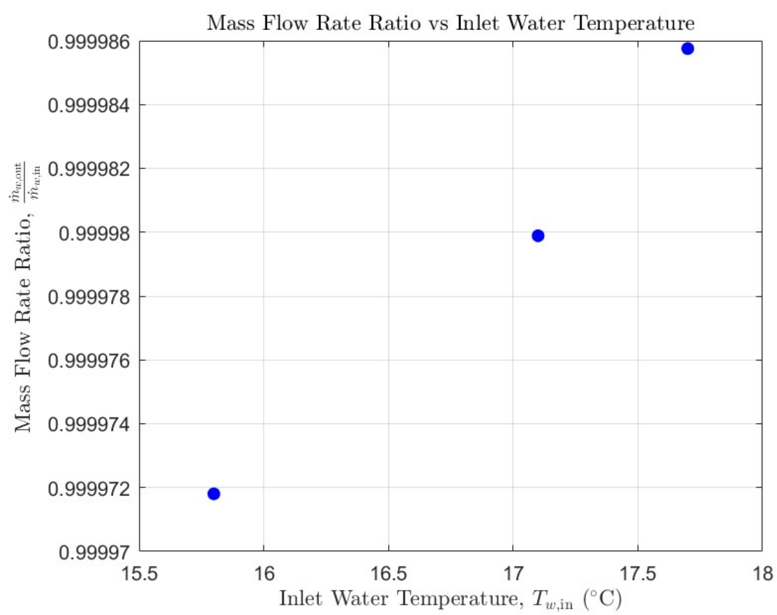

Figure 1e. Ratio of water outlet mass flow rate over water inlet mass flow rate as a function of water inlet temperature.

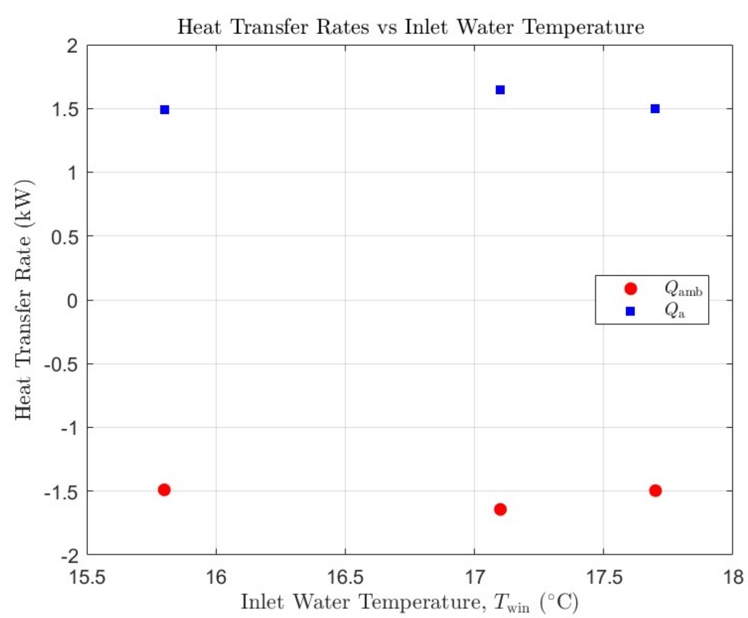

Figure 1f. Heat transfer rate to the dry air and the surroundings as a function of water inlet temperature.

Short-Answer Questions

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]*

Based off Figure 1d, the dry bulb temperature seems to first decrease as it enters the tower at point A (air inlet), while the humidity seems to increase. Then, as the air traverses through the tower, the dry bulb temperature seems to increase as the specific humidity increases as well. In terms of evaporation, the reason this happens is that the concentration of humidity increases as more water is evaporater into the air. At the top of the tower, the temperature of the water is higher than the temperature at the base, meaning that more water is evaporating, increases the humidity of the tower at that specific point, as well as increasing the dry bulb temperature.

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]*

Less than 1% of the inlet water is evaporated, with evaporation slightly decreasing as water temperature increases due to a reduced vapor pressure gradient between the water and air. At higher temperatures, more heat is transferred as sensible heat rather than latent heat, limiting evaporation. Additionally, rising water temperatures increase air humidity near saturation, further reducing the air's capacity to absorb water vapor. This reflects the cooling tower's design to minimize water loss while efficiently dissipating heat.

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]*

Based on the analysis of the data, the average makeup water flow rate required is .7654 g/s. This seems to make sense as across all experiments, we recorded the initial and final height of the makeup water as well as the total time of the experiment. Using this data, we can see that our results seem to be similar to our calculated value by 17.2%.

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]*

The efficiency decreases as the water flow rate increases because higher flow rates reduce the residence time of water in the cooling tower, limiting heat and mass transfer. Additionally, at higher flow rates, the water may not fully equilibrate with the air, reducing the effectiveness of heat exchange. This leads to a smaller temperature difference between the water and air, decreasing the cooling tower's overall efficiency.