TFES Lab (ME EN 4650)
Flat Plate Convection

Required Figures and Tables

Captions

A meaningful and comprehensive caption must accompany all figures and tables. For the three figures, the caption is placed *below* the figure and includes the label Figure 1x., where x denotes the letter a–c according to the plot order listed below. For the table, the caption is placed *above* the table and includes the label Table 1d.

Plots and Tables

1a. Plot the surface temperature T_s in units of K (on the vertical axis) versus the nondimensional length x' (on the horizontal axis), comparing the measured data with the theoretical prediction, where $x' = (x - \xi)/L_h$. The limits on the horizontal axis should go from 0 to 1. Use the following linestyles: ○ 14 measurements obtained on the *top* surface, □ 2 measurements obtained on the *bottom* surface, — theoretical prediction assuming convection only, and – – theoretical prediction that corrects for the effect of radiation. Do not connect the data points with a line. Include a legend.

1b. Plot the local heat transfer coefficient h_x in units of W/m^2·K (on the vertical axis) versus the nondimensional length x' (on the horizontal axis) comparing the experimentally determined values to the theoretical prediction, where $x' = (x - \xi)/L_h$. The limits on the horizontal axis should go from 0 to 1. Use open circles for the experimental values (do not connect with a line) and a solid line for the theoretical prediction. Include a legend.

1c. Plot the local Nusselt number Nu_x (on the vertical axis) versus the nondimensional length x' (on the horizontal axis) comparing the experimentally determined values to the theoretical prediction, where $x' = (x - \xi)/L_h$. The limits on the horizontal axis should go from 0 to 1. Use open circles for the experimental values (do not connect with a line) and a solid line for the theoretical prediction. Include a legend.

1d. Create a table as shown below with the values from your calculations for the average Nusselt number $\overline{Nu}_L$, average heat transfer coefficient $\overline{h}_L$, and net heat transfer rate q_s from the *top surface*. Note, the average heat transfer coefficient should be calculated over the heated portion only from $x = \xi$ to $x = L$.

	$\overline{Nu_L}$	$\overline{h}_L$ (W/m^2·K)	q_s (W)
Measured			
Theoretical			

Short-Answer Questions

2a. Calculate the percent difference between the theoretical and experimental values of Nu_x, h_x, and T_s as a function of x',

$$\epsilon_Y = \frac{Y_{\text{exp}} - Y_{\text{th}}}{Y_{\text{th}}} \cdot 100,$$

where Y denotes the quantity of interest. State the ranges of ϵ_Y (min & max percentage values) for each quantity (Nu_x, h_x, and T_s). Describe the trend in ϵ_Y with x', and comment whether there are regions along the plate (in terms of x') where the agreement between theory and experiment are more/less favorable for each quantity. [2–4 sentences]

2b. State the percent difference between the experimental and theoretical values for the average heat transfer coefficient and average Nusselt number based on the values given in your table from 1d. When calculating the percent difference, use the same form of the equation as given above for 2a. Offer a viable explanation as to why these differences are so high, and suggest one modification to the experiment or data analysis methods that might lead to better agreement. [3–4 sentences]

2c. State the percentage contribution of heat flux lost to the surroundings via radiation compared to the net heat flux to the top surface by the resistive heaters,

$$\frac{q''_{\text{rad},L}}{q''_s} \cdot 100,$$

where q''_s is the net heat flux to the top surface based on the power supply measurements as given in equation (12) of the Handout, and $q''_{\text{rad},L}$ is the average radiation flux as given in equation (28) of the Handout. Does radiation heat transfer help to explain any discrepancies that are observed between the experimental and theoretical data? Explain why or why not. [2–3 sentences]

2d. State the Reynolds number (based on L) for the flow over the heated surface, where L is measured from the leading edge to the end of the heated surface. Comment on whether the boundary layer is expected to be laminar over the entire heated surface. Comment on how you could verify (experimentally) that the boundary layer is indeed laminar or turbulent. [2–3 sentences]