CONVECTIVE HEAT TRANSFER LAB WORKSHEET

Ch En 385 – Knotts

Overview

You will be using the Gunt WL 440 experimental apparatus to measure data to find the convective heat transfer coefficient flow over the exterior surface of a flat plat and a cylinder. Four apparatus, each at different conditions, will be set up and at steady state conditions when you arrive. You will change the conditions on three of the apparatus once you record the initial steady-state data.

The procedure below is arranged to maximize the amount of data you can collect. Unlike momentum transfer (fluid flow), which comes to steady state within a few seconds for most normal operating conditions, heat transfer takes several minutes to hours (depending on the system). Moreover, certain geometries come to steady state quicker than others. With this apparatus, the flat plate under forced convection comes to steady state in about 10 minutes after a setpoint change while the cylinder takes about 30 minutes. Make sure to answer the analysis questions while waiting for new set points to reach steady state.

Experimental Procedure

Refer to the Prelab for information on running the apparatus.

1. Record the data specified in Table 1 for two horizontal cylinders.
2. Change the fan speed of one cylinder to a medium speed. (To change fan speed, you can use the arrow buttons or type directly into the input box and press the "Enter" key.)
3. Change the heat rate of the other cylinder to a higher value. (To change the heat rate, you can use the arrow buttons or type directly into the input box and press the "Enter" key.)
4. Record the data specified in Table 2 for the flat plate with forced convection.
5. Change the fan speed on the flat plate with forced convection to a value between 90-100%.
6. Record the data specified in Table 3 for the flat plate with free convection.
7. Change the heat rate of the free convection plate to a higher value.
8. Monitor the status of each apparatus using the chart recorder. Work on the Analysis questions below while waiting for each apparatus to reach steady state conditions. The forced convection flat plate should do so before the others.
9. Record the data specified in Table 2 for the forced convection flat plate once steady state has been reached for the new conditions.
10. Repeat Steps 5, 8, and 9 for the forced convection flat plate at different fan speeds while you have time in the lab.
    a. You should be able to obtain one or two more data points (3-4 total conditions).
    b. Make the changes in fan speed big enough to see substantial changes.
11. Record the data specified in Table 1 for the two horizontal cylinders once each has reached steady state for the new setpoints.
12. Record the data specified in Table 3 for the free convection flat plate once it has reached steady state for the new set point.

Analysis

1. Calculate the convective heat transfer coefficient (h_{exp}) for each experimental condition in Tables 1-3. (Refer to the Prelab if needed.)
2. Calculate the Reynolds number for each condition in Tables 1-2.
3. Use an appropriate Nusselt number correlation and calculate the heat transfer coefficient (h_{corr}) for each condition in Tables 1-2. Determine the error between the experimental and the correlation h's.
4. Plot h_{exp} and h_{corr} as a function of Re on the same graph. Explain the behavior.
5. Calculate Nu_{exp} from your experimental data. Plot Nu_{exp} and Nu_{corr} on the same plot. Explain the behavior.
6. Comment on the behavior of the values for h obtained from the cylinder operating at the same air velocity but different heat rates. Comment on the behavior of the values for h obtained from the cylinder operating at the same heat rate but different velocities.
7. Calculate the heat flux for the flat plate and the cylinder operating at the same conditions. Explain the behavior. Make sure to include a discussion of the h's for each. (Are the h's the same or different? Which geometry transfers heat better?)
8. Comment on free vs forced confection using the data from the flat plate.

Table 1 Experimental Data—Forced Convection over Cylinders

Run #	Fan Speed (%)	Heat Rate (W)	Temperatures (°C)			Air Speed (m/s)
			Ambient Air (T1)	Surface (T4)	Exit Air (T2)	
1						
2						
3						
4						

Table 2 Forced Convection on a Vertical Plate

Run #	Fan Speed (%)	Heat Rate (W)	Temperatures (°C)			Air Speed (m/s)
			Ambient Air (T1)	Surface (T4)	Exit Air (T2)	
1						
2						
3						
4						
5						

Table 3 Free Convection on a Vertical Plate

Run #	Fan Speed (%)	Heat Rate (W)	Temperatures (°C)			Air Speed (m/s)
			Ambient Air (T1)	Surface (T4)	Exit Air (T2)	
1						
2						