Heat Transfer Workshop 8 Convection Introduction

Name ________________________ **Read about fluid convection**

Convective heat transfer occurs whenever there is a fluid next to a surface with a temperature difference. Your wrist is a good example. There is air movement due to buoyancy even in a room with no apparent overall air motion. In reality there is always some air motion – if a door is opened, if a person moves, if a piece of electronics is activated. These all cause unsteady and seemingly random air motion and surface convection. Even though this heat flux may not be very large, it can still be measured with the heat flux sensors in the course kits.

The effect of fluid motion on convection is incorporated in a coefficient h that is used to correlate heat flux $q"$ with the temperature difference between the surface T_s and the fluid T_{fluid} . For example

$$q" = h\left(T_s - T_{fluid}\right)$$

This convection heat transfer coefficient is non-dimensionalized in the Nusselt number by a characteristic length L_c and the thermal conductivity of the fluid k

$$Nu = \frac{hL_c}{k}$$

The characteristic length is the same as used in the Reynolds number

$$Re = \frac{VL_c}{\nu}$$

where the fluid velocity is V and the kinematic viscosity of the fluid is ν. Correlations for the Nusselt number are often given in terms of the Reynolds number of the flow.

The heat transfer coefficient can be determined if the heat flux and the fluid and surface temperature are measured.

$$h = \frac{q"}{\left(T_s - T_{fluid}\right)}$$

This is a great advantage of having a heat flux sensor to measure the heat flux. If the correlation between the Reynolds and Nusselt number are known for the specific geometry, heat transfer measurements can even be used as a method to find the fluid velocity. This will be demonstrated in the current workshop.

Heat Transfer Workshop 8 Convection Results

Name ________________________

Your first challenge is to measure heat transfer convection coefficients using the heat flux sensor system. Tape the heat flux sensor to the inside of your wrist to measure the surface temperature and heat flux. Either use tape over top of the sensor or double-sided tape underneath the sensor to hold it on to your wrist. Keep the second thermocouple out in the room to record the air temperature. Take about 20 seconds of data under each of three conditions (it can all be recorded in the same file). First turn your wrist with the sensor facing up and not moving, then turn your wrist so the sensor is facing down not moving, then move your arm in a circle to give motion relative to the air. What is the maximum heat flux that you can achieve moving your arm?

Calculate the heat transfer coefficients and corresponding Nusselt numbers for each condition. Neglect the effects of radiation. Use the diameter of your wrist as the characteristic length, $L_C = d =$ _____ for Re and Nu, assuming your arm is a cylinder. Record the average values for the three conditions in the table below and calculate the corresponding heat transfer coefficient and Nusselt number.

	Wrist Facing Up	Wrist Facing Down	Arm moving
T_{air} (°C)			
T_s (°C)			
q" (W/m^2)			
h (W/m^2-K)			
$Nu = hL_c/k$			

The heat transfer correlation for air flow over a cylinder at the stagnation point is

$$Nu = 0.95\sqrt{Re}$$

Use this correlation to estimate the maximum velocity you achieved moving your arm based on your measured Nusselt number. Find the required air properties at room temperature from an appropriate table of thermal and fluid properties.

Air Properties:

Diagrams, Equations and Calculations:

1. For your arm moving, Re =

2. What was the corresponding maximum Velocity, V =

3. Which of the three orientations of the sensor on your wrist would you expect to give the highest heat flux? Why?

4. Which orientation would you expect to give the lowest heat flux?
Based on buoyancy, Why? How does this compare with what you measured?