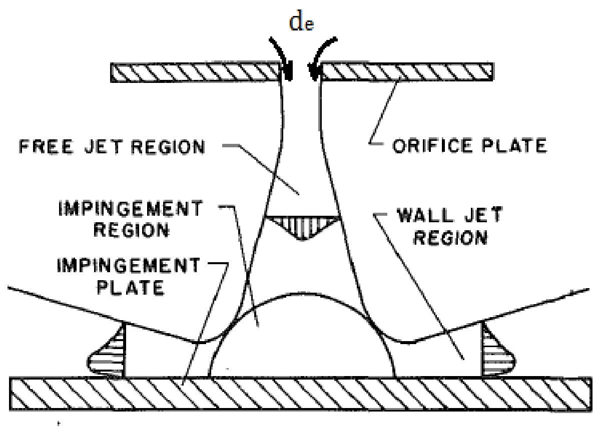
Heat Transfer Workshop 9 Introduction to Jets

Name ________________________

An air jet is a good means for providing convective heat transfer with a surface. This is why you blow on your food if it is too hot. A sketch of a typical air jet is shown in the figure. Large arrays of hot air jets are often used in industrial drying processes. Fans pressurize large plenums with many small orifice holes in a plate that then impinge on the opposing surface.



A common correlation for the heat transfer on a flat surface in the impingement region beneath an impinging air jet is

$$Nu = 0.83\,\sqrt{Re}$$

where $Re = Vd/v$ and $Nu = hd/k.$

The air thermal conductivity is k and the kinematic viscosity is v. The effective diameter of the jet at the exit is d and the velocity is V. The velocity can be determined from Bernoulli's equation. in terms of the plenum pressure p relative to atmospheric.

$$\frac{p}{\rho} + \frac{1}{2}\,V^2 = Constant$$

where ρ is the fluid density. Therefore, the plenum pressure difference above the atmosphere is

$$\Delta p = \frac{1}{2}\,\rho\,V^2$$

and the velocity of the jet is

$$V = \sqrt{\frac{2\,\Delta p}{\rho}}$$

The heat transfer coefficient between the jet and the surface is defined as

$$h = \frac{q''}{(T_j - T_s)}$$

in terms of the heat flux q'', the jet temperature T_j and the surface temperature T_s.

Heat Transfer Workshop 9 Jet Results

Name ________________________

Your challenge today is to measure the convective heat transfer coefficient when you blow on something. This is a pretty good mechanism to cool a bite of food, for example. Tape the heat flux sensor to your piece of aluminum as a heat sink and place it on a surface at room temperature. Put the wire connection side down next to the metal to get a positive heat flux. Tape the second thermocouple so that the bead is sitting above the sensor, but not touching it. This will provide a measure of the air temperature from your lungs. Start the data acquisition and blow as long and hard as you can. Try several different distances and openings of your mouth to optimize the heat flux to the surface. Then stop and save your data.

Note that this is a highly transient event and the direction of heat flux and temperatures may switch momentarily, giving what appears to be negative values of h. Use the plots of heat flux and temperature to interpret your heat transfer coefficients.

1. Give the maximum value of measured heat flux that you achieved.

Maximum $q'' =$

2. Record the temperatures of the surface and jet when the maximum heat flux occurs.

$T_s =$

$T_j =$

3. Calculate the corresponding heat transfer coefficient and Nusselt number. Look in a mirror to estimate the diameter of your mouth when you blew. Use this as the jet diameter, $d =$ _____.

$h =$ __________

$Nu = hd/k =$ __________

4. From the Nusselt number correlation given in the Introduction, determine the corresponding velocity that this heat transfer measurement estimates, $V =$ ____________

5. Your lungs can provide an air pressure of several inches of water. What lung pressure is required to provide the air velocity you calculated in 4? Assume that Bernoulli equation applies. (249 Pa = 1 in. H_2O)

$\Delta p =$ _________ Is this value reasonable?

6. Show equations and calculations.

<u>Air properties at 300 K</u>
Thermal conductivity, $k =$
Density, $\rho =$
Kinematic viscosity, $\nu =$