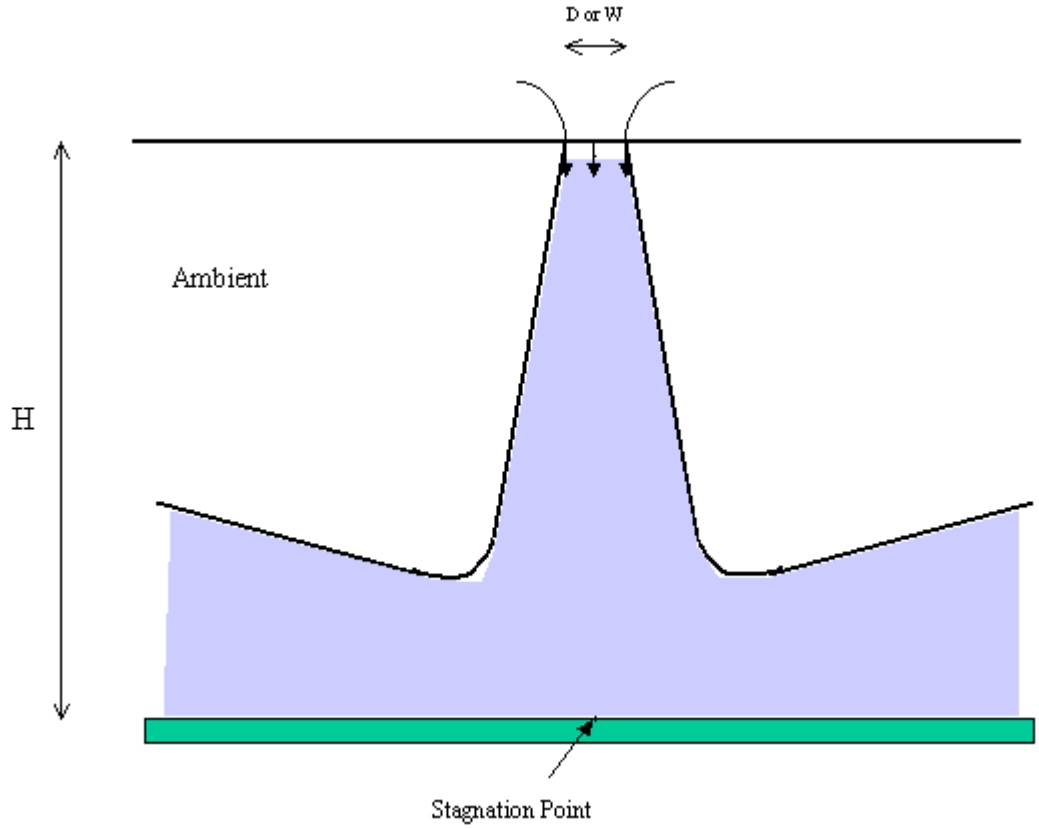
# Impingment Heat Transfer from a Single Jet

Impingement cooling has applications in many industrial processes. It is used in cooling heated parts of gas turbine engines, deicing of aircraft wings and in cooling electronics components. In impingement cooling a single jet or an array of such jets impinge on a surface. The heat transfer coefficient for convective heating, cooling or drying is therefore increased.

The schematics of a typical impingement is shown below. The jet of fluid is discharged through a nozzle or a slot and is directed towards the surface for which the enhanced heat transfer coefficient is sought.




The average Nusselt number for a single round jet may be calculated as:

$$\overline{Nu} = \mathrm{Pr}^{0.42} GF_1$$

where

$$F_1 = 2\mathrm{Re}^{1/2}(1 + 0.005\mathrm{Re}^{0.55})^{1/2}$$

and

$$G = \frac{D}{r}\frac{1 - 1.1D/r}{1 + 0.1(H/D - 6)D/r}$$

The ranges of validity are:

$$2000 \le \mathrm{Re} \le 400{,}000$$

$$2 \le \frac{H}{D} \le 12$$

$$2.5 \le \frac{r}{D} \le 7.5$$

For a single slot nozzle the correlation is given by:

$$\overline{Nu} = \mathrm{Pr}^{0.42}\frac{3.06}{x/W + H/W + 2.78}\mathrm{Re}^{m}$$

where

$$m = 0.695 - \left[\frac{x}{2W} + \left(\frac{H}{2W}\right)^{1.33} + 3.06\right]^{-1}$$

and the ranges of validity are:

$$3000 \le \mathrm{Re} \le 90{,}000$$

$$2 \le \frac{H}{W} \le 10$$

$$4 \le \frac{x}{W} \le 20$$

In both cases Nusselt number is averaged over an area defined by r or x, the distance on the target surface from the stagnation point.

Also

$$\overline{Nu} \equiv \frac{\bar{h}D_h}{k}$$

$$\mathrm{Re} \equiv \frac{V_e D_h}{\nu}$$

where $D_h$ is the hydraulic diameter, $V_e$ is the nozzle exit velocity, $\nu$ is the kinematic viscosity, $k$ is the fluid thermal conductivity and $\bar{h}$ is the avrage heat transfer equation.

**Caution:** The above correlations should be used for conditions for which they were developed. All nozzles were of the bell-shaped mouth. The behavior is different for sharp-edged orifice. Also, attention must be given to an appropriate reference temperature when applying the Newton's law of cooling.