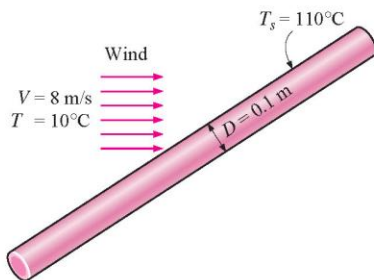


# Mech 262 – Thermodynamics 2

## Tutorial: Convective Heat Transfer Coefficient

Do the question in the follow example problem in two different ways:

- Using the formula for Nu that is included as part of the 'Part 1' Convective Heat Transfer class hand out (different than the one below).
- Assume the flow over the pipe is in still air (a calm day). That means ... Natural Convection.
- Compare the example results with yours.



**FIGURE 12-42**  
Schematic for Example 12-5.

### EXAMPLE 12-5 Heat Loss from a Steam Pipe in Windy Air

A long 10-cm-diameter steam pipe whose external surface temperature is 110°C passes through some open area that is not protected against the winds (Fig. 12-42). Determine the rate of heat loss from the pipe per unit of its length when the air is at 1 atm pressure and 10°C and the wind is blowing across the pipe at a velocity of 8 m/s.

**Solution** A steam pipe is exposed to windy air. The rate of heat loss from the steam is to be determined.

**Assumptions** 1 Steady operating conditions exist. 2 Radiation effects are negligible. 3 Air is an ideal gas.

**Properties** The properties of air at the average film temperature of  $T_f = (T_s + T_\infty)/2 = (110 + 10)/2 = 60^\circ\text{C}$  and 1 atm pressure are (Table A-22)

$$k = 0.02808 \text{ W/m} \cdot ^\circ\text{C} \quad \text{Pr} = 0.7202$$

$$\nu = 1.896 \times 10^{-5} \text{ m}^2/\text{s}$$

**Analysis** The Reynolds number is

$$\text{Re} = \frac{VD}{\nu} = \frac{(8 \text{ m/s})(0.1 \text{ m})}{1.896 \times 10^{-5} \text{ m}^2/\text{s}} = 4.219 \times 10^4$$

The Nusselt number can be determined from

$$\begin{aligned} \text{Nu} &= \frac{hD}{k} = 0.3 + \frac{0.62 \text{ Re}^{1/2} \text{ Pr}^{1/3}}{[1 + (0.4/\text{Pr})^{2/3}]^{1/4}} \left[ 1 + \left( \frac{\text{Re}}{282,000} \right)^{5/8} \right]^{4/5} \\ &= 0.3 + \frac{0.62(4.219 \times 10^4)^{1/2} (0.7202)^{1/3}}{[1 + (0.4/0.7202)^{2/3}]^{1/4}} \left[ 1 + \left( \frac{4.219 \times 10^4}{282,000} \right)^{5/8} \right]^{4/5} \\ &= 124 \end{aligned}$$

and

$$h = \frac{k}{D} \text{Nu} = \frac{0.02808 \text{ W/m} \cdot ^\circ\text{C}}{0.1 \text{ m}} (124) = 34.8 \text{ W/m}^2 \cdot ^\circ\text{C}$$

Then the rate of heat transfer from the pipe per unit of its length becomes

$$A_s = pL = \pi DL = \pi(0.1 \text{ m})(1 \text{ m}) = 0.314 \text{ m}^2$$

$$\dot{Q} = hA_s(T_s - T_\infty) = (34.8 \text{ W/m}^2 \cdot ^\circ\text{C})(0.314 \text{ m}^2)(110 - 10)^\circ\text{C} = \mathbf{1093 \text{ W}}$$

The rate of heat loss from the entire pipe can be obtained by multiplying the value above by the length of the pipe in m.

**Discussion** The simpler Nusselt number relation in Table 12-1 in this case would give  $\text{Nu} = 128$ , which is 3 percent higher than the value obtained above using Eq. 12-47.