ME 211 – Thermo I
Fall 2013
SS-SF Analysis of a Pumping System

Supplemental Problems 6

1. Consider a pump with an inlet pressure of 100 kPa and an exit pressure of 300 kPa. The volumetric flow rate for the pumping is 50 L/sec. The inlet pipe has a diameter of 7.5 cm and the exit pipe has a diameter of 5 cm. The inlet to the system is located 3 meters below the pump drive shaft and the exit for the system is located 15 meters above the drive shaft.

Given the information noted, with appropriate assumptions, determine the power input to the pump (which is the power delivered by the motor). The answer should be in kW and HP.

Some assumptions are required:

A. The flow is steady and incompressible
B. The pump is driven by an external motor so that the heat generated by the motor is dissipated to the atmosphere. We will assume the pump to be adiabatic.
C. The elevation difference between the inlet and outlet of the pump is significant
D. The inlet and outlet diameters are unequal and thus the inlet and exit velocities are unequal.

We consider the fluid to be incompressible and there is little temperature change through the pump. The density of water for this application is 1000 kg/m^3 C (Table A-3).

To determine the power input we need to know the increase in the mechanical energy of the fluid as it flows through the pump, which is

$$\Delta\dot{E}_{\text{mech,fluid}} = \dot{E}_{\text{mech,out}} - \dot{E}_{\text{mech,in}} = \dot{m}\left(\frac{P_2}{\rho} + \frac{V_2^2}{2} + gz_2\right) - \dot{m}\left(\frac{P_1}{\rho} + \frac{V_1^2}{2} + gz_1\right)$$

We note:

$$\Delta\dot{E}_{\text{mech,fluid}} = Power$$

Our task is to complete the analysis with the above equation.