Homework #8

MEMS 0051 - Introduction to Thermodynamics

Assigned July 26$^{\text{th}}$, 2018
Due July 30$^{\text{th}}$, 2018

Starting with the Conservation of Energy equation:

$$\frac{d\,E}{dt} = \dot{Q} - \dot{W} + \sum_{i=1}^{N} \dot{m}_i \left(h_i + \frac{V_i^2}{2} + g z_i \right) - \sum_{j=1}^{M} \dot{m}_j \left(h_j + \frac{V_j^2}{2} + g z_j \right),$$

and the Continuity equation:

$$\frac{d\,m}{dt} = \sum_{i=1}^{N} \dot{m}_i - \sum_{j=1}^{M} \dot{m}_j,$$

Solve the following:

Problem #1

Steam enters a turbine through a pipe with a diameter of 0.2 [m]. The steam enters with a velocity of 100 [m/s], a pressure of 14,000 [kPa] and a temperature of 600 °C. The steam is exhausted through a pipe with a diameter of 0.8 [m], a pressure of 500 [kPa] and a temperature of 180 °C. Determine:

a) the exit velocity of the steam;
b) the mass flow rate of the steam.

Problem #2

A device has one inlet with a cross-sectional flow area of 0.6 [m^2] in which steam enters with a velocity of 50 [m/s], a pressure of 1,000 [kPa] and a temperature of 400 °C. There are two outlets. One outlet has saturated liquid exiting through a 0.018 [m^2] pipe with a mass flow rate of 50 [kg/s] at a pressure of 150 [kPa]. Determine:

a) the mass flow rate at the inlet;
b) the mass flow rate of the second outlet.

Problem #3

Air enters a device at 1,000 [kPa] and 580 [K] and leaves with a volumetric flow rate of 1.8 [m^3/s] at 100 [kPa] and 500 [K]. Heat is transferred from the device to the surroundings at 347 [kJ] per kilogram of air entering the device. Determine:

a) the power developed by the device;
b) the the volumetric flow rate at the inlet.

Problem #4

Air flows through a diffuser with a mass flow rate of 0.5 [kg/s] from an inlet condition of 300 [kPa], 290 [K] and 400 [m/s] to an exit condition of 1,4000 [kPa] and 40 [m/s]. Determine:

a) the exit temperature of the air;
b) the inlet cross-sectional flow area.

Problem #5

A turbine with sufficient insulation accepts steam at the rate of 85 [m^3/min] at 3,000 [kPa] and 400 °C. A portion of the steam is siphoned from the turbine at a pressure of 500 [kPa], a temperature of 180 °C at a velocity of 20 [m/s]. The remainder of the steam, with a mass flow rate of 40,000 [kg/hr] expands to a pressure of 6 [kPa] with a quality of 90%. Determine:

a) the power developed by the turbine;
b) the diameter of the siphon.

Problem #6

An open feedwater heater (OFWH) accepts liquid water at 1,000 [kPa] and a temperature of 50 °C. The OFWH also accepts water with a mass flow rate per that of inlet one, i.e. $\dot{m}_2/\dot{m}_1$=0.22. Saturated liquid water exits the OFWH. Determine:

a) the temperature of the second incoming stream, if superheated;
b) the quality of the second incoming stream, if saturated.