ASSIGNMENT 4

1. Joule postulated that the temperature of water when it comes down a water fall rises. Consider the water fall to be an open thermodynamic system and determine the minimum height through which the water should fall for its temperature to raise by 1^oC. Assume C_p = 4.186 kJ/kg-K for water. List all other assumptions made while solving the problem. [427 m].

2. Steam is supplied to a turbine with h_i = 2.8 MJ/kg and it leaves with h_e = 2.2 MJ/kg. The entrance and exit velocities are 180 m/s and 300 m/s respectively. If the heat loss is 20 kJ/kg. What is the work done? [551.2 kJ/kg].

3. A steady flow system receives 45 kg/min of gas at 2 bar, 90^oC, with negligible velocity, and discharges it at a point 25m above the entrance section at a temperature of 300^oC with a velocity of 2500 m/min. During this process 1.4 kW of heat is supplied from external source and the increase in enthalpy is 8.4 kJ/kg. Determine the power output. [-5.74 kW]

4. A centrifugal air compressor compresses 6 m^3/min of a gas from 8 N/cm^2 to 64 N/cm^2. The inlet and exit specific volumes are 0.8 m^3/kg and 0.4 m^3/kg respectively. The duct diameters are 10 cm at the inlet and 5 cm at the exit. Determine (a) rate of flow work (b) mass flow rate (c) change in velocity. [0.125 kg/s, 12.73 m/s, 24 kW]

5. A steam turbine receives steam at a rate of 6000 kg/hr and develops a power of 600 kW. Neglecting heat losses, determine the change in specific enthalpy of steam flowing through the turbine if (a) the entrance and exit velocities and heights are negligible and (b) the entrance and exit velocities are 70 m/s and 400 m/s respectively and inlet is 5 m above the exit. [-360 kJ/kg, -437.6 kJ/kg]

6. In a steady flow apparatus, the work done by the system is 50 kJ/kg of fluid. The specific volume, pressure, and velocity at the inlet and exit are 0.4 m^3/kg, 6 bar, 15 m/s and 0.6 m^3/kg, 1 bar, 250 m/s respectively. The inlet is 30 m above the exit and the total heat loss is 8 kJ/kg of fluid. What is the change in specific internal energy? [91.5 kJ/kg]

7. A ship propulsion system incorporates a compressor which receives steam at 3.4 bar with 5 percent moisture. It delivers it dry and saturated at 6 bar. Steam flow rate is 4 kg/s. The compressor is adiabatic. Diameter of the inlet and exit are 20 cm. the mechanical efficiency of the machine is 92%. Determine the power required to drive the compressor. [574 kW]

8. The inlet conditions for the nozzle of a steam turbine are 50 bar, 350^oC. The exit conditions are 10 bar, 0.9 dry. If the steam flow rate is 10,000 kg/hr, determine the velocity and exit area. [992 m/s, 4.892 cm^2]

9. The inlet conditions of a water pump are 1 bar, 25^oC and the exit pressure is 200 bar. the pump consumes 70 kW of power and pumps 10,000 litres of water per hour (at inlet conditions). Determine the temperature of water at the exit of the pump. If we define the ideal

pump as the one which does the pumping isothermally, what is the efficiency of this pump. [26.3°C, 79%]

10. Feed water at 0.1 bar from a condenser is pumped into the boiler at 20 bar. Water at the exit of the condenser is saturated and the compression is isentropic. Determine the work done per kg of water pumped and the flow work. [-2.01 kJ/kg. 2.01 kJ/kg]

11. Water at a rate of 60 kg/min enters a pump at 1 bar, 40°C. The pump power is 60 kW, and the pump raises the pressure to 5 bar. The water then passes through a boiler in which 2000 kJ/kg of heat is added. Assuming negligible pressure drop in the boiler, determine the state at the exit of the boiler, and the velocity at that point if the diameter of the exit duct is 20 cm. [0.7529, 9.0 m/s]

12. Water flows at a steady rate of 1500 kg/min through a horizontal venturimeter with inlet and throat diameter of 7.0 cm and 3.5 cm respectively. If there is no transfer of heat and work, and no change in internal energy and the density remains constant at 1000 kg/m^3, what will be the pressure drop between inlet and throat in bar. [3.18 bar]

13. A constant air duct of diameter 10 cm discharges a fluid and is heated over a 5 m length with a constant heat flux. The conditions at inlet and exit are:

INLET : Velocity, temperature and pressure uniform across the section, T = 30°C,
p = 1 bar.
EXIT : p = 1 bar uniform,
v = 150[1-(r^2/R^2)] m/s
T = 350 [1+(r^2/R^2)]°C

Determine the heat flux if the density and specific heat at constant pressure remain constant at 1.0 kg/m^3 and 1.0 kJ/kg-K respectively. [114000 kW/m^2]

14. Wet steam at 7 bar is passed through a throttling calorimeter. The state of steam after throttling is 0.5 bar, 100°C. What is the dryness fraction of the steam at 7 bar. [0.9608]
15. A gas turbine was found to have the following inlet and exit conditions averaged over a 1 minute interval of time.
    INLET : 800 K, 8 m/s, (40 cm duct)
    EXIT : 400 K, 2 bar, 5 m/s, (80 cm duct)

The power output was 1 MW and the total heat loss during the minute was 8000kJ.The working fluid was an ideal gas with RMM = 29 and C_p = 1. kJ/kg-K. Determine for interval, (a) mass accumulated in the system, and (b) increase in the internal energy of the system. [0, 37.2 MJ]

16. A rigid insulated bottle of volume V_0 is perfectly evacuated. the stopper is opened and ambient air (at p_0 and T_0) is allowed to flow in. When the flow stops, the stopper is replaced. Determine the final temperature of the air in the bottle. [γT_0]
17. A steam turbine has an inlet state of 10 bar, 200°C. the exit state is 2 bar, 5% moisture. The heat loss was 50 kW and the steam flow rate is 3 kg/s. Determine the power of the turbine. [644.2 kW]
18. A nozzle is used to expand air form 8 bar, 50°C to 1 bar, (-)60°C. the nozzle is horizontal and was insulated. Determine the exit velocity and exit area, if the flow rate is 3 kg/min. Will the

answers be different if the nozzle length is 20 cm and the discharge is upwards. [470.2 m/s, 65 mm^2]

19. An open thermodynamic system consists of a boiler and a turbine in series. The inlet to the boiler is at 20 bar, saturated liquid. The boiler exit / turbine inlet is at 18 bar dry saturated steam. The turbine exit pressure is 1 bar. The process through the turbine is isentropic. The turbine products 50 MW of power. Determine the mass flow rate and the rate of heat transfer in the boiler. [307.7 kg/s, 581.2 MW]