MECH 225 Engineering Science 2

Tutorial Sheet - Steady Flow Energy Equation

1. A fluid ‘A’ having a specific enthalpy of 2260 kJ/kg flows into a rigid mixing tank at the rate of 0.75 kg/s. A second fluid ‘B’ having a specific enthalpy of 160 kJ/kg also flows into the tank at a steady rate. During mixing, the heat rejection is 1260 kJ/min. If the specific enthalpy of the mixture flowing from the tank is 1040 kJ/kg, and the fluid level in the tank remains steady, calculate the rate of flow of fluid B.

   (1.016 kg/s)

2. A steam turbine uses 3.6 tonne of steam per hour. At inlet to the turbine the steam has a velocity of 27.5 m/s, and a specific enthalpy of 3000 kJ/kg. The steam leaves the turbine with a velocity of 182.5 m/s and a specific enthalpy of 2220 kJ/kg. If the process is adiabatic, calculate the output of the turbine.

   (763.7 kW)

3. Fluid at 10.35 bar having a specific volume of 0.18 m^3/kg is throttled to a pressure of 1 bar. If the specific volume of the fluid after throttling is 0.107m^3/kg, calculate the change in specific internal energy during the process.

   (175.6 kJ/kg)

4. The following data refer to a gas nozzle

Section	Pressure [bar]	Specific Volume [m^3/kg]	Specific Internal Energy [kJ/kg]
Inlet	4.8	0.520	725
Intermediate	2.6	0.825	620
Outlet	1.0	1.750	510

   It may be assumed that the inlet velocity is negligible, and that the process is adiabatic. If the area of flow at the intermediate section is 645 mm^2, calculate the rate of gas flow through the nozzle and the required outlet area.

   (24.84 kg/min; 951 mm^2)

5. A nozzle is supplied with steam having a specific enthalpy of 2780 kJ/kg at the rate of 9.1 kg/min. At outlet from the nozzle the velocity of the steam is 1070 m/s. Assuming that the inlet velocity of the steam is negligible and that the process is adiabatic, determine:

   (a) the specific enthalpy of the steam at the nozzle exit.
   (b) the outlet area, if the final specific volume of the steam is 18.75 m^3/kg.

   (2208 kJ/kg, 2658 mm^2)

6. Air enters a centrifugal compressor at 1 bar and leaves at 2.1 bar. During the passage of the air through the compressor, the specific internal energy of the air increases by 56 kJ/kg, and the specific volume decreases from 0.825 m^3/kg to 0.5 m^3/kg. Assuming that the flow is adiabatic and that the changes in kinetic energy are negligible, calculate the power required to drive the compressor when the air flow rate is 135 kg/min.

(177 kW)

7. Air, which may be assumed a perfect gas, flows steadily through a heater of constant cross-section. The initial temperature and pressure of the air are 15 ^oC and 125 kPa respectively and the velocity of entry is 25 m/s. The exit conditions are 60 ^oC and 100 kPa. If the heater is horizontal and the air mass flow rate is 18 kg/s, find:

(a) the cross-sectional area of the heater
(b) the rate of heat transfer to the air

Data for air: specific gas constant $R = 0.287$ kJ/kgK
specific heat capacity at constant pressure $C_p = 1.005$ kJ/kgK

(0.476 m^2; 820.2 kJ/s)

8. Steam with specific enthalpy of 2400 kJ/kg flows at the rate of 0.4 kg/s into a small condenser and leaves as condensate with specific enthalpy of 160 kJ/kg. The specific volume of the incoming steam is 18.5 m^3/kg and the diameter of the inlet pipe is 300 mm. The condenser is supplied with cooling water which enters at 10^{o}C and leaves at 20^{o}C. Calculate the velocity of steam entering the condenser and the mass flow rate of cooling water, assuming negligible velocity at exit for the condensate. Neglect heat transfer to surroundings and take specific heat of cooling water as 4.18 kJ/kgK.

(104.7 m/s; 21.49 kg/s)

9. A simple steam plant has the following data:

Location	Pressure	Temp/Quality
Leaving boiler	30 bar	300 ^oC
Entering turbine	28 bar	275 ^oC
Leaving turbine/entering condenser	0.1 bar	0.9
Leaving condenser/entering pump	0.1 bar	45.8 ^oC

If the specific work input to the feed pump is 6.2 kJ/kg, determine the following/kg:

(a) heat transfer in the line between boiler and turbine
(b) turbine work
(c) heat transfer in condenser
(d) heat transfer in boiler

(60.9 kJ/kg (loss), 589.3 kJ/kg, 2152.8 kJ/kg (loss), 2796.8 kJ/kg)