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| **Benha University****Mechanical Engineering Department****First term (2014-2015)** |  **Sheet No (3)** | **Faculty of Engineering-Shoubra****3rd year (Mechanical Power)** **Fluid Mechanics (3)** |

**1- Air at a pressure of 680 kpa and a temperature of 833 K enters a converging nozzle through a line of 4.6 x 10-3 m2 area and expands to a delivery -region pressure of 33 Kpa. Assuming isentropic expansion and a mass rate of flow of 1 kg/s, find:**

**a) The stagnation enthalpy.**

**b) The temperature and enthalpy at discharge.**

**c) The Mach number and velocity at discharge.**

**2- Air at 1 MPa and 600°C enters a converging nozzle, with a velocity of 150 m/s. Determine the mass flow rate through the nozzle for a nozzle throat area of 50 cm2 when the back pressure is (a) 0.7 MPa and (b) 0.4 MPa.**

**3- Air at 403 K and 101.3 kpa enters a convergent nozzle at velocity 150 m/s and expands isentropically to an exit pressure of 76 kpa. The nozzle inlet area is 50 cm2. Find:**

**a) The stagnation pressure and temperature.**

**b) The Mach number at inlet and outlet.**

**c) The back pressure required to obtain sonic condition at exit.**

**d) The maximum mass flow rate.**

**4- Nitrogen enters a duct with varying flow area at T1 = 400 K, P1 = 100 kPa, and M1 =0.3. Assuming steady isentropic flow, determine T2, P2, and M2 at a location where the flow area has been reduced by 20 percent.**

**5- Air lows steadily and isentropically into an aircraft inlet a mass flow rate of 100 kg/s. at a section where the cross-sectional area is 0.5 m2, the temperature and pressure are 200 K and 20 kpa, respectively. Determine the velocity, pressure and cross-sectional area at a downstream section where the temperature is 350 K. Sketch the flow passage, and show the process on T-s diagram.**

**6- A convergent – divergent nozzle discharge air into a receiver where the static pressure is 15 bars. A duct with constant area 0.03 m2 feeds the nozzle with air at 100 bar, 400 K and a velocity such that the Mach number is 0.3. The exit area is such that pressure at the nozzle exit exactly matches the receiver pressure. Assume steady, one –dimensional flow, perfect gas, and isentropic flow**

**a) Calculate the flow rate.**

**b) Determine the throat and exit areas.**

**7- A convergent – divergent nozzle has an exit area to throat area of 2.0, air enters this nozzle with a stagnation pressure of 1000 kpa and stagnation temperature of 360 K. The throat area is 500 mm2 .Determine the mass flow rate, exit pressure, exit temperature, exit Mach number and exit velocity for the following conditions:**

**a) Sonic velocity at the throat, diverging section acting as a nozzle.**

**b) Sonic velocity at the throat, diverging section acting as a diffuser.**

**8- At a point upstream of the throat in a converging-diverging nozzle, the pressure, temperature and velocity of the air are 200 kpa, 400 K and 200 m/s, respectively. The exit and throat cross-sectional area of nozzle are 0.002 m2 and 0.001 m2, respectively. Determine the Mach number, temperature and pressure at the exit plane. Also find the back pressure and mass flow rate. The nozzle is operating at its design condition. Show the process on T-S diagram.**

**9- Air flows isentropically at the rate of 0.5 kg/s through a supersonic convergent – divergent nozzle. At the inlet, the pressure is 680 kpa, the temperature is 295 K and the area is 6.5 cm2. If the exit area is 13 cm2, calculate:**

**a) The stagnation pressure and temperature.**

**b) The area and velocity at the throat.**

**c) The exit pressure, temperature and Mach number.**

**d) What will be the maximum rate of flow and the corresponding exit Mach number if the flow is completely subsonic in the nozzle?**

**10- Air enters a converging–diverging nozzle at 1.0 MPa and 800 K with a negligible velocity. The flow is steady, one-dimensional, and isentropic For an exit Mach number of M= 2 and a throat area of 20 cm2, determine (a) the throat conditions, (b) the exit plane conditions, including the exit area, and (c) the mass flow rate through the nozzle.**