C 80610 (Pages : 2) Name.....

Reg. No.....

EIGHTH SEMESTER B.TECH. (09 SCHEME) (ENGINEERING) DEGREE EXAMINATION, APRIL 2015

ME 09 802—COMPRESSIBLE FLUID FLOW

Time : Three Hours Maximum : 70 Marks

Part A

Answer **all** *questions.*

1. Differentiate between Steady flow and Unsteady flow.
2. Define stagnation temperature.
3. State the application of various types of nozzles.
4. Define Fanno flow. Give two examples of Fanno flow in thermal systems.
5. Why is it desirable to locate the shock wave at the diffuser throat during the operation of the tunnel ?

(5 × 2 = 10 marks)

Part B

Answer any **four** *questions.*

6. Derive the energy equation for a flow process.
7. The cross-section of the exit of a control surface enclosing an aircraft propeller is 9 $m.^2$ The mean value of air velocities at the entry and exit of the control surface are 133 m/s and 170 m/s respectively. Take the density of air at 1.25 kg./$m.^3$ Determine the thrust acting on the propeller. Assume incompressible and steady flow.
8. Superheated steam is supplied to a supersonic nozzle at the design flow rate of 1.0 kg/s (per $cm.^2$ of the throat area). If the stagnation temperature of steam is 800 K, determine the stagnation pressure of the steam required for this flow rate. Take R = 0.477 kJ/kgK, γ = 1.278 for steam. Assume isentropic flow.
9. Derive an equation describing a Fanno curve. Show three Fanno curves at three mass flow densities.
10. The conditions of a gas in a combustor at entry are :

    P_1 = 0.343 bar, T_1 = 310 K, C_1 = 60 m/s.

    Determine the Mach number, pressure, temperature and velocity at the exit if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5 kJ/kg. Take γ = 1.4, C_p = 1.005 kJ/kg-K.
11. Discuss about strength of normal shock wave.

(4 × 5 = 20 marks)

Turn over

Part C

Answer **all** *questions.*

12. (a) The pressure, temperture and Mach number at the entry of a flow passage are 2.45 bar, 26.5° C. and 1.4 respectively. If the exit Mach number is 2.5, determine for adiabatic flow of a perfect gas (γ = 1.3, R = 0.469 kJ/kg.K) :

(i) Stagnation temperature ; (ii) Temperature and velocity of gas at exit ; and (iii) The flow rate per square meter of the inlet cross-section.

Or

(b) Derive the momentum equation for a flow through a control volume.

13. (a) Air is discharged from a reservoir at p_0 = 6.91 bar and T_0 = 325°C. through a nozzle to an exit pressure of 0.98 bar. If the flow rate is 3600 kg/hr. determine for isentropic flow (i) throat area, pressure and velocity, (ii) exit area, Mach number ; and (iii) maximum velocity.

Or

(b) Explain the effect of Mach number on compressibility.

14. (a) Air enters a long circular duct (d = 12.5 cm., f = 0.0045) at Mach number of 0.5, pressure, 3.0 bar and temperature 312 K. If the flow is isothermal throughout the duct, determine : (i) the length of the duct required to change the Mach number to 0.7 ; (ii) pressure and temperature of air at M = 0.7 ; (iii) the length of the duct required to attain limiting Mach number ; and (iv) State of air at the limiting Mach number.

Or

(b) Obtain an equation representing the Rayleigh line. Draw Rayleigh lines on the h-s and p-v planes for two different values of the mass flow.

15. (a) Derive the Rankine-Hugoniot relation for a normal shock wave.

Or

(b) The following data refers to a supersonic wind tunnel :

Nozzle throat area = 200 cm.^{2}
Test section cross-section = 337.5 cm.^{2}
Working fluid : air (γ = 1.4, C_p = 0.287 kJ/kg.K)

Determine the test section Mach number and the diffuser throat area if a normal shock is located in the test section.

(4 × 10 = 40 marks)