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Question Paper Code : 91660

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2014.

Sixth Semester

Mechanical Engineering

ME 2351/ME 64/10122 ME 602 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2008/2010)

(Common to PTME 2351/10122 ME 602 — Gas Dynamics and Jet Propulsion for B.E. (Part-Time) Fifth Semester — Mechanical Engineering — Regulation 2009/2010)

Time : Three hours Maximum : 100 marks

Use of Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Find the maximum possible velocity in a medium of air when static temperature is 200°C and velocity is 120 m/s.

2. When does the maximum mass flow occur for an isentropic flow with variable area and what type of nozzle used for sonic flow and supersonic flow?

3. Air at P_0 = 10 bar and T_0 = 400 K is supplied to a 50 mm diameter pipe, the friction factor for the pipe surface is 0.002. If the Mach number changes from 3 at entry to 1 at the exit. Determine the length of the pipe.

4. What are the assumptions made for fanno flow? And give the two practical examples where the fanno flow occurs.

5. What are the properties changes across a normal shock? Is the flow through a normal shock an equilibrium one?

6. Give the difference between normal and oblique shocks.

7. Why ramjet engine does not require a compressor and a turbine?

8. Find the optimum propulsive efficiency when the jet velocity is 500 m/s and flight velocity is 900 m/s.

9. What are the properties of solid propellants?

10. Define characteristic velocity.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Difference between transonic flow and hypersonic flow. (4)

(ii) Derive the expression for pressure co-efficient equation for compressible flow. (10)

(iii) Name the different regions of compressible fluid flow. (2)

Or

(b) (i) Derive the expression for mass flow rate in terms of Mach number. (8)

(ii) A nozzle in a wind tunnel gives a test-section Mach number of 2.0. Air enters the nozzle from a large reservoir at 0.69 bar and 310 K. The cross-sectional area of the throat is 1000 cm^2. Determine the following quantities for the tunnel for one dimensional isentropic flow :

(1) Pressures, temperatures and velocities at the throat and test sections,

(2) Area of cross-section of the test section,

(3) Mass flow rate and

(4) Power required to drive the compressor. (8)

12. (a) Prove that the variation of flow parameter and the maximum possible heat transfer $Q_{max} = C_p T \times \frac{\left(1 - M^2\right)^2}{2(1+\gamma)M^2}$. (16)

Or

(b) (i) A circular duct of 35 cm diameter passes gas at a Mach number of 2.0. The static pressure and temperature are 1 bar and 410 K respectively. A normal shock occurs at a Mach number of 1.4 and the exit Mach number is 1. If the co-efficient of friction is 0.002, calculate :

(1) Length of the duct upstream and downstream of the shock wave,

(2) Mass flow rate of the gas, and

(3) Change of entropy for upstream of the shock, across the shock and downstream of the shock. Take γ = 1.3 and R = 0.285 kJ/kg K. (12)

(ii) Explain the difference between Fanno flow and Isothermal flow. (4)

13. (a) Derive the expression for Rankine- Hugoniot equations (Desity ratio across the shock). (16)

Or

(b) (i) What is oblique shock waves? And what are the assumptions are used for oblique shock flow? (4)

(ii) An oblique shock wave occurs at the leading edge of a symmetrical wedge. Air has a Mach number of 2.1 and deflection angle (δ) of 15°. Determine the following for strong and weak waves.

(1) Wave angle.

(2) Pressure ratio,

(3) Density ratio,

(4) Temperature ratio and

(5) Downstream Mach number. (12)

14. (a) Derive the expressions for the jet thrust, propeller thrust, propulsive efficiency, thermal efficiency, overall efficiency and the optimum value of flight to jet speed ratio for a turbojet engine. (16)

Or

(b) A ramjet engine propels an aircraft at a Mach number of 1.4 and at an altitude of 6000 m. The diameter of the inlet diffuser at entry is 40 cm and the calorific value of the fuel is 43 MJ/kg. The stagnation temperature at the nozzle entry is 1500 K. The properties of the combustion gases are same as those of air. (γ = 1.4, R = 287 J/kg K). Determine the following :

(1) The efficiency of the ideal cycle,

(2) Flight speed,

(3) Air flow rate,

(4) Diffuser pressure ratio,

(5) Fuel air ratio,

(6) Nozzle pressure ratio,

(7) Nozzle jet Mach number.

(8) Propulsive efficiency and

(9) Thrust. Assume, Diffuser efficiency, η_D = 0.92, Combustion efficiency, η_B = 0.97 and Nozzle jet efficiency, η_N (or) η_j = 0.95. Stagnation pressure loss in the combustion chamber = 0.02 P_{02}. (16)

15. (a) (i) Describe with a schematic diagram the principle of working and construction of a magneto hydrodynamic rocket engine. (8)

(ii) In rocket engine, propellant flow rate is 5.2 kg/s, nozzle exit diameter is 9 cm, nozzle exit pressure is 1.02 bar, ambient pressure is 1.013 bar, thrust chamber pressure is 22 bar and thrust is 7.2 kN. Calculate the following :

(1) Effective jet velocity

(2) Actual jet velocity,

(3) Specific impulse and

(4) Specific propellant consumption. (8)

Or

(b) (i) What are the advantages and disadvantages of liquid propellant rocket engine? (4)

(ii) A rocket has the following data : Combustion chamber pressure = 36 bar, Combustion chamber temperature = 3600 K, Oxidizer flow rate = 41 kg/s, Mixer ratio = 5 and Ambient pressure = 585 N/m^2. Determine :

(1) Nozzle throat area,

(2) Thrust,

(3) Thrust coefficient,

(4) Characteristic velocity and

(5) Exit velocity of exhaust gases.

Take γ =1.3 and R = 287 J/kg K. (12)