T 8252

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2006.

Fifth Semester

Mechanical Engineering

ME 1303 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2004)

Time : Three hours　　　　Maximum : 100 marks

(Use of approved gas tables is permitted.)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define stagnation state of a system.

2. An air jet (γ = 1.4, R = 287 J/kg-K) at 400 K has sonic velocity. Determine its velocity.

3. Define one dimensional steady flow.

4. Show an adiabatic expansion process through a nozzle on T-s coordinates.

5. Give the assumptions that are used in the analysis of Rayleigh flow process.

6. Give two examples of Fanno flow in thermal systems.

7. Define a shock wave.

8. What are the differences between oblique and normal shocks?

9. Name three commonly used aircraft engines.

10. What do you mean by mono propellant? Give examples.

PART B — (5 × 16 = 80 marks)

11\. (a) (i) What is the effect of Mach number on the Compressibility? Prove for $\gamma = 1.4$.

$$\frac{p_o - p}{\frac{1}{2}\rho c^2} = 1 + \frac{1}{4}M^2 + \frac{1}{40}M^4 + \cdots\cdots$$

where p_o – stagnation pressure, p – static pressure ρ – density, c – velocity. (12)

(ii) Air at 200 kPa flows at a velocity of 50 m/sec. Find the Mach number at a point where its density is 2.9 kg/m³. (4)

Or

(b) (i) Speed of an aircraft is 800 km/hr. The stagnation conditions are 105 kPa & 308 K. Find static conditions and flight Mach number. (Take γ = 1.4, c_p = 1.005 kJ/kg-K) (6)

(ii) Air flows from a reservoir at 550 kPa and 343 K. Assuming isentropic flow, calculate the velocity, temperature, pressure at a section where M = 0.6. (6)

(iii) Velocity of an aircraft which has same Mach number at all altitudes, flying at an altitude of 11000 m is 50 m/sec lower than that of its velocity at mean sea level. Determine its Mach number. (4)

12\. (a) A reservoir whose temperature can be varied in a wide range of temperature receives air at a constant pressure of 150 kPa. The air is expanded isentropically in a nozzle to an exit pressure of 101.5 kPa. Determine (without using Gas tables) the values of the temperature to be maintained in the reservoir to produce the following velocities at the nozzle exit. (i) 100 m/sec (ii) 250 m/sec. (16)

Or

(b) A subsonic diffuser operating under isentropic conditions has inlet area of 0.15 m². The inlet conditions are $c_1 = 240$ m/sec, $T_1 = 300$ K, $p_1 = 70$ kPa. The velocity leaving the diffuser is 120 m/sec. Calculate for air (i) mass flow rate (ii) stagnation pressure at exit (iii) stagnation temperature at exit (iv) static pressure at the exit (v) change in entropy (vi) exit area. (16)

13. (a) Air flowing in an insulated duct with friction coefficient $f = 0.002$. At inlet the velocity is 130 m/sec, temperature 400 K and pressure is 250 kPa. The diameter of the duct is 16 cm. (i) find the length of the pipe required that gives 20% drop in stagnation pressure. (ii) find the properties of air at a section 3.5 m from inlet and (iii) find the maximum length of pipe. (16)

Or

(b) A combustion chamber delivers the gases at a Mach number of 0.9 at 250 kPa and 1273 K. If the ratio of the stagnation temperatures at the exit and entry is 3.74, determine the Mach number, pressure and temperature of the gas at entry. What is the amount of heat added and the maximum heat that can be added? (16)

14. (a) Starting from the energy equation for flow through a normal shock, obtain the Prandtl–Meyer equation. (16)

Or

(b) Air with Mach number 2.5 enters a convergent duct with an area ratio $A_2/A_1 = 0.5$. Under certain conditions, normal shock occurs at a test section where $A_t/A_1 = 0.6$. For this condition, find exit Mach number and pressure ratio across the duct. (A_1, A_2, A_t – Area at inlet, exit and test section respectively) (16)

15. (a) A turbo jet has a speed of 750 km/hr while flying at an altitude of 10000 m. The propulsive efficiency of the jet is 50% and the overall efficiency of the turbine plant is 16%. The density of the air at 10000 m altitude is 0.173 kg/m^3. The drag on the plane is 6250 N. Calorific value of the fuel is 48000 kJ/kg. Calculate (i) absolute velocity of the jet (ii) diameter of the jet and (iii) power output of the unit in kW. (16)

Or

(b) (i) The effective jet exit velocity from a rocket is 2700 m/sec. The forward flight velocity is 1350 m/sec and the propellant consumption is 78.6 kg/sec. Calculate thrust, thrust power and propulsive efficiency. (6)

(ii) Explain a solid propellant rocket engine with a neat sketch. (10)

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