B 2339

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2007.

Fifth Semester

Mechanical Engineering

ME 333 — GAS DYNAMICS AND SPACE PROPULSION

Time : Three hours Maximum : 100 marks

(Use of Standard Gas Tables Permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define the stagnation state and stagnation properties.
2. Differentiate between a nozzle and diffuser.
3. State any two examples of Rayleigh flow encountered in thermal Systems.
4. What is meant by Choking in Fanno flow.
5. Under what conditions a compression wave changes into a shock wave?
6. State two practical situations where oblique shock waves are produced.
7. Define Specific Thrust and Specific Impulse.
8. What is" after burning "in turbojet engines?
9. State any four applications of rocket engines.
10. State four commonly used Oxidizers.

PART B — (5 × 16 = 80 marks)

11. (a) (i) Derive an expression for acoustic velocity in terms of temperature of fluid. (8)

(ii) Air (c_p = 1.05 kJ/kg K, γ = 1.38) at P_1 = 3 bar and T_1 = 500 K flows with a velocity of 200 m/sec in a 30 cm duct. Calculate the mass flow rate, stagnation temperature, Mach number and stagnation pressure. (8)

Or

(b) (i) Prove that $\frac{P_0 - P}{\frac{1}{2}\rho c^2} = 1 + \frac{M^2}{4} + \frac{M^4}{40} + \ldots$ (8)

(ii) A reservoir whose temperature can be varied in a wide range of temperature receives air at constant pressure of 1.5 bar. The air is expanded isentropically in a nozzle to an exit pressure of 1.015 bar. Determine the values of temperature to be maintained in the reservoir to produce the following velocities at the nozzle exit :

(1) 100 m/s and (2) 250 m/s. (8)

12. (a) A combustion chamber in a gas turbine plant receives air at 350 K, 0.55 bar and 75 m/s. The air fuel ratio is 29 and the calorific value of the fuel is 41.87 MJ/kg. Taking γ = 1 .4 and R= 0.287kJ/kg K for the gas determine the initial and final Mach numbers, final pressure, temperature and velocity of the gas, percent stagnation pressure loss in the combustion chamber and the maximum stagnation temperature attainable. (16)

Or

(b) (i) Derive the following equation for a Fanno flow

$$\frac{F}{F^*} = \frac{1 + \gamma M^2}{M\left\{(\gamma+1)\left[2 + (\gamma-1)M^2\right]\right\}^{0.5}}$$ (8)

(ii) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 3.45 bar and 38° C respectively and the coefficient of friction 0.005. If the Mach number at entry is 0.15, determine the diameter of the duct, length of the duct, pressure and temperature at the exit, and the stagnation pressure loss. (8)

13. (a) The velocity of a normal shock wave moving into stagnant air (p = 1 bar and t = 17°C) is 500 m/s. If the area of the cross section of the duct is constant, determine the pressure, temperature, velocity of air, stagnation temperature and Mach number imparted upstream of the wavefront. (16)

Or

(b) Derive the Prandtl — Meyer relations. (16)

14. (a) Describe the working of a Ramjet engine with a neat sketch. State the advantages and disadvantages. (16)

Or

(b) An aircraft flies at 960 kmph. One of its turbojet engines take in 40 kg/s of air and expands the gases to the ambient pressure. The air fuel ratio is 50 and lower calorific value of the fuel is 43 MJ/kg. For maximum thrust power, determine jet velocity, thrust, specific thrust thrust power, thermal efficiency, overall efficiency and TSFC. (16)

15. (a) (i) Enumerate the types of Rocket engines. (8)

(ii) Explain the general working of a solid propellant rocket with a neat sketch. (8)

Or

(b) (i) A rocket engine has the following data :

Propellant flow rate = 5 kg/s, ; Nozzle exit diameter = 10 cm ; Nozzle exit pressure = 1.02 bar; Ambient pressure = 1.013 bar; Thrust chamber pressure = 20 bar; Thrust = 7 kN. Determine the effective jet velocity, actual jet velocity, specific impulse and the specific propellant consumption

Calculate the values of thrust and specific impulse for an altitude where ambient pressure is 10 mbar. (8)

(ii) A rocket flies at 10080 kmph with an effective exhaust jet velocity of 1400 m/s and propellant flow rate of 5 kg/s. If the heat of reaction of the propellants is 6500 kJ/kg of the propellant mixture , determine the propulsion efficiency and propulsive power, engine output, thermal efficiency and overall efficiency. (8)
