5th GDJP

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Question Paper Code : D 2483

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2010.

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 compressible flow and Mach number.

2. Define stagnation state.

3. How do the area and velocity vary in supersonic flow of nozzle and diffuser?

4. Where are the convergent nozzles and convergent – divergent nozzles used?

5. Give two practical examples for Fanno flow and Rayleigh flow.

6. What are the assumptions made in the analysis of Rayleigh process?

7. Mention the useful applications of shock wave.

8. What are the situations where shocks are undesirable?

9. What is meant by hypergolic propellant?

10. What is a bypass engine and define bypass ratio?

65

PART B — (5 × 16 = 80 marks)

11. (a) The pressure, temperature 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 $(\gamma = 1.3, R = 0.469 \text{ kJ/kg K})$.

(i) Stagnation temperature.

(ii) Temperature and velocity of gas at exit,

(iii) The flow rate per square metre of the inlet cross – section.

Or

(b) Air $(\gamma = 1.4, R = 287.43 \text{ J/kg K})$ enters a straight axisymmetric duct at 300 K, 3.45 bar and 150 m/s and leaves it at 277 K, 2.058 bar and 260 m/s. The area of cross-section at entry is 500 cm². Assuming adiabatic flow determine.

(i) Stagnation Temperature.

(ii) Maximum Velocity.

(iii) Mass flow rate and

(iv) Area of cross – section at exit.

12. (a) A supersonic nozzle expands air from $P_0 = 25$ bar and $T_0 = 1050$ K to an exit pressure of 4.35 bar ; the exit area of the nozzle is 100 cm². Determine.

(i) throat area ;

(ii) pressure and temperature at the throat ;

(iii) temperature at exit ;

(iv) exit velocity as fraction of the maximum attainable velocity ;

(v) mass flow rate.

Or

(b) A conical diffuser has entry and exit diameters of 15 cm and 30 cm respectively. The pressure, temperature and velocity of air at entry are 0.69 bar, 340 K and 180 m/s respectively. Determine :

(i) the exit pressure

(ii) the exit velocity and

(iii) the force exerted on the diffuser walls.

Assume isentropic flow, $\gamma = 1.4, C_p = 1.00$ kJ/kg – K.

13. (a) 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 is 0.005. If the Mach number at entry is 0.15, determine :

(i) the diameter of the duct

(ii) length of the duct

(iii) pressure and temperature at the exit

(iv) stagnation pressure loss.

Or

(b) The stagnation temperature of air in a combustion chamber is increased to 3.5 times its initial value. If the air at entry is at 5 bar, 105°C and a Mach number of 0.25 determine

(i) the Mach number, pressure and temperature at the exit.

(ii) stagnation pressure loss, and

(iii) the heat supplied per kg of air.

14. (a) A supersonic nozzle is provided with a constant diameter circular duct at its exit. The duct diameter is same as the nozzle exit diameter. Nozzle exit cross-section is three times that of its throat. The entry conditions of the gas ($\gamma = 1.4, R = 0.287$ kJ/kg – K) are $P_0 = 10$ bar, $T_0 = 600\ K$. Calculate the static pressure, Mach number and the velocity of the gas in the duct :

(i) when the nozzle operates at its design condition,

(ii) when a normal shock occurs at its exit.

Or

(b) The ratio of the exit to entry area in a subsonic diffuser is 4.0. The Mach number of a jet of air approaching the diffuser at $P_0 = 1.013$ bar, $T = 290$ K is 2.2. There is a standing normal shock wave just outside the diffuser entry. The flow in the diffuser is isentropic. Determine at the exit of the diffuser :

(i) Mach number

(ii) Temperature, and

(iii) Pressure

(iv) The stagnation pressure loss between the initial and final states of the flow.

15. (a) Explain with a neat sketch the principle of operation of a ramjet engine and state its advantages and disadvantages.

Or

(b) (i) Explain the working of a turbo-pump feed system used in a liquid propellant rocket. (8)

(ii) Describe the important properties of liquid and solid propellants desired for rocket propulsion. (8)

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