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B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2008.

Fifth Semester

Mechanical Engineering

ME 1303 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2004)

Time : Three hours Maximum : 100 marks

Gas tables can be permitted.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is a Mach Cone?

2. Define Mach number.

3. Plot the variation of Area ratio with Mach number.

4. How the velocity vary along the axis of flow in supersonic nozzle and diffuser?

5. What is Rayleigh flow? Give two practical examples.

6. Draw Fanno curve and represent subsonic and supersonic flows.

7. How is the shock formed?

8. Where is the shock wave advantageous?

9. What is after burning in turbojet engine?

10. What are the different types of rocket engines?

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 ($\gamma = 1.3$), $R = 0.469$ kJ/kg – K.

(i) stagnation temperature

(ii) temperature and velocity of gas at exit, and

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

Or

(b) Air ($\gamma = 1.4$, $R = 287.43$ J/kg – K) enters a straight axi-symmetric 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 cm^2. Assuming adiabatic flow determine :

(i) stagnation temperature

(ii) maximum velocity

(iii) mass flow rate and

(iv) area of cross-section at exit.

12. (a) Air flowing in a duct has a velocity of 300 m/s, pressure 1.0 bar and temperature 290 K. Taking $\gamma = 1.4$ and $R = 287$ J/kg K. Determine :

(i) stagnation pressure and temperature

(ii) velocity of sound in the dynamic and stagnation conditions

(iii) stagnation pressure assuming constant density.

Or

(b) Air is discharged from a reservoir at $p_0 = 6.91$ bar and $t_0 = 325^\circ$ 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.

13. (a) 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.

Or

(b) A long pipe of 25.4 mm diameter has a mean coefficient of friction of 0.003. Air enters the pipe at a Mach number of 2.5, stagnation temperature 310 K and static pressure 0.507 bar. Determine for a section at which the Mach number reaches 1.2.

(i) static pressure and temperature

(ii) stagnation pressure and temperature

(iii) velocity of air

(iv) distance of this section from the inlet and

(v) mass flow rate of air.

14. (a) A gas ($\gamma = 1.3$) at $p_1 = 345$ mbar, $T_1 = 350$ K and $M_1 = 1.5$ is to be isentropically expanded to 138 mbar. Determine :

(i) deflection angle

(ii) final Mach number and

(iii) the temperature of the gas.

Or

(b) 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.

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

Or

(b) Describe the important properties of liquid and solid propellants desired for rocket propulsion and give examples for both the propellants.