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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Sixth Semester

Mechanical Engineering

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

(Regulations 2008/2010)

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

Time : Three hours Maximum : 100 marks

Use of Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write any two applications of nozzle and diffuser.

2. "Higher the velocity of supersonic flow, smaller the angle of mach cone". Comment on the validity of this statement.

3. What do you mean by friction chocking?

4. Complete the following table with increases, decreases, remains constant for a flow through a constant-area duct with heat transfer :

Parameter	Subsonic flow		Supersonic flow	
	Heating	Cooling	Heating	Cooling
Static Temperature				

5. How shock condensation of a shock wave is defined?

6. What is compression corner?

7. What is the significance of low and high TSFC in jet propulsion?

8. Draw T-s diagram of ideal and actual brayton cycle and bring out the differences between them.

9. What is bi-propellant? Give example.

10. What is the role of inhibitors in rocket propulsion system?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Air is discharged from a reservoir at 1 MPa and 500 K through a nozzle to an exit pressure of 0.09 MPa. If the flow rate through the nozzle is 3600 kg/h determine for isentropic flow

(1) Area, pressure and velocity at throat section

(2) Mach number and area at exit section. (10)

(ii) A fluid flows through a variable area (CD) duct. Assume that the favorable pressure gradient is maintained throughout the duct. Now using this condition fill in the following blanks with the words decreasing or increasing. (6)

If M < 1 (and dA is ————————), then dp and dv must be ———————— and ————————

If M > 1 (and dA is ————————), then dp and dv must be ———————— and ————————

Or

(b) (i) Discuss the Von Karman's rules of supersonic flow. (8)

(ii) Calculate the velocity and mach number of a supersonic aircraft flying at an altitude of 1000 m where the temperature is 280 K. Sound of the aircraft is heard 2.15 seconds after the passage of aircraft on the head of an observer. (8)

12. (a) (i) A CD nozzle having a throat diameter of 7.5 mm supplies air to an insulated duct of diameter 0.015 m. The total conditions of air at nozzle entry are 0.75 MPa and 27°C. The flow through the nozzle is isentropic. The friction coefficient 'f' is 0.005. Calculate the L_{max} of the duct that can be provided without any discontinuity in the nozzle or duct. Find the static as well as stagnation temperature and pressure of medium at duct exit for maximum duct length condition. (12)

(ii) A converging nozzle (unchoked) is provided between big tank and insulated 1 D duct. Flow starts from big tank to the duct via a nozzle. Sketch the pressure and Mach number variation along the system. (4)

Or

(b) Prove that the Mach numbers at the maximum enthalpy and maximum entropy points on the Rayleigh line are $\frac{1}{\sqrt{\gamma}}$ and 1.0 respectively.

13. (a) Air flows through a C-D nozzle from a reservoir where stagnation temperature is known to be 333 K. At some section 'x' in the diverging section, a normal shock occurs. The location of the shock is such that the static pressure measured at the throat is 0.8 times the total pressure measured after the shock. If the flow is isentropic except across the shock, determine

(i) The area ratio A_x/A_{throat}

(ii) The air velocity behind the shock.

Or

(b) Air having a Mach number 3.0, approaches a symmetrical wedge having a wedge angle of 30°. The pressure and temperature of the air are 1.0 bar and 27°C. Find the Mach number and velocity of flow downstream of the shock wave, assuming that a weak oblique shock is formed. Also find the pressure, density, temperature and total pressure downstream of the shock wave.

14. (a) A jet propelled aircraft flying at a mach number 0.6 at an altitude of 5.0 km inducts air at a rate of 20 kg/s. The diffuser recovery is 0.9. The compressor pressure ratio is 5.0 and the maximum total temperature in the cycle is 1300 K. The gases expand in the nozzle to a pressure of 0.7 bar. The isentropic efficiencies of the compressor, turbine and nozzle are 0.8, 0.85 and 0.92 respectively. The calorific value of the fuel is 44 MJ/kg. Assume that the products of combustion have the same properties as that of air. Calculate

(i) Air-fuel ratio

(ii) Power output of turbine

(iii) Exhaust jet velocity

(iv) Engine thrust and

(v) Overall efficiency.

Or

(b) Explain with sketches the working of the by-pass engine. How thrust equation is derived for bypass engine? What are the merits and demerits of such engines over its competitors?

15. (a) (i) Draw and explain various types of burning configuration of a solid propellant. (8)

(ii) Compare the performances of propellant pump feed system and gas feed system. (8)

Or

(b) The following conditions refer to a rocket :

Propellant flow rate = 193 kg/s,

Nozzle exit diameter = 600 mm,

Nozzle exit pressure = 1.1 bar,

Ambient pressure = 1.013 bar,

Thrust chamber pressure = 37 bar,

Thrust produced = 380 kN.

Find the effective jet velocity, jet velocity specific impulse total impulse and the SPC.
