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B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2014.

Sixth Semester

Mechanical Engineering

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

(Regulation 2008/2010)

(Common to PTME 2351 – Gas Dynamics and Jet Propulsion for B.E. (Part-Time) Fifth Semester – Mechanical Engineering – Regulation 2009)

Time : Three hours Maximum : 100 marks

Use of Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between nozzle and diffuser.

2. When does maximum flow occur for an isentropic flow with variable area duct?

3. Give assumptions made on Rayleigh flow.

4. Define critical condition in Fanno flow.

5. Why the efficiency of a machine, experiencing shock wave is considerably low?

6. What is the use of pitot tube in supersonic flow?

7. Define thrust power and propulsive efficiency of aircraft engine.

8. Why a ram jet engine does not require a compressor and turbine?

9. Why rocket is called as non breathing engine? Can rocket work at vacuum?

10. What is the use of inhibitors in solid propellants?

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PART B — (5 × 16 = 80 marks)

11. (a) (i) Air flows down a variable area duct. Measurements indicate that the temperature is 278 K and the velocity is 150 m/s at a certain section of the duct. Measurements at a second section indicate that the temperature has decreased to 253 K. Assuming that the flow is adiabatic and one dimensional, find the velocity at this second section. (6)

(ii) Typical cruising speeds and altitudes for three commercial aircraft are:

Dash 8: Cruising speed- 500 km/hr at an altitude of 4500m.

Boeing 747: Cruising speed: 978 km/hr at an altitude of 9500 m

Find the Mach number of the aircraft when flying at these cruise conditions. (10)

Or

(b) Air flows through a nozzle which has inlet areas of 0.001 m^2. If the air has a velocity of 80 m/s, a temperature of 301 K and a pressure of 700 kPa at the inlet section and a pressure of 250 kpa at the exit, find the mass flow rate through the nozzle and assuming one-dimensional isentropic flow, the velocity at the exit section of the nozzle. (16)

12. (a) Air flows out of a pipe with a diameter of 0.3 m at a rate of 1000 m^3/ min at a pressure and temperature of 150 kPa and 293 K respectively. If the pipe is 50m long, find assuming that $f = 0.005$, the Mach number at the exit, the inlet pressure and the inlet temperature. (16)

Or

(b) The condition of a gas in a combustor at entry is: $p_1 = 0.343$ bar, $T_1 = 310$ K, $c_1 = 60$ m/sec. Determine the Mach number, pressure, temperature and velocity at the exit if the increase in stagnation enthalpy of the gas between entry and exit is 1172.5 kJ/kg. Take $c_p = 1.005$ kJ/kg K, $\gamma = 1.4$. (16)

13. (a) A normal shock occurs in the diverging section of a convergent - divergent air nozzle. The throat area is 1/3 times exit area and the static pressure at exit is 0.4 times the stagnation pressure at the entry. The flow is throughout isentropic except through the shock. Determine:

(i) Mach numbers M_x and M_y

(ii) The static pressure and

(iii) The area of cross section of the nozzle at the section of nozzle where the normal shock occurs. (16)

Or

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(b) 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) the deflection angle

(ii) final Mach number

(iii) the temperature of the gas.

14. (a) Derive the following relations for aircraft engine

(i) Flight to jet speed ratio $\sigma = 1 - \frac{F}{\dot{m}_a c_j}$ (6)

(ii) Thrust in a turbojet engine

$$F = \dot{m}_a (c_j - u) = \dot{m}_a (c_e - u) + (p_e - p_a) A_e.$$ (10)

Or

(b) An aircraft flies at 90 km/hr. One of its turbojet engines takes in 40 kg/s of air and expands the gases to the ambient pressure. The air-fuel ratio is 50 and the lower calorific value of the fuel is 43 MJ/kg. For maximum thrust power determine:

(i) jet velocity

(ii) thrust

(iii) specific thrust

(iv) thrust power

(v) propulsive, thermal and overall efficiencies.

15. (a) Explain the working principle of a Turbo-pump feed system with a schematic diagram for liquid propellant rocket engines.

Or

(b) Describe briefly the important applications of rocket propulsion in the following fields

(i) Aircrafts

(ii) Military

(iii) Space

(iv) scientific.

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