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B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019

Sixth Semester

Mechanical Engineering

ME 6604 – GAS DYNAMICS AND JET PROPULSION

(Regulations 2013)

(Common to PTME 6604 – Gas Dynamics and Jet Propulsion for B.E. (Part-Time) – Fifth Semester – Mechanical Engineering – Regulations 2014)

Time : Three Hours | Maximum : 100 Marks

Use of Standard Gas Tables Permitted.

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. What do you understand by compressibility effect ?
2. Differentiate between first and third critical of CD nozzle.
3. In Rayleigh flow, what is the Mach number at which the total enthalpy is maximum ?
4. How do you specify the equivalent diameter for non circular cross sections ?
5. Distinguish between 'Shock angle' and 'deviation angle'.
6. What is the response of change of fluid stagnation states across a normal shock ?
7. What is after burning in turbojet engines ?
8. Differentiate between pressure thrust and momentum thrust.
9. Compare the merits and demerits of bi-propellants with monopropellants.
10. What is weight flow co-efficient ?

PART – B **(5×13=65 Marks)**

11. a) i) Discuss the change of Mach number in CD nozzle under various back pressure. **(5)**

ii) An airplane is traveling while you are observing from the ground. How will you know whether it is subsonic or supersonic ? Explain. **(5)**

iii) How fluid stagnation states will change if the fluid flow in diffuser follows an adiabatic process ? **(3)**

(OR)

b) Air flows through a convergent-divergent (CD) nozzle. At some section in the nozzle, pressure = 2 bar, velocity = 170 m/s and temperature = 200°C and cross sectional area = 1000 mm^2. Assuming isentropic flow conditions, determine : (i) stagnation temperature and stagnation pressure (ii) sonic velocity and Mach number and flow at this section (iii) velocity, Mach number and flow area at outlet section where pressure is 1.1 bar (iv) pressure, temperature, velocity and flow area at throat section.

12. 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 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,and
   V) Verify the exit Mach number through exit velocity and temperature.

(OR)

b) 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 $\gamma = 1.4$ and R = 0.287 kJ/kg K for the gas, determine
   a) The initial and final Mach numbers.
   b) Final pressure, temperature and velocity of the gas.
   c) Percent stagnation pressure loss in the combustion chamber, and
   d) The maximum stagnation temperature attainable.

13. a) i) Derive the expression for the pressure ratio across the normal shock wave.
   ii) A normal shock wave is standing in the test section of a supersonic wind tunnel.
   Upstream of the wave, Mach No = 3 and pressure = 0.5 atm and Temperature = 200 K.
   Find Mach number pressure, temperature and velocity after the shock wave.

(OR)

b) i) Explain the formation of attached and detached oblique shock over the wedge and sharp corner.
   ii) A supersonic stream at Mach No. = 3, pressure = 1 atm, and temperature = 288 K encounters a compression corner which deflects the stream by an angle 20°. Calculate the shock wave angle and pressure, temperature and Mach Number after the shock wave.

14. a) A jet aircraft is flying at an altitude of 5500 m (density ratio = 0.58), ambient pressure is 51 kPa and temperature is –20°C. The velocity of the aircraft is 270 m/s. If heating value of the fuel is 44 MJ/kg, the pressure ratio across the compressor is 6 and inlet area is 0.95 m^2, determine the velocity of the jet leaving the engine, thrust power and the propulsive efficiency. Take maximum temperature as 1200 K.

(OR)

b) i) Explain the working of turbofan engine with neat sketch. **(8)**
   ii) Describe advantages and disadvantages of turbofan engine over turbojet engine and turboprop engine. **(5)**

15. a) Describe the important properties of liquid and solid propellants desired for rocket propulsion.

(OR)

b) Calculate the thrust, specific impulse, propulsive efficiency, thermal and overall efficiencies of a rocket engine from the following data
Effective jet velocity = 1250 m/s, Flight to jet speed ratio = 0.8,
oxidizer flow rate = 3.5 kg/s, fuel flow rate = 1 kg/s,
heat of reaction of exhaust gases = 2,500 kJ/kg.

PART – C **(1×15=15 Marks)**

16. a) i) Using stagnation enthalpy equation, obtain the below form

$$\frac{a^2}{\gamma-1}+\frac{1}{2}c^2=\frac{1}{2}\,c_{max}^2=\frac{a_0^2}{\gamma-1}=h_0\,.$$ **(10)**

   ii) Derive the expression for the propulsive efficiency of jet engine in terms of speed ratio. **(5)**

(OR)

b) Air at Mach number 0.5 pressure 3 bar and temperature 47°C enters a 15 cm diameter circular duct. If the coefficient of friction factor is 0.005, for choked condition, determine length of duct, change in entropy, change in impulse function and loss in total pressure.

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