C 60588 (Pages : 3) Name.....................

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EIGHTH SEMESTER B.TECH. (ENGINEERING) DEGREE EXAMINATION, APRIL 2014

(2009 Scheme)

ME/PTME 09 802—COMPRESSIBLE FLUID FLOW

Time : Three Hours Maximum : 70 Marks

Part A

Answer **all** *the questions.*

Each question carries 2 *marks.*

1. What is a continuum ? Under what conditions the assumption of a continuum is valid ?
2. Define Stagnation enthalpy.
3. What is impulse function ?
4. Define Fanno flow. Give two examples of Fanno flow in thermal systems.
5. Under what condition a compression wave changes into a shock wave ?

(5 × 2 = 10 marks)

Part B

Answer any **four** *questions.*

Each question carries 5 *marks.*

6. Explain the difference between Flow and Non-flow work. Carbon-di-oxide expands isentropically through a nozzle from a pressure of 3 bar to 1 bar. If the initial temperature is 473 K, determine the final temperature, the enthalpy drop and the change in the internal energy.

   Take $\gamma = 1.24$, $R = 0.189$ kJ/kg-K.
7. Discuss the wave propagation in elastic medium.
8. Describe the behaviour of flow in a convergent-divergent nozzle when it is operated at (a) pressure ratio higher than the design value, and (b) pressure ratio lower than the design value.
9. Derive an equation describing a Fanno curve. Show three Fanno curves at three mass flow densities.

Turn over

10. The Mach number at the exit of a combustion chamber is 0.9. The ratio of stagnation temperatures at exit and entry is 3.74. If the pressure and temperature of the gas at exit are 2.5 bar and 1000°C respectively. Determine (a) Mach number, pressure and temperature of the gas at entry, and (b) the heat supplied per kg of the gas.

Take $\gamma = 1.3$, $c_p = 1.218$ kJ/kg-K.

11. Discuss about impossibility of a shock in subsonic flow.

(4 × 5 = 20 marks)

Part C

Answer **all** *the questions.*

Each question carries 10 *marks.*

12. (a) Air $\left(c_p = 1.05 \text{ kJ/kg-K}, \ \gamma = 1.38\right)$ at $p_1 = 3 \times 10^5$ N/m^2 and $T_1 = 500$ K flows with a velocity of 200 m/s in a 30 cm diameter duct. Calculate : (a) mass flow rate ; (b) stagnation temperature ; (c) Mach number, and (d) stagnation pressure values assuming the flow as compressible and incompressible respectively.

Or

(b) Derive the momentum equation for a control volume.

13. (a) A nozzle in a wind tunnel gives a test-section Mach number of 2.0. Air enters the tunnel from a large reservoir at 0.69 bar and 310 K. The cross sectional area of the throat is 1000 cm^2. Determine the following quantities for the tunnel for one dimensional isentropic flow :

(i) pressures, temperature and velocities at the throat and test sections.

(ii) area of cross-section of the test section.

(iii) mass flow rate.

(iv) power required to drive the compressor.

Or

(b) Explain the effect of Mach number on compressibility.

14. (a) Air at $P_0 = 10$ bar, $T_0 = 400$ K is supplied to a 50 mm diameter pipe. The friction factor for the pipe surface is 0.002. If the Mach number changes from 3.0 at the entry to 1.0 at the exit. Determine : (i) the length of the pipe ; and (ii) the mass flow rate.

Or

(b) Air at $p_1 = 3$ bar, $T_1 = 288$ K and $M_1 = 1.5$ is brought to sonic velocity in a frictionless constant area duct through which heat transfer can occur. (i) Determine the final pressure and temperature, and the heat added during the process, and (ii) what will be the Mach number, pressure and temperature of air if this heat is extracted from the air ?

15. (a) Derive the Rankine-Hugoniot relation for a normal shock wave.

Or

(b) The velocity of a normal shock wave moving into stagnant air (p = 1.0 bar, t = 17°C) is 500 m/s. If the area of cross-section of the duct is constant, determine (i) pressure (ii) temperature (iii) velocity of air ; (iv) stagnation temperature ; and (v) Mach number imparted upstream of the wave front.

(4 × 10 = 40 marks)