Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Seventh Semester B.Tech Degree Examination (Regular and Supplementary), December 2020

Course Code: ME409
Course Name: COMPRESSIBLE FLUID FLOW

Max. Marks: 100 Duration: 3 Hours

Use of Approved Data Book is Permitted. Assume suitable values for missing data.

PART A

Answer any three full questions, each carries 10 marks. Marks

1 Stating suitable assumptions, prove the law of conservation of energy for a control volume. (10)

2 a) Derive adiabatic steady flow elliptic energy equation. Represent various flow regimes on steady flow adiabatic ellipse. (6)

b) Show that pressure coefficient in compressible fluids varies as a function of Mach number. (4)

3 Explain the effect of Mach number variation on area ratio in subsonic and supersonic flows and show that for one dimensional isentropic flow (10)

$$\frac{dA}{A} = \frac{dP}{\rho C^2}[1 - M^2]$$

4 The conditions of air (γ = 1.4, Cp = 1.0 kJ/kg) the entry of a nozzle are p = 2bar, T= 330K and C =145 m/s. If the exit pressure is 1.5 bar, determine for the isentropic flow the Mach number at entry and exit, flow rate and maximum possible flow rate. What is the shape of the Nozzle? (10)

PART B

Answer any three full questions, each carries 10 marks.

5 State and prove Prandtl-Mayer relationship for a normal shock waves. (10)

6 a) Can shock waves develop in a subsonic flow? Justify your answer. (4)

b) Air enters a 30cm diameter duct at a Mach number of 2.5, temperature of 400K and a pressure of 100kPa. A normal shock wave occurs at a Mach number of 1.7 and the exit Mach number is 0.8. The coefficient of the friction is 0.004. Calculate the length of duct upstream and downstream of normal shock, change in entropy and stagnation pressure losses. (6)

7 a) Define Fanno flows. Prove that at the point of maximum entropy Mach number is unity on the Fanno curve. (6)

b) Derive the following relations for Fanno flow (i) $\frac{P_o}{P_{o*}}$ and (ii) $\frac{F}{F^*}$ (4)

8 Air at an inlet temperature of 60^{o}C flows with subsonic velocity through an insulated pipe having inside diameter of 50 mm and a length of 5m. The pressure at the exit of pipe is 101kPa and the flow is chocked at the end of the pipe. If the mean friction factor is 4f=0.005, determine the inlet Mach number, exit temperature and the mass flow rate. (10)

PART C

Answer any four full questions, each carries 10 marks.

9 a) Explain the process of thermal chocking in Rayleigh flow. (4)

b) Citing suitable examples explain the Rayleigh flow. (6)

10 Derive an expression for maximum possible heat transfer in Rayleigh flow in terms of Mach number. (10)

11 Air fuel mixture enters a combustion chamber with an initial velocity of 150 m/s, pressure of 4 bar and temperature of 410K. The Mach number at the exit of the combustion chamber is 0.8. (Take γ=1.3, C_p=1.14 kJ/kg K, calorific value of fuel as 43 MJ/kg.) find 1) The entry Mach number ii) Stagnation pressure loss iii) Exit temperature and pressure iv) Air-fuel ratio (10)

12 a) List different temperature measurements employed in supersonic flow. Explain any two with neat sketches. (6)

b) Why do investigators prefer to use thermocouple for the temperature measurements in high velocity streams? (4)

13 With the neat sketch explain a closed circuit supersonic wind tunnel indicating all the relevant components. Why the design of diffuser throat area is made larger than the nozzle throat area in supersonic tunnels. (10)

14 a) Explain how the Pitot tube could be used in compressible flow to measure the Mach number in supersonic flow. (4)

b) With the help of neat sketch explain the working of interferometer. (6)

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