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2013

ENGINEERING THERMODYNAMICS & FLUID MECHANICS

Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) If heat engine attains 100% thermal efficiency, it violets
   a) Zeroth law of thermodynamics
   b) 1st law of thermodynamics
   c) 2nd law of thermodynamics
   d) none of these.

ii) The more effective way of increasing efficiency of a Carnot engine is to
   a) increase higher temperature
   b) decrease higher temperature
   c) increase lower temperature
   d) decrease lower temperature.

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iii) Air standard efficiency of Otto Cycle depends on

a) ratio of specific heats b) cut-off ratio

c) compression ratio d) both (a) and (c).

iv) The flow field represented by the velocity vector $V = axi + by^2 j + czt^2 k$, where a, b and c are constants is

a) three-dimensional and unsteady

b) two-dimensional and steady

c) three-dimensional and steady

d) two-dimensional and unsteady.

v) Pitot tube is used to measure

a) dynamic viscosity b) kinematic viscosity

c) mass density d) velocity of flow.

vi) PMM-1 is impossible according to

a) 2nd law of thermodynamics

b) 3rd law of thermodynamics

c) 1st law of thermodynamics

d) zeroth law of thermodynamics.

vii) During throttling, which of the following properties does not change ?

a) Internal energy b) Entropy

c) Pressure d) Enthalpy.

viii) Which fluid does not experience shear stress during flow ?

a) Pseudo-plastic b) Dilatant

c) Inviscid d) Newtonian.

ix) The differential equation of pressure variation in a static fluid may be written as (y measured vertically upward and γ is specific weight)

a) $dP = -\gamma dy$ b) $\gamma dp = -dy$

c) $\gamma dy = -\rho dP$ d) $\gamma dP = -\rho dy$.

The standard atmospheric pressure is 101·32 kPa. The local atmospheric pressure at a location was 91·52 kPa. If a pressure is recorded as 22·48 kPa (gauge), it is equivalent to

a) 123·80 kPa (abs) b) 88·84 kPa (abs)

c) 114·00 kPa (abs) d) 69·04 kPa (abs).

For an ideal gas, for which process can temperature of a system decrease even if heat is added to it ?

a) Isobaric b) Isothermal

c) Isentropic d) Polytropic

The area under a curve, representing a non-cyclic process on a temperature entropy (T-S) plane represents

a) heat transfer for a reversible process

b) work transfer for a reversible process

c) heat transfer for any process

d) work transfer for any process.

xiii) Oil spreads on the surface of water because

a) oil is less dense than water

b) oil is immiscible in water

c) oil has less surface tension than water

d) oil has low vapour pressure.

xiv) Spot the odd out.

a) Thermal conductivity b) Kinetic energy

c) Work d) Pressure.

xv) An engine is supplied with 1120 kJ/s of heat and th source and sink are maintained at constant fixe temperatures of 560 K and 280 K respectively. If he rejection is 840 kJ/s, indicate the given cycle is

a) reversible

b) irreversible

c) impossible

d) unpredictable, insufficient data.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following $3 \times 5 =$

2. A 0·025 m^3 vessel contains 0·3 kg of steam at 2 MP Determine the quality, enthalpy and entropy of steam. Giv t_s = 212·2°C, v_f = 0·001177 m^3/kg, v_g = 0·0995 m^3/k h_f = 908·5 kJ/kg, h_{fg} = 1888·7 kJ/kg, s_f = 2·447 kJ/kg- s_{fg} = 3·590 kJ/kg·K.

3. 0·2 m^3 of an ideal gas at a pressure of 2 MPa and 600 K expanded isothermally to 5 times the initial volume. It is the cooled to 300 K at constant volume and then compresse back polytropically to its initial state. Determine the net wor done and heat transfer during the cycle.

4. At the inlet to a certain nozzle the specific enthalpy of flui passing is 2800 kJ/kg. The nozzle is horizontal and there i negligible heat loss from it. (i) Find the velocity at exit of th nozzle, (ii) If the inlet area is 900 cm^2 and specific volume a inlet is 0·187 cm^3/kg, find the mass flow rate, (iii) If th specific volume at the nozzle exit is 0·498 m^3/kg, find th exit area of the nozzle.

5. a) Derive an expression for displacement work in a proces where $PV^n = C$.

   b) A paddle wheel used for mixing and stirring of fluid turns 600 r.p.m. when 2·5 Nm torque is applied to it What is power transmitted to the liquid by the wheel ?

   $2 + 3$

6. a) Establish the equivalence of Kelvin-Planck and Clausius statements.

   b) A heat engine produces work equivalent to 80 kW with an efficiency of 40%. Determine the heat drawn from the source and rejected to the sink. $2 + 3$

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GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. $3 \times 15 = 45$

Bernoulli's equation, stating the assumptions. 2

dimensional flow is described in the Lagrangian dinate system as

$= x_0 e^{-kt} + y_0(1 - e^{-1kt})$

$= y_0 e^{kt}$

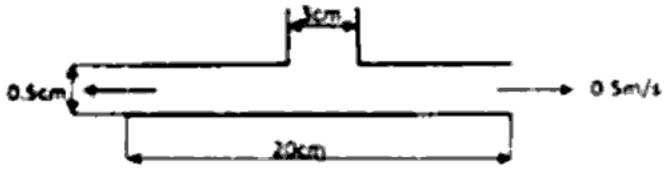
nd the equation of path line of the particle and the velocity components in Eulerian system. 7

A venturimeter has inlet and throat diameters of 300 mm and 150 mm. Water flows through it at the rate of 0·065 m^3/s and the differential gauge is deflected 1·2 m. The specific gravity of the manometric liquid is 1·6. Determine the coefficient of discharge of the venturimeter. 6

State and prove Pascal's law of pressure at a point of a fluid body. 5

The velocity vector for a two dimensional incompressible flow field is given by $V = \left(\frac{x}{x^2 + y^2}\right) i + \left(\frac{y}{x^2 + y^2}\right) j$. State, whether the flow field is continuous or discontinuous. 5

A diffuser consists of two parallel plates 20 cm in diameter and 0·5 cm apart and connected to a 3 cm diameter pipe. If the streamlines are assumed to be radial in the diffuser, what mean velocity in the pipe will correspond to an exit velocity of 0·5 m/s ? 5



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9. a) What is pure substance ?

b) What is the critical point ? State the values of crit pressure and critical temperature of water ?

c) Why is the Carnot cycle not practicable for a st power plant ?

d) At the inlet to a certain nozzle, the enthalpy of the f passing is 3000 kJ/kg and the velocity is 60 m/s. At discharge end, the enthalpy is 2762 kJ/kg. The no is horizontal and there is negligible heat loss from it.

i) Find the velocity at the exit from the nozzle.

ii) If the inlet area is 0·1 m^2 and the specific volu at inlet is 0·187 m^3/kg, find the mass flow rate.

iii) If the specific volume at the nozzle exit 0·498 m^3/kg, find the exit area of the nozzle.

2 + 2

10. a) In a steam turbine, steam at 20 bar, 360°C is expan to 0·08 bar. It then enters a condenser, where i condensed to saturated liquid water. The pump fe the water back into the boiler. Assume ideal proces find, per kg of steam, the net work and the c efficiency.

b) An air standard Otto cycle has as compression r of 8, temperature and pressure at the beginning compression are 20°C and 1 bar respectively. constant volume heat addition is 1800 kJ/kg. Calcu the maximum temperature and pressure of the c temperature of the end of expansion process. What the efficiency and mean effective pressure (m.e.p.) of cycle ? C_v = 0·718 kJ/kg K and γ = 1·4.

11. a) Two reversible heat engines are arranged in a serie such a way that the heat rejected by the first engin absorbed by the second engine. The first engine rece 400 kJ of heat from a reservoir maintained temperature 600°C, while the second engine rejects h

to a reservoir having temperature 0°C. If the work output of the first engine is twice than that of the second, determine

i) efficiency of both the engines

ii) heat rejected by the second engine

iii) intermediate temperature. 7

Air at temperature of 15°C passes through a heat exchanger with a velocity of 30 m/s where its temperature is raised to 800°C. It then enters a turbine with same velocity of 30 m/s and expands until the temperature falls to 650°C. On leaving the turbine, air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500°C. If the air flow rate is 2 kg/s, find out

i) the rate of heat transfer to the air in the heat exchanger

ii) the power output from turbine, assuming no heat loss

iii) the velocity at exit from nozzle, assuming no heat loss.

Take, C_p = 1·0005 kJ/kg K & $h = C_p.t$ (h = enthalpy, t = temperature) 8

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