W2-5

Department of Mechanical Engineering
MNNIT Allahabad

Subject: Engineering Thermodynamics (ME 1301) ; **Maximum Marks:** 20 ; **Time:** 1:30 h

Note: Attempt all questions. Assume missing data, if any. In Q. 1, each term is of 1 marks.

Q. 1: Define the following terms: (a) Flow work, (b) Macroscopic and Microscopic point of view, (c) Perpetual motion machine of first kind, (d) Thermodynamic equilibrium. **(4)**

Q. 2: Derive the work done in processes where (i) $pV = C$ and, (ii) $pV^{r} = C$. **(2+2)**

Q. 3: Draw the an Engine indicator, Indicator diagram and write expressions of mean effective pressure, indicated power, brake power, and indicated thermal efficiency. **(3)**

Q. 4: Air flows steadily at the rate of 0.4 kg/s through an air compressor, entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m^3/kg, and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m^3/kg. The internal energy of the air leaving is 88 kJ/kg greater that that of the air entering. Cooling water jacket surrounding the cylinder absorbs heat from the air at the rate of 59 W. Calculate the power required to drive the compressor and inlet and outlet cross-sectional areas. **(4)**

Q. 5: A gas undergoes a thermodynamic cycle consisting of the following processes: (i) Process 1–2: Constant pressure p = 1.4 bar, $V_1 = 0.028$ m^3, $W_{12} = 10.5$ kJ, (ii) Process 2–3: Compression with pV = constant, $U_3 = U_2$, (iii) Process 3–1: Constant volume, $U_1 - U_3 = -26.4$ kJ. There are no significant changes in KE and PE. (a) Sketch the cycle on a p–V diagram. (b) Calculate the net work for the cycle in kJ. (c) Calculate the heat transfer for process 1–2. (d) Show that $\sum Q = \sum W$ (in cycle). **(5)** PL

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Subject: Engineering Thermodynamics (ME1301/ME1304) | **Maximum Marks: 20**
Time: 1:30 h

Note: Attempt all questions. Assume missing data, if any.

Q. 1: Explain adiabatic thermodynamic process and derive expression for work done during adiabatic process. **(1+2)**

Q. 2: A quantity of a certain gas is compressed polytropically in a cylinder from an initial state of 0.085 m^3 and 1 bar pressure to a final state of 0.034 m^3 and 4 bar. The temperature rise is observed to be 146 K. Take: for this gas c_p = 1.02 kJ/kg K and c_v = 0.725 kJ/kg K. Calculate: (i) the mass of the gas, (ii) the change in internal energy and (iii) the heat transferred. **(3)**

Q. 3: Air at 7 bar and 400 °C expands to 4 bar in a nozzle. Calculate the velocity at exit, after assuming reversible and adiabatic expansion, and velocity at inlet negligible. **(1+1)**
If, before the air (γ=1.4) enters the nozzle, it is first throttled by a valve so that the pressure is reduced to 6 bar at nozzle inlet, what is the final velocity. Assume reversible and adiabatic expansion and the same outlet pressure.

Q. 4: Explain: (i) Zeroth law of thermodynamics and its significance, **(1 mark each)**
(ii) Perpetual motion machine of first kind,
(iii) Flow work,
(iv) Enthalpy

Q. 5: A 4-stroke, six cylinder gasoline engine is run at speed of 4000 RPM. The area of indicator diagram of one cylinder is 4.0×10^3 mm^2 and its length is 80 mm. The bore of the cylinders is 150 mm and the piston stroke is 140 mm. The spring constant is 25×10^6 N/m^3. The mechanical efficiency of the engine is 88% and fuel consumption is 0.20 kg/min per cylinder. Calorific value of gasoline = 42 MJ/kg. Determine the indicated power (I.P.), brake power (B.P.), friction power (F.P.), indicated thermal efficiency (I.T.E.). **(4)**

Q. 6: (i). State first law of thermodynamics and its limitations. **(2+2)**
(ii). Differentiate between total energy and internal energy of the system.

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Subject: Engineering Thermodynamics (ME 13101) Maximum Marks: 20 ; Time: 1 ... h

Session: 2018-19 ; **Semester: III**

Note: Attempt all questions. Assume missing data, if any.

Q. 1: **(a)** Define thermodynamic equilibrium with suitable example. (2+2)

(b) Define various thermodynamic systems with suitable examples.

Q. 2: A four stroke, multi-cylinder, single-acting, Otto cycle operated engine uses petrol and runs at a speed of 2000 RPM. There are four cylinder in the engine. The bore of cylinder is 160 mm and piston stroke is 190 mm. The area of indicator diagram of one cylinder is 2500 mm^2 and its length is 60 mm. The spring constant is 2.5×10^7 N/m^3. Determine (a) indicated power of one cylinder and total indicated power developed, (b) If mechanical efficiency is 85%, find Shaft power and friction power, (c) Find the torque transmitted to crankshaft and the angular velocity. (4)

Q. 3: Air (C_p = 1.005 kJ/kg K and C_v = 0.718 kJ/kg K) undergoes two thermodynamic processes: Process 1-2 expansion from initial pressure p_1= 300 kPa, initial volume v_1= 0.019 m^3/kg to final Pressure p_2= 150 kPa during which the *p-v* relation is given by pv^γ = constant. Process 2-3 is isobaric process in such a manner that volume of air at thermodynamic state 3 is equal to initial volume of the air. Sketch the processes on a *p-v* diagram and determine the work done per unit mass (4)

Q. 4: Derive Steady flow energy equation and compare it with Euler and Bernoulli equations. (4)

Q. 5: A fluid (air having flow rate 4.5 kg/s and enthalpy $h = c_p t$) is flowing steadily through frictionless Nozzle and then expands in Turbine. On exit to Turbine a heat exchanger is attached. For the nozzle, inlet and outlet air temperatures are 800 °C and 700 °C. Calculate the exit velocity from the nozzle if the inlet velocity of air from nozzle is 2 m/s. This air is allowed to expand in turbine and leaves it at velocity 500 m/s and temperature 200 °C. Calculate work done in turbine. Further this air is allowed to mix with chilled air (temperature at -25 °C) of mass flow rate 5 kg/s in a heat exchanger. Find the value of enthalpy of exit air from the heat exchanger. Assume that all the devices are operated at control surface having perfectly insulated boundary. (4)