

(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 3989

Roll No.

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B.Tech.

(SEMESTER-IV) THEORY EXAMINATION, 2012-13

APPLIED THERMODYNAMICS

Time : 3 Hours]

[Total Marks : 100

SECTION – A

1. Attempt **all** question parts : **10 × 2 = 20**
- (a) Prove that specific heat at constant volume (c_v) of a Vander Wall's Gas is a function of temperature alone.
 - (b) Define adiabatic flame temperature with example.
 - (c) What are the various types of safety valves used in a boiler ?
 - (d) State the comparison between Jet and Surface condenser.
 - (e) Draw indicator diagram with and without clearance in steam engine.
 - (f) What are the effects of friction on the flow through a steam nozzle ?
 - (g) State the comparison between Rankine and Carnot cycle.
 - (h) What is the function of governors in steam turbines ?
 - (i) What is the basic difference between Rocket and Jet propulsion ?
 - (j) Define propeller efficiency.

SECTION – B

2. Attempt any **three** question parts. **10 × 3 = 30**
- (a) Derive the following :
 - (i) Expression for Joule – Thompson Co-efficient
 - (ii) Maxwell relations (any two)



- (b) A boiler generates 7.5 kg of steam per kg of coal burnt at a pressure of 11 bar form of feed water having a temperature of 70 °C. The efficiency of boiler is 75% and factor of evaporation 1.15. Specific heat of steam at constant pressure is 2.3. Calculate :
- Degree of superheat and temperature of steam generated
 - Calorific value of coal in kJ/kg
 - Equivalent evaporation in kg of steam per kg of coal
- (c) Superheated steam at a pressure of 10 bar and 400 °C is supplied to a steam engine. Adiabatic expansion takes place to a release point at 0.9 bar and it exhausts into a condenser at 0.3 bar. Neglecting clearance, determine for a flow rate of 1.5 kg/s :
- Quality of steam at the end of expansion and the end of constant volume operation.
 - Power developed.
 - Specific steam consumption.
 - Modified Rankine cycle efficiency.
- (d) Explain clearly what you mean by saturation curve and missing quantity. Suggest the ways by which missing quantity is reduced.
- (e) With the aid of the schematic diagram and thermodynamic process, explain the working of a turbo propeller engine.

SECTION – C

Attempt all questions :

10 × 5 = 50

3. Attempt any two parts.

5 × 2 = 10

- With a neat sketch, explain the working of Evaporative condenser.
- Define and explain Equivalent Evaporation.
- What is steam trap ? Sketch expansion type of steam trap with parts.

4. Attempt any **one** part.

10 × 1 = 10

- (a) Derive the equation for Clausius Clapeyron Equation for evaporation of liquids.
- (b) A sample fuel has the following percentage composition by weight
Carbon = 84%, hydrogen = 10%, oxygen = 3.5%, nitrogen = 1.5% and Ash = 1%.
- (i) Determine the stoichiometric air fuel ratio by mass
- (ii) If 20% excess air is supplied, find percentage composition of dry flue gas by volume.

5. Attempt any **one** part.

10 × 1 = 10

- (a) A double acting single cylinder steam engine runs at 250 rpm and develops 30 kW. The pressure limits of operation are 10 bar and 1 bar. Cut off is 40% of the stroke. The L/D ratio is 1.25 and diagram factor is 0.75. Assume dry saturated steam at inlet, hyperbolic expansion and negligible effect of piston rod.

Find :

- (i) Mean effective pressure
- (ii) Cylinder dimension
- (iii) Indicated thermal efficiency
- (b) Steam at a pressure of 15 bar and dryness fraction 0.97 is discharged through a convergent divergent nozzle to a back pressure of 0.2 bar. The mass flow rate is 9 kg/kW-hr, if the power developed is 220 kW. Determine the throat pressure and number of nozzles required if each nozzle has a throat of rectangular cross section of 4 mm × 8 mm. If 12% of overall isentropic enthalpy drop occurs in the divergent portion due to friction, find the cross section of the exit rectangular.

6. Attempt any **one** part :

10 × 1 = 10

- (a) Steam at 20 bar, 360 °C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler.
- (i) Assuming ideal process, find per kg of steam the net work and the cycle efficiency.
- (ii) If the turbine and the pump have each 80% efficiency, find the percentage reduction in the net work and cycle efficiency.

- (b) In a stage of impulse reaction turbine, steam enters with a speed of 245 m/sec, at an angle of 30° in the direction of blade motion. The mean speed of the blade is 145 m/sec, when the rotor is running at 300 r.p.m. The blade height is 10 cm. The specific volume of steam at nozzle outlet and blade outlet are $3.45 \text{ m}^3/\text{kg}$ and $3.95 \text{ m}^3/\text{kg}$ respectively. The turbine develops 287 kW of power. Assuming the efficiency of nozzle and blades combined considered is 90% and coefficient of discharge 0.8 ; Find :
- (i) The enthalpy drop in each stage
 - (ii) Degree of reaction
 - (iii) Stage efficiency

7. Attempt any two parts.

$5 \times 2 = 10$

- (a) A turbojet power plant uses aviation kerosene having calorific value of 43 MJ/kg. The fuel consumption is 0.18 kg per hr per thrust, when thrust is 9 kN. The aircraft velocity is 500 m/s the mass of air passing through the compressor is 27 kg/s. Calculate the air fuel ratio and overall efficiency.
- (b) What are the two types of cycle arrangement possible for a gas turbine and what is the basic difference between the two arrangements ?
- (c) State the assumptions made in actual and ideal cycle analysis of a gas turbine.