

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

PAPER ID : 4069

Roll No.

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B.Tech.

THIRD SEMESTER EXAMINATION, 2006-07

APPLIED THERMODYNAMICS

Time : 3 Hours

Total Marks : 100

- Note :**
- (i) Attempt **ALL** questions.
 - (ii) All questions carry equal marks.
 - (iii) In case of numerical problems assume data wherever not provided.
 - (iv) Use of Steam Tables and Mollier Charts is permitted.
 - (iv) Be precise in your answer.

1. Attempt **any four** parts of the following : (5×4=20)
- (a) What is the difference between Path Function and Point Function. Explain it by p-v diagram. What is the amount of work done in free expansion process ?
 - (b) Derive the steady flow energy equation for a single stream entering and a single stream leaving a control volume and explain the various terms in it. Give the differential form of S.F.E.E. Also define unsteady flow process.
 - (c) What does the Clausius-Clapeyron equation signify ? Derive the relation and discuss its application.

- (i) volume expansion
- (ii) isothermal compressibility and
- (iii) adiabatic compressibility.

Determine the volume expansivity of steam at 350 kPa and 300°C.

- (e) From a combustion chamber, hot air is available continuously at 1550°K and 9 bar for expansion through a turbine. The air leaves the turbine at 1 bar and 910°K. Determine
 - (i) availability for the flow system; and
 - (ii) effectiveness.

Take $C_p = 1.005 \text{ kJ/kg-}^\circ\text{K}$ and atmospheric temperature 20°C. Changes in potential and kinetic energy may be neglected.

- (f) Using Maxwell relation show that :

$$C_p \cdot dT = T \cdot ds + T \left(\frac{\partial v}{\partial T} \right)_p \cdot dp$$

Also briefly discuss relevance of Maxwell relations.

2. Attempt *any four* parts of the following : (5x4=20)

- (a) Determine the work output per kg of steam and the quality of steam leaving steam turbine if steam undergoes reversible adiabatic expansion in steam turbine from 0.6 MPa, 300°C to 60 kPa.

- (b) Determine the equivalent evaporation per kg of fuel and boiler efficiency of a boiler having steam generation in boiler at 3 MPa, 350°C at the rate of 4×10^4 kg/hr. Feed water enters economiser at 100°C and during one hour test 5×10^3 kg fuel having calorific value of 3.5×10^4 kJ/kg is consumed.
- (c) Name two accessories of a fire tube boiler plant and draw neat sketches to explain their working.
- (d) What are the different methods of producing draught. Explain any one method in detail.
- (e) What are the different terms (heat utilization and losses) which are to be taken into account for finding out the heat balance of a boiler? Explain them and also define boiler efficiency.
- (f) Determine the height of chimney required for producing a draught equivalent to 15 mm of water, if the flue gas temperature is 525 K, ambient temperature is 25°C and minimum 18 kg air per kg of fuel is required.
3. Attempt *any two* parts of the following : (10x2=20)
- (a) Draw p-V and T-S diagram for a modified Rankine Cycle and derive the expression for thermal efficiency for this cycle considering the pump work into account. Also explain how and why it is different from Rankine cycle for steam engine.
- (b) Using neat sketches enumerate and explain the various parts of a steam engine. Also explain saturation curve and missing quantity of steam using p-v diagram.

Dry saturated steam at pressure of 6 bar through nozzles at the rate of 4.5 kg/sec and discharges at a pressure of 1.6 bar. The loss due to friction occurs only in the diverging portion of the nozzle and its magnitude is 12% of the total isentropic enthalpy drop. Assume the isentropic index of expansion $n=1.135$. Determine the cross-sectional area at the throat and exit of the nozzles. Also explain choked flow through nozzle.

4. Attempt *any two* parts of the following : (10x2=20)
- (a) (i) Why does the efficiency of a Rankine cycle increase with increasing boiler pressure when the condenser is maintained at constant pressure ?
- (ii) What is bleeding and how does it affect the cycle efficiency and specific work output ?
- (b) Determine the maximum blade efficiency and blade speed to steam velocity ratio of a De-Laval turbine. This turbine has nozzle angle of 20° , symmetrical blades, blade velocity coefficient of 0.85 and actual blade efficiency as 90% of maximum blade efficiency. Also define reheat factor and discuss its relevance with the help of h-s diagram.
- (c) Draw the velocity diagram of a velocity compounded impulse and 50% reaction turbine stage. Show the calculations for finding out the tangential force, axial force, blade efficiency and stage efficiency for both the impulse and reaction turbine.

- (a) (i) Discuss with the help of graph, the variation of specific output with pressure ratio at various maximum cycle temperatures for a gas turbine plant.
- (ii) What are the different factors which cause the difference between an ideal cycle and real cycle of a gas turbine plant ? Define polytropic efficiency and its relevance.
- (b) Explain with the help of enthalpy-entropy diagram a turbojet gas turbine engine. How it is different from turbo-prop engine ? Also explain rocket engine briefly.
- (c) Prove that optimum pressure ratio for maximum thermal efficiency for gas turbine plant is given by :

$$r_p \text{ optimum} = \left[\frac{T_3 / T_1}{1 + \sqrt{\left(\frac{T_3}{T_1} - 1 \right) \left(\frac{1}{\eta_c \eta_t} - 1 \right)}} \right]^{\frac{\gamma}{\gamma - 1}}$$

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