CBCS SCHEME

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17AE46

Fourth Semester B.E. Degree Examination, June/July 2019
Turbomachines

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Use of Thermodynamic data hand book is allowed.

Module-1

1 a. With a neat sketch explain the major components of a turbomachine. **(06 Marks)**

b. Define specific speed of a turbine. Write expressions for specific speed of a turbine and a pump. Mention the significance of specific speed. **(04 Marks)**

c. A single stage centrifugal pump with 300mm impeller diameter rotates at 2000rpm supplying 3 m^3/s to a height of 30m with an efficiency of 75%. Find the number of stages and diameter of each impeller of a similar multistage pump to lift 5 m^3/s of water to a height of 200m when running at 1500 rpm. **(10 Marks)**

OR

2 a. Starting from the fundamentals arrive at the alternate form of Euler turbine equation. **(08 Marks)**

b. Define degree of reaction and explain how static and dynamic pressure heads influence it. Why degree of reaction for an impulse turbine is zero? **(06 Marks)**

c. Find the degree of reaction for a sprinkler through which water leaves the jet with an absolute velocity of 3 m/s. The sprinkler arms are 0.2m in length and it rotates at 140rpm. **(06 Marks)**

Module-2

3 a. With reference to a compression process explain: i) Stage efficiency ii) Polytropic efficiency. Represent the same on separate T-s or h-s diagrams. **(10 Marks)**

b. Each stage of a 4-stage air compressor delivering 45 kg/s of air operates at a pressure ratio of 1.2 with a stage efficiency of 65%. Calculate the i) Overall efficiency ii) Overall pressure ratio. Also determine the power required to drive the compressor if inlet air temperature is 20°C. Assume $\nu = 1.4$ and $C_p = 1.005$ kJ/kg.K for air. **(10 Marks)**

OR

4 a. Derive an expression for polytropic efficiency of an expansion process in the turbine in terms of adiabatic and polytropic expansion indices 'γ' and 'n' respectively. Show the process on a h-s diagram. **(08 Marks)**

b. Define 'reheat factor' and explain the same. **(04 Marks)**

c. In a three stage turbine the pressure ratio of each stage is 3. If the turbine stage efficiency is 75%, determine the overall efficiency and reheat factor. **(08 Marks)**

Module-3

5 a. Explain the phenomenon of surging and choking in a compressor. **(08 Marks)**

b. Define: i) Pressure coefficient ii) Power input factor with reference to a centrifugal compressor. **(04 Marks)**

c. A centrifugal compressor has the following running conditions: Impeller tip diameter = 100cm, mass flow rate of air = 30kg/s, inlet condition = 1 bar and 25°C, total pressure ratio = 2.125, Mechanical efficiency = 97%, slip coefficient = 0.9, running speed = 5950rpm. Determine: i) air exit temperature ii) total-to-total efficiency iii) Power input. **(08 Marks)**

OR

6 a. Draw the velocity triangle for an axial compressor stage and show that for an axial flow compressor degree of reaction is given by $R = \frac{Va}{2U}(\tan\beta_1 + \tan\beta_2)$, where all notations have their usual meaning. **(10 Marks)**

b. If 50% reaction axial flow compressor has blades with angle at inlet and outlet as 45° and 10° respectively. The inlet static temperature is 36°C with a pressure ratio of 5:1 and overall isentropic efficiency of 80%. The blade speed is 200m/s and both blade speed and axial velocity are constant. If the workdone factor is 0.87, find the number of stages required. **(10 Marks)**

Module-4

7 a. With reference to flow passage write a brief description of subsonic, transonic and supersonic turbines. **(10 Marks)**

b. At a stage in a 50% reaction axial flow turbine the rotor speed is 210m/s. Steam emerges from the nozzle inclined at 28° to the wheel plane with axial component equal to blade speed. Determine the rotor blade angles and the utilization factor. **(10 Marks)**

OR

8 a. Mention different types of losses in a radial flow turbine and define nozzle loss coefficient. **(10 Marks)**

b. An inward flow reaction turbine has outer and inner diameter of the wheel as 1m and 0.5m respectively, the vanes are radial at inlet and the discharge is radial at outlet. Water enters the vanes at an angle of 10°. Assuming velocity of flow to be constant and equal to 3m/s find: i) The speed of the wheel ii) The vane angle at outlet iii) The degree of reaction. **(10 Marks)**

Module-5

9 a. Define the following terms with reference to a centrifugal pump: i) NPSH ii) Operating characteristic curves iii) Manometric head iv) Overall efficiency. **(10 Marks)**

b. A four stage centrifugal pump has four identical impellers keyed to the same shaft running at 500rpm. The total manometric head developed is 40m, discharging $0.3m^3/s$. If the outlet vane angle is 45° for each impeller of 5cm width and 50cm outlet diameter, determine the manometric efficiency. **(10 Marks)**

OR

10 a. A Kaplan turbine a 5MW generator at 150rpm under a head of 5.5m. The generator and overall efficiencies are respectively 93% and 88%. The tip diameter of the runner is 4.5m and the hub diameter is 2m. Assuming 94% hydraulic efficiency and no exit whirl, determine inlet and outlet runner vane angles at the mean diameter of vanes. **(10 Marks)**

b. For an impulse turbine (Pelton wheel) show that the hydraulic efficiency is maximum at $U = (V_1/2)$, where U is the peripheral speed and V_1 is the inlet jet velocity. Consider the effect of friction. **(10 Marks)**

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