CBCS SCHEME

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15AE46

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

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. With usual notations, derive expressions for unit discharge coefficient, head coefficient power coefficient, using dimensional analysis. **(09 Marks)**

b. A hydraulic turbine has a scale ratio of 1:10. Following data refers to model and prototype, model: P = 25kW, N = 500rpm, H = 10m, $\eta_0 = 0.8$. Prototype : H = 130m. Determine the discharge speed, power and overall efficiency of the prototype. **(07 Marks)**

OR

2 a. Define utilization factor. Obtain a relation between degree of reaction and utilization factor. **(08 Marks)**

b. In a mixed flow turbomachine the fluid enters such that the absolute velocity is axial at the inlet and at outlet relative velocity is radial. What is the degree of reaction and energy input to the fluid, if relative velocity at outlet is same as tangential blade speed at inlet? The following data may be used,

i) Inlet diameter = 16cm,
ii) Exit diameter = 50cm,
iii) Speed = 3000rpm,
iv) Blade angle at inlet = 45°. **(08 Marks)**

Module-2

3 a. Define preheat factor, and derive the expression for preheat factor. **(08 Marks)**

b. In an axial flow compressor, air is taken at 1 bar and 288K. The delivery pressure of the compressor is 6.4 bars. The final temperature of air is 578K. Determine the following:

i) Overall isentropic efficiency
ii) Polytropic efficiency
iii) Number of stages required if the actual temperature rise per state is limited to 14.5K. Assuming that $\eta_p = \eta_s$. **(08 Marks)**

OR

4 a. Define polytropic efficiency of turbine and derive an expression for finite stage efficiency of a turbine. **(08 Marks)**

b. A gas turbine has 2 stages and develops 20mW power. The inlet temperature is 1450K. The overall pressure ratio is 7.5. Assume that pressure ratio of each stage is same and the expansion isentropic efficiency of 0.88. Calculate:

i) Pressure ratio of each stage
ii) Polytropic efficiency
iii) Stage efficiency
iv) Power of each stage. **(08 Marks)**

Module-3

5 a. Define the following:
i) Surging
ii) Choking
iii) Pre-rotation with refer to centrifugal compressor. **(09 Marks)**

b. A centrifugal compressor has a pressure ratio of 4:1 with an isentropic efficiency of 80% when running at 15000rpm and inducting air at 293K. Curved vanes at inlet give the air a prewhirl of 25° to the axial direction at all radii and mean diameter of eye is 250mm. If the absolute air velocity at inlet is 150m/s, impeller tip diameter is 600mm, calculate the slip factor. **(07 Marks)**

OR

6 a. Show that the degree of reaction (R) for an axial flow compressor is given by : $R = \frac{V_f}{U}\left[\frac{\tan\gamma_1 + \tan\gamma_2}{2}\right]$, where V_f = flow velocity, U = tangential speed of the rotor, γ_1 and γ_2 are air angles of the blades at inlet and outlet respectively. **(08 Marks)**

b. An 8 stage axial flow compressor provides an overall pressure ratio of 6:1with an overall isentropic efficiency of 89% when the temperature of air at inlet is 19°C. The work is divided equally between the stages. A 50% reaction is used with a mean blade speed of 190m/s and a constant axial velocity 100m/s through the compressor. Estimate the power required and blade angles. Assume a work done factor of 1. **(08 Marks)**

Module-4

7 a. Draw the velocity triangles at inlet and outlet of an axial flow turbine when i) R = 0 ii) R = 0.5 and iii) R = 1. Discuss the energy transfer in these cases. **(09 Marks)**

b. Find the utilization factor and the degree of relation for a sprinkler shown in Fig.Q.7(b), the water leaves the jet with an absolute velocity of 3m/s and the sprinkler arms are 0.2m in length and it rotates at a speed of 140rpm. **(07 Marks)**

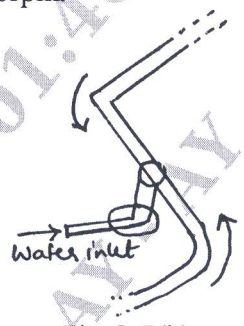

Fig.Q.7(b)

OR

8 a. Explain briefly:
i) Nozzle loss coefficient
ii) Rotor loss coefficient writing suitable expressions for a radial gas turbine. **(06 Marks)**

b. A hydraulic reaction turbine of the radial inward flow type works under a head of 160m of water. At the point of fluid entry, the rotor blade angle is 119° and diameter of the runner is 3.65m. At the exit, the runner diameter is 2.45m. If the absolute velocity at the wheel outlet is radially directed with a magnitude of 15.5m/s and the radial component of velocity at the inlet is 10.3m/s. Find the power developed by the machine, assuming that the 88% of the available head of the machine is converter into work and the flow rate is $110m^3/s$. Find also the degree of reaction and the utilization factor. **(10 Marks)**

Module-5

9 a. Define the following terms with respect to centrifugal pumps i) NPSH ii) Manometric efficiency. **(04 Marks)**

b. Derive an expression for minimum starting speed of a centrifugal pump. **(06 Marks)**

c. A centrifugal pump with 1.2m diameter runs at 200rpm and pumps 1.88 m^3/s, the average lift being 6m. The angle which the vane make at exit with the tangent to the impeller is 26° and the radial velocity is 2.5m/s. Determine the manometric efficiency and the least speed to start pumping if the inner diameter of the impeller is 0.6m. **(06 Marks)**

OR

10 a. Show that the hydraulic efficiency of pelton wheel is maximum when peripheral wheel velocity is half the absolute velocity of jet at inlet. Further show that, $(\eta_h)_{max} = \left(\frac{1+k\cos\beta_2}{2}\right)$. **(08 Marks)**

b. In a tidal power plant, a bulb turbine (axial flow turbine) operates a 5MW generator at 150rpm under a head of 5.5m. The generator efficiency is 93% and the overall efficiency of the turbine is 88%. The tip of the runner is 4.5m and the hub diameter is 2m. Assuming hydraulic efficiency of 94% and no exit whirl, determine the runner vane angles at inlet and exit at the mean diameter of the vanes. **(08 Marks)**

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