CBCS SCHEME

USN | | | | | | | | | | | **15AE46**

Fourth Semester B.E. Degree Examination, Dec.2018/Jan.2019
Turbomachines

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any FIVE full questions, choosing one full question from each module.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. A model of a turbine built to a scale of 1:4 is tested under a head of 10m. The prototype has to work under a head of 50m at 450 rpm. i) what speed should the model run if it develops 60KW using 0.9 cumecs at this speed ii) what power will be obtained from the prototype assuming that its efficiency is 3% better than that of model. **(08 Marks)**

b. Performance of a turbo machine depends on the following variables : Discharge (Q), Speed (N), Size (D), Energy per unit mass flow (gH), Power (P), Density of fluid (ρ), Dynamic viscosity of the fluid (μ). Using the dimensional analysis, obtain the π – terms. **(08 Marks)**

OR

2 a. Derive an alternative form of Euler's turbine equation and explain significance of each energy components. **(08 Marks)**

b. Air enters in an axial flow turbine with a tangential components of absolute velocity equal to 600m/s in the direction of rotation. If the rotor exit , the tangential component of the absolute velocity is 100 m/s in a direction opposite to that of rotational speed. The tangential blade speed is 250 m/s. Evaluate i) the change in total enthalpy of air between the inlet and outlet of the rotor ii) the power in KW if the mass flow rate is 10 kg/s iii) change in total temperature across the rotor. **(08 Marks)**

Module-2

3 a. Define the term polytropic efficiency of a compressor. Show that the polytropic efficiency during compression process is given by **(08 Marks)**

$$\eta_p = \frac{\frac{\gamma-1}{\gamma}\ell_n(P_2/P_1)}{\ell_n(T_2/T_1)}$$, draw the T – S diagram.

b. An air compressor has eight stages of equal pressure ratio 1.35. The flow rate through the compressor and its overall efficiency are 50 kg/s and 82% respectively. If the conditions of air at entry are 1.0 bar and $t_1 = 40^0$C, determine i) The state of air at the compressor exit ii) Polytropic are small stage efficiency iii) Efficiency of each stage and iv) Power required to drive the compressor assuming overall efficiency of the drive as 90%. **(08 Marks)**

OR

4 a. Define Overall efficiency. Show that the overall efficiency during expansion process is given by

$$\eta_0 = \frac{1-P_{ro}^{-\eta_p\left[\frac{\gamma-1}{\gamma}\right]}}{1-P_{ro}^{-\left[\frac{\gamma-1}{\gamma}\right]}}$$, draw T – S diagram. **(08 Marks)**

b. The overall pressure ratio across a three stage gas turbine is 11 and its efficiency is 88%. If the pressure ratio of each stage is the same and the inlet temperature is 1500 K, determine i) pressure ratio in each stage ii) polytropic efficiency iii) stage efficiency iv) reheat factor v) exit temperature and vi) total power output for a mass flow rate of 50 kg/sec. Assume for gas $C_p = 1.005$ kJ/kg ^{0}K and $\gamma = 1.4$. **(08 Marks)**

Module-3

5 a. With respective T – S and velocity diagram, show that the pressure co-efficient is given by
i) $\phi_p = \eta_c \mu \psi$ ii) $\phi_p = 1 - \phi_2 \cot \beta_2$, where (08 Marks)
ϕ_p = pressure coefficient ; η_c = compressor efficiency ; μ = slip factor
ψ = power input factor ; ϕ_2 = flow co-efficient at the exit.

b. The following data refers to a single – sided centrifugal compressor :
Mass flow rate of air = 9 kg/s , Eye tip diameter = 300mm , Slip factor = 0.9 , Total isentropic efficiency = 80% , Eye root diameter = 150 mm , Outer diameter of the impeller = 500 mm , Power input factor = 1.04 , Rotational speed = 18000 rpm , Inlet stagnation pressure = 1.1 bar , Inlet stagnation temperature = 295^0 K. Compute
i) Pressure ratio of the compressor ii) Inlet angle of the impeller vane of the root and tip radii of the eye iii) The axial depth of the impeller channel at the periphery of the impeller. (08 Marks)

OR

6 a. For an axial flow compressor, show that degree of reaction
$R = \frac{V_a}{U} \tan(\gamma_m)$, Where V_a – axial flow velocity , U = blade speed and γ_m = mean blade angle with respect to axial direction. (08 Marks)

b. An axial flow compressor takes in $1000 m^3$/min of free air at 0.9 bar and 15^0C. The blades are of aerofoil type having projected area and blade length as 19.25 cm^2 and 6.75cm respectively. The blades ring mean diameter is 60cm and speed is 6000 rpm. On each blade ring there are 50 blades and the blades occupy 10% of the axial area of flow. Values of C_L and C_D are 0.6 and 0.05 respectively at zero angle of incidence. Assuming isentropic compression , calculate the pressure rise per blade ring and the power input per stage. Assume axial inlet. (08 Marks)

Module-4

7 a. Show that with the help of velocity triangles for maximum utilization, in impulse and reaction axial flow turbines, when V_1 and α_1 are same in both the machines.
$U_R = 2U_I$, where U_R = Blade speed of 50% reaction turbine , U_I = Blade speed of impulse turbine. (08 Marks)

b. At a 50% reaction stage axial flow turbine, the mean blade diameter is 60cm. The maximum utilization factor is 0.9 steam flow rate is 10kg/s. Calculate the inlet and outlet absolute velocities and power developed if the speed is 2000 rpm. (08 Marks)

OR

8 a. In a slow speed inward flow radial turbine, degree of reaction is R and utilization factor is $\in$. Assuming the radial velocity component is constant throughout and there is no tangential component of absolute velocity at the outlet, show that the inlet nozzle angle is given by

$$\alpha_1 = \text{Cot}^{-1} \sqrt{\left(\frac{1-R}{1-\in}\right)^{\in}}$$ (08 Marks)

b. An inward flow turbine has an inlet angle of 20^0, the water leaves radially, speed of the wheel = 350 rpm. Velocity of flow is 4m/s. The inner and outer diameter of the turbine are 30cm and 60cm respectively. Width of the wheel at inlet is 12cm. Find the blade angle and power developed. Also what will be the value of R? (08 Marks)

Module-5

9 a. Explain the following with diagram :
i) Pumps in series ii) Pumps in parallel. **(06 Marks)**

b. Show that the pressure rise in the impeller of a centrifugal pump when the frictional and other losses in the impeller are neglected is given ,

$$\frac{1}{2g}\left[V_{f_1}^{\ 2} + U_2^2 - V_{f_2}^{\ 2}\operatorname{cosec}^2 \beta_2\right]$$

Where V_{f_1} and V_{f_2} are the flow velocities at inlet and outlet of the impeller , U_2 = tangential speed of impeller at exit, β_2 = exit blade angle. **(10 Marks)**

OR

10 a. A double jet Pelton – Wheel is required to generate 7500 KW when the available head at the base of the nozzle is 400m. The jet is deflected through 165^0 and the relative velocity of the jet is reduced by 15% in passing over the buckets. Determine i) the diameter of each jet ii) Total flow iii) Force exerted by the jets in the tangential direction. Assume generator efficiency is 95% , $\eta_0 = 80\%$, Speed ratio = 0.47. **(08 Marks)**

b. An Inward flow reaction turbine has a runner 0.5m diameter and 7.5cm wide. The inner diameter is 0.35m. The effective area of flow is 93% of the gross area and the flow velocity is constant. The guide vane angle is 23^0 , inlet vane angles is 97^0 and the outlet vane angle is 30^0. Calculate the speed, so that the water enters without shock and the power from supply head of 60cm. Assume hydraulic friction losses 10% and mechanical efficiency is 94%. What is the specific speed of the machine? **(08 Marks)**

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