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10ME56

Fifth Semester B.E. Degree Examination, Dec.2014/Jan.2015
Turbomachines

Time: 3 hrs. Max. Marks:100

Note: *1. Answer any FIVE full questions, selecting atleast TWO questions from each part.*
2. Use of steam tables and thermodynamic data hand book is permitted.

PART – A

1 a. Explain the significance of first and second law of thermodynamics applied to a trubomachine. **(06 Marks)**

b. Define the specific speed of a pump. Obtain an expression for the same in terms of discharge, speed and head. **(06 Marks)**

c. A one-fourth scale turbine model is tested under a head of 10 metres. The prototype is required to work under a head of 30 metres and to run at 425rpm. Estimate the speed of the model if it develops 125 kW and uses 1.1 m^3/s of water at this speed. Also calculate the power output of the prototype and suggest the type of turbine. **(08 Marks)**

2 a. Explain static and stagnation state for a fluid. **(04 Marks)**

b. What is reheat factor? Show that reheat factor is greater than unity. **(06 Marks)**

c. A multistage axial flow compressor, the air is taken at 1 bar and 15°C and compressed to a pressure of 6.4 bar. The final true temperature is 300°C due to the compression process. Determine the overall compression efficiency and also the polytropic efficiency. Determine the number of stages required if the true temperature rise is limited to 13°K for each stage. Assume polytropic efficiency is equal to stage efficiency. **(10 Marks)**

3 a. Derive utilization factor for a turbine. Derive an expression relating utilization factor with degree of reaction for an axial flow turbine. **(10 Marks)**

b. The mean rotor blade speed of an axial flow turbine stage with 50% reaction is 210 m/s. Steam emerges from the nozzle inclined at 28° to the plane of the wheel with axial component equal to blade speed. Assuming symmetric inlet and outlet velocity triangles, determine the rotor blade angle and utilization factor. Also determine the degree of reaction to make the utilization maximum if the axial velocity, blade speed, as well as nozzle angle remain the same. **(10 Marks)**

4 a. Draw the velocity diagram for a power absorbing radial flow turbo machine and show that $R = \frac{1}{2}\left[1 + \frac{V_{m_2} \cot \beta_2}{U_2}\right]$. **(10 Marks)**

b. Draw the velocity triangles at inlet and outlet of an axial flow compressor from the following data. Degree of reaction 0.5, inlet blade angle 45°, axial velocity of flow which is constant throughout 120 m/s, speed of rotation 6500 rpm, radius of rotation 20cm, blade speed at inlet is equal to blade speed at outlet. Calculate angles at inlet and outlet. Also calculate power needed to handle 1.5 kg/s of air. **(10 Marks)**

PART – B

5 a. Show that maximum blade efficiency $\eta_{\text{blade max}} = \frac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}$ for a 50% reaction Parson's turbine. **(10 Marks)**

b. Steam emerging from a nozzle to a impulse De-Laval turbine with a velocity of 1000 m/s. The nozzle angle is 20°. The mean blade velocity is 400m/s. The blades are symmetrical ($\beta_1 = \beta_2$). The mass flow rate of steam is 1000 kg/hr. Friction factor is 0.8. Calculate the following: i) Blade angles; ii) Axial thrust; iii) Work done per kg of steam; iv) Power developed. **(10 Marks)**

6 a. Write a short note on draft tubes in a reaction hydraulic turbine. **(04 Marks)**

b. In a power station single jet Pelton wheel produces 23110 kW under a head of 1770m while running at 750 rpm.
Estimate: i) Jet diameter; ii) Mean diameter of the runner; iii) Number of buckets.
Assume the necessary data suitably. **(06 Marks)**

c. An inward flow reaction turbine works under a head of 110m. The inlet and outlet diameters of the runner are 1.5m and 1.0m respectively. The width of the runner is constant throughout as 150mm. The blade angle at outlet is 15°. The hydraulic efficiency is 0.9. Calculate:
i) The speed of the turbine.
ii) The blade angles.
iii) The power produced when the discharge velocity is 6m/s. **(10 Marks)**

7 a. What is minimum starting speed of a centrifugal pump? Derive an expression for the minimum starting speed. **(06 Marks)**

b. A centrifugal pump is to discharge 0.118 m^3/s of water at a speed of 1450rpm against a head of 25m. The impeller diameter is 25cm and its width at the outlet is 5cm and manometric efficiency is 75%. Calculate the vane angle at the outlet. **(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 makes at exit with the tangent to the impeller is 26° and the radial velocity of flow is 2.5 m/s. Find the manometric efficiency and the least speed to start pumping if the inner diameter being 0.6m. **(08 Marks)**

8 a. With neat sketch explain, slip, slip coefficient and slip factor. **(06 Marks)**

b. Explain the phenomenon of surging and stalling. **(04 Marks)**

c. The mean diameter of the rotor of an axial flow compressor is 0.5m and it rotates at 15000 rpm. The velocity of flow 220 m/s, is constant and the velocity of whirl at the inlet is 80m/s. The inlet pressure and temperature are 1 bar and 300°K. The stage efficiency is 0.88. The pressure ratio through the stage is 1.5. Calculate:
i) Fluid deflection angle.
ii) The degree of reaction if work done factor is 0.8. **(10 Marks)**

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