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10ME56

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

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Define turbomachines. Briefly classify Turbo-machines. **(06 Marks)**

b. Define specific speed of pumps. Show that specific speed of pump is given by,

$$N_S = \frac{N\sqrt{Q}}{H^{\frac{3}{4}}}.$$ **(06 Marks)**

c. Tests on a turbine runner 1.25 m in diameter at 30 m head gave the following results, power developed = 736 kW, speed is 180 rpm and discharge 2.70 m³/sec. Find the diameter speed and discharge of a runner to operate at 45 m head and give 1472 kW at the same efficiency. What is the specific speed of both the turbines? **(08 Marks)**

2 a. Show that for a finite number of stages for expansion the overall isentropic efficiency is given by,

$$\eta_e = \frac{1-\left[1-\eta_{st}\left\{1-\left(\frac{1}{P_r}\right)^{r-1}\right\}\right]^m}{\left\{1-\left(\frac{1}{P_r}\right)^{\frac{m(r-1)}{r}}\right\}}$$

where m = number of stages, P_r – Press ratio per stage, η_{st} = stage efficiency, r = ratio of specific heats. **(10 Marks)**

b. The output of a three stage gas turbine is 30 MW at the shaft coupling at an entry temperature of 1500 K. The overall pressure ratio across the turbine is 11.0 and efficiency 88%. If the pressure ratio of each stage is the same, determine (i) Pressure ratio of each stage (ii) Polytropic efficiency (iii) The mass flow rate, (iv) The efficiency and power of each stage. Assume $\gamma_{air} = 1.4$, $C_P = 1.005$ KJ/kgK, $\eta_{mech} = 91\%$. **(10 Marks)**

3 a. Why the discharge blade angles has considerable effect in the analysis of a turbomachine? Give reasons. **(04 Marks)**

b. Draw the velocity triangles at inlet and outlet of an axial flow turbine when (i) R is – ve. (ii) R = 0 (iii) R = 0.5 (iv) R = 01 (v) R>1. Discuss the energy transfer in each case. **(10 Marks)**

c. Liquid water flows at a rate of 31.5 kg/sec through a rotor of an axial flow turbine, where inlet and outlet mean diameters are 18.5 cm and 20 cm respectively. The other datas are: speed = 6000 rpm, V_1 = 35 m/sec and is directed axially, V_2 = 160 m/sec such that $\alpha_2 = 30°$. Using mean inlet and outlet diameter find : (i) Torque exerted (ii) V_{r_1} and V_{r_2}. **(06 Marks)**

4 a. Define degree of reaction for an axial flow machine. Prove that degree of reaction for an axial flow device (assuming constant velocity of flow) is given by,

$$R = \frac{V_f}{2U}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \times \tan\beta_2}\right].$$ **(10 Marks)**

b. At a stage of an impulse turbine, the mean rotor diameter is 80 cm, its rpm is 3000 rpm. The absolute velocity of fluid discharge from a nozzle inclined at 20° to plane of wheel is 300 m/sec. If utilization factor is 0.85 and relative velocity at rotor exit equals that at inlet, find the inlet and exit rotor angles. Also find power for $\dot{m}$ of 1 kg/sec. **(10 Marks)**

PART – B

5 a. Show that the maximum efficiency of a Parson's reaction turbine is,

$$\eta_{b_{max}} = \frac{2\cos^2\alpha_1}{1+\cos^2\alpha_1}.$$ **(10 Marks)**

b. Steam issues from a nozzle of a De-laval turbine with a velocity of 1200 m/sec. Nozzle angle is 20°. Blade speed is 400 m/sec. The inlet and outlet blade angles are equal. Mass flow rate is 900 kg/hr. Calculate : (i) Blade angles (ii) Relative velocities, if blade velocity co-efficient is 0.8. (iii) Tangential force on the blades (iv) Power developed (v) Blade efficiency. **(10 Marks)**

6 a. Draw the cross sectional view of a Kaplan turbine and explains its working. Also sketch the velocity triangles at inlet and outlet. **(10 Marks)**

b. A Pelton wheel produces 15,500 KW under a head of 350 m at 500 rpm. If overall efficiency of the wheel is 84%. Find:
(i) Required number of jets and diameter of each jet.
(ii) Number of buckets.
(iii) Tangential force exerted.
Assume : Jet ratio = 9.5, Q = 160°, $\phi = 0.46$ **(10 Marks)**

7 a. What is cavitation? What are the causes for cavitation? Explain the steps to be taken to avoid cavitation. **(06 Marks)**

b. Draw the different types of casing and label the parts. **(06 Marks)**

c. The outer diameter of the impeller of a centrifugal pump is 40 cm and a width of the impeller at outlet is 5 cm. The pump is running at 800 rpm and working against a total head of 1.5 m. The Vane angle at outlet is 40° and manometric efficiency is 75%. Determine (i) Velocity of flow at outlet. (ii) Velocity of water leaving the vane (iii) Angle made by the absolute velocity at outlet with the direction of motion at outlet. **(08 Marks)**

8 a. With a neat schematic diagram, explain an axial flow compressor. Also sketch, the general velocity triangles for an axial flow compressor. **(10 Marks)**

b. Backward swept centrifugal fan develops a pressure of 75 mm WG. It has an impeller diameter of 89 cm and runs at 720 rpm. The blade angle at the tip is 39° and the width of the impeller is 10 cm. Assuming a constant velocity of flow of 9.15 m/s and density of 1.2 kg/m^3, determine the fan efficiency, discharge, power required, stage reaction and pressure coefficient. **(10 Marks)**

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