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17ME53

Fifth Semester B.E. Degree Examination, July/August 2021
Turbo Machines

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions.

1 a. Summarize the difference between a positive displacement machines and turbomachines. **(08 Marks)**

b. Test on a turbomachine runner of diameter 1.25m runs at 30m head and gave the following results. Power developed – 736kW, speed of 180rpm with a discharge of 2.7m^3/s. Find the diameter, speed and discharge of a runner to operate at 45m head and gives 1472kW at the same efficiency. What is specific speed of both the turbines? **(08 Marks)**

c. Discuss briefly the effect of Reynold's number on a fluid flow in turbomachines. **(04 Marks)**

2 a. Show that the polytropic efficiency during the process of expansion is given by

$$\eta_p = \frac{\ell_n\left(\frac{T_2}{T_1}\right)}{\frac{\gamma-1}{\gamma}\ell_n\left(\frac{P_2}{P_1}\right)}$$ **(10 Marks)**

b. A stream of combustion gases at the point of entry to a turbine has a static temperature of 1050K, static pressure of 600kPa and a velocity of 150m/s. For the gases, C_p-1.004kJ/kg K and γ-1.41. Find the total temperature and total pressure of the gases. Also find the difference between their static and total enthalpies. **(10 Marks)**

3 a. Considering the elements of energy transfer. Derive an alternate form of Euler Turbine equation. **(10 Marks)**

b. In an axial flow turbine, the discharge blade angles are 20° each, for both the stator and the rotor. The steam speed at the exit of the fixed blade is 140m/s. The ratio of $\frac{V_a}{u} = 0.7$ at the entry and 0.76 at the exit of the rotor blade. Find: i) The inlet rotor blade angle ii) Power developed by the blade ring for a mass flow rate of 2.6kg/sec iii) Degree of reaction. **(10 Marks)**

4 a. Derive theoretical Head-Capacity (H-Q) relation in case of radial flow pump (centrifugal)

$$H = u_2^2 - \frac{u_2^2 Q \cot\beta_2}{A_2}$$

β_2 = discharge blade angle with respect to tangential direction. Explain the effect of discharge angle on it. **(10 Marks)**

b. An axial flow compressor has the following data entry conditions: 1 bar and 20°C, degree of reaction = 50%, mean blade ring diameter = 60cm, rotational speed = 18000rpm, blade angle at rotor and stator exit = 65°. Axial velocity = 180m/s, mechanical efficiency = 96.7%. Find:

i) Blade angle at rotor and stator inlet

ii) Power required to drive the compressors. **(10 Marks)**

5 a. With a neat sketch, explain the pressure-velocity compounding of steam turbine. **(10 Marks)**

b. In a Curtis stage with two rows of moving blades the rotor are equiangular. The first rotor has angle of 29° each while second rotor has angle of 32° each. The velocity of steam at the exit nozzle is 530m/s and the blade co-coefficients are 0.9 in the first, 0.95 in the stator and in the second rotor. If the absolute velocity at the stage exit should be axial, Find:
i) Mean blade speed ii) Rotor efficiency iii) Power output for a flow rate of 32kg/sec. **(10 Marks)**

6 a. Derive the condition for maximum efficiency of reaction steam turbine and hence prove that

$$\eta_{b\max} = \frac{2\text{Cos}^2\alpha_1}{1+\text{Cos}^2\alpha_1}$$ **(10 Marks)**

b. A Parson's turbine is running at 1200rpm. The mean rotor diameter is 1m. Blade outlet angle is 23°, speed ratio is 0.75 stage efficiency is 0.8. Find Enthalpy drop in this stage. **(10 Marks)**

7 a. Show that for a Pelton turbine the maximum hydraulic efficiency is given by

$\eta_{max} = \frac{1+C_b\text{Cos}\beta_2}{2}$ where C_b = blade velocity coefficient, β_2 = Blade discharge angle.. **(10 Marks)**

b. In a power station, a pelton wheel producer 15000kW under a head of 350m while running at 500rpm. Assume turbine efficiency of 0.84, coefficient of velocity for nozzle as 0.98, speed ratio 0.46 and bucket velocity coefficient 0.86. Calculate:
i) Number of jet ii) Diameter of each jet iii) Tangential force on the buckets if the bucket deflect the jet through 165°. **(10 Marks)**

8 a. Define the following: i) Monometric Head ii) Hydraulic Efficiency iii) Mechanical Efficiency iv) Overall efficiency v) Volumetric efficiency. **(10 Marks)**

b. In a Francis turbine, the discharge is radial, the blade speed at inlet is 25m/s. At the inlet tangential component of velocity is 18m/s. The radial velocity of flow is constant and equal to 2.5m/s. Water flows at the rate of $0.8m^3$/sec. The utilization factor is 0.82. Find:
i) Euler's head ii) Power developed iii) Degree of reaction (R) iv) Inlet blade angle Draw the velocity triangles. **(10 Marks)**

9 a. What are the applications of multistage centrifugal pumps? With a neat sketch, explain centrifugal pumps in series and parallel. **(10 Marks)**

b. A centrifugal pump working in a dock, pumps 1565*l*/sec, against head (mean lift) of 6.1m, when the impeller rotates at 200rpm. The impeller diameter is 122cm and the area at outlet periphery is $6450cm^2$. If the vanes are set back at an angle of 26° at the outlet. Find:
i) Hydraulic efficiency ii) Power required to drive the pump. If the ratio of external to internal diameter is 2, find the minimum speed to start pumping. **(10 Marks)**

10 a. For axial flow compressor, show that

$$E = V_f u\left[\frac{\tan\beta_2 - \tan\beta_1}{\tan\beta_1\tan\beta_2}\right]$$ **(10 Marks)**

b. What are the types of diffuser used in centrifugal compressor? Explain any two. **(10 Marks)**

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