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10ME56

Fifth Semester B.E. Degree Examination, Jan./Feb. 2021
Turbomachines

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. How are turbo machines classified? Compare turbo machines with positive displacement machines. **(08 Marks)**

b. Define unit speed, and obtain an expression for unit speed. **(04 Marks)**

c. The diameter of a centrifugal pump, which is discharging $0.03 m^3/s$ of water against a total head of 20m is 0.40m. The pump is running at 1500rpm. Find the head, discharge and ratio of powers of a geometrically similar pump of diameter 0.25m when it is running at 3000rpm. **(08 Marks)**

2 a. What is Reheat factor in a multistage turbine? Prove that reheat factor is greater than unity. **(08 Marks)**

b. Define: i) Stage efficiency ii) Polytropic efficiency. **(04 Marks)**

c. An air compressor has eight stages of equal pressure ratio 1.3. The flow rate through the compressor and its overall efficiency are 45kg/s and 80% respectively. If the conditions of air at entry are 1 bar and 35°C, determine: i) State of air at compressor exit ii) Polytropic efficiency iii) Stage efficiency. **(08 Marks)**

3 a. Write the general equation for utilization factor and prove that for maximum utilization factor the speed ratio $\rho = \frac{\cos\alpha_1}{2}$ in impulse turbine, and $\rho = \cos\alpha_1$ for 50% reaction turbine. Draw the velocity triangles for both the cases. **(10 Marks)**

b. In a mixed flow turbomachine the fluid enters such that the absolute velocity is axial at 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 of inlet? The following data may be used:

i) Inlet diameter = 16cm
ii) Exit diameter = 50cm
iii) Speed = 3000rpm
iv) Blade angle = 45° at inlet. **(10 Marks)**

4 a. Show that with the help of velocity triangles, for maximum utilization and same amount of energy transfer in impulse and 50% reaction turbine

$U_R = \sqrt{2U_I^2}$

Where U_R = Blade speed of 50% reaction turbine

U_I = Blade speed of Impulse turbine. **(10 Marks)**

b. A single stage axial flow blower with no inlet guide vanes but a row of stationary vanes down stream of rotor operates at 3600 rpm. The tip and hub diameter of the rotor are 200mm and 125mm respectively. The air flow rate through the stage is 0.45kg/s. The air is sucked through an angle of 20° towards axial direction during passage through the rotor at the arithmetic mean diameter. Assuming standard atmospheric conditions (1 bar, 25°C) and no losses in the rotor compute power input and degree of reaction. **(10 Marks)**

PART – B

5 a. Show the expansion of steam through an impulse turbine in a number of stages on h-s diagram, and explain i) Stage efficiency ii) Reheat factor iii) Internal turbine efficiency. **(08 Marks)**

b. The following data refer to a single stage impulse turbine. Isentropic nozzle heat drop = 251kJ/kg nozzle efficiency = 90%; nozzle angle = 20°; ratio of blade speed to whirl component of steam speed = 0.5, blade velocity coefficient = 0.9; the velocity of steam entering the nozzle = 20m/s.
Determine:
i) The blade angles at inlet and outlet if the steam enters into the blades without shock and leaves the blades in an axial direction.
ii) Blade efficiency.
iii) Power developed if the steam flow is 8kg/s. **(12 Marks)**

6 a. Classify hydraulic turbines with examples. **(06 Marks)**

b. Explain the function of draft tube. Mention the different types of draft tube. **(04 Marks)**

c. An axial flow turbine of runner diameter 4.5m is running at 40rpm. The guide blade angle at inlet is 145° and runner blade angle at outlet is 25° to the direction of vanes. The axial flow area of water through runner is $25m^2$. If the runner blade angle at inlet is radial determine: i) Hydraulic efficiency of the turbine; ii) Discharge through turbine; iii) Power developed. **(10 Marks)**

7 a. Explain the working of a single stage centrifugal pump with neat sketch. **(06 Marks)**

b. What are the effects of cavitation? Give the necessary precautions against cavitation. **(04 Marks)**

c. A centrifugal pump with 1.2m diameter runs at 200rpm, and pumps 1880 *l*ts/s, the average lift being 6m. The angle which the vanes make at exit with the tangent to the impeller is 26° and the radial velocity of flow is 2.5m/s. Determine the monometric efficiency and the least speed to start pumping against head of 6m, the inner diameter of the impeller being 0.6m. **(10 Marks)**

8 a. Explain briefly the phenomenon of surge and chocking in centrifugal compressor. **(08 Marks)**

b. What is meant by slip? **(02 Marks)**

c. A centrifugal compressor compresses 30kg of air per second at a rotational speed of 15000rpm. The air enters the compressor axially, and the conditions at the exit sections are, radius = 0.3m, relative velocity of air at the tip is 100m/s at an exit angle of 80°. Find the torque and power required to drive the compressor and also the ideal head developed. Take P_{01} = 1 bar and T_{01} = 300k. **(10 Marks)**

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