USN

06ME55

Fifth Semester B.E. Degree Examination, June/July 2015

Turbo Machines

Time: 3 hrs. Max. Marks:100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of steam tables permitted***

PART – A

1 a. Define a turbo machine. With a simple sketch explain the parts of a turbomachine. **(06 Marks)**

b. Gases from a combustion chamber enter a gas turbine at a total pressure of 7 bar and total temperature 1100 k. Total pressure and total temperature at the turbine exit are 1.5 bar and 830 k. Using $\gamma = 1.3$ and molecular weight = 28.7, evaluate total-to-efficiency and total-to static efficiency, if the exit velocity is 250m/s. Assume adiabatic, steady flow. **(08 Marks)**

c. Define and explain significance of following dimensionless terms employed in incompressible turbo machine analysis.
i) The flow co-efficient.
ii) The head co-efficient.
iii) The power co-efficient. **(06 Marks)**

2 a. Derive Euler-turbine equation from first principles and state assumption made. **(10 Marks)**

b. The total power input at a stage in an axial flow compressor with symmetric inlet and exit velocity triangles (Degree of recaction = 0.5) is 27.85 kJ/kg of air flow. If the blade speed is 180 m/s through out the rotor, draw the velocity triangles at inlet and exit. Compare the inlet and outlet rotor blade angles. Assume axial velocity componenet to be 120m/s. **(10 Marks)**

3 a. Define Degree of Reaction and utilization factor of a turbine. Hence, show that utilization factor $\in$ is given by, $\in = \dfrac{v_1^2 - v_2^2}{v_1^2 - Rv_2^2}$ with usual notations. **(10 Marks)**

b. In a radial inward flow hydramatic turbine, the degree of rection is 0.866 and the utilization factor for the runner is 0.968. If the tangential speeds of the wheel at the inlet and out let are respertively 11 m/s and 5.5 m/s, draw the velocity tringles at the inlet and outlet, assuming that the radial velocity is 5 m/s, the same at all points on the runner. The absolute velocity at the runner outlet is purely radial with no tangential companent. Find the power output for a volume flow rate of $1.6 m^3$ of water per sec. **(10 Marks)**

4 a. Define the following with the help of h-s diagram for power generating and power absorbing turbo machines.
i) Total to total efficiency.
ii) Total to static efficiency.
iii) Static to total efficiency.
iv) Static to static efficiency. **(12 Marks)**

b. Define the term infinitesinal stage efficiency of a turbine. Show that the polytropic efficiency during expansion process is given by

$$\eta_p = \frac{\ln\left(\frac{T_2}{T_1}\right)}{\frac{\gamma - 1}{\gamma} \text{in}\left(\frac{p_2}{p_1}\right)}$$

(08 Marks)

PART – B

5 a. Explain the phenomenon of slip in centrifugal compressors and hence explain the significance of slip factor in deciding the number of vanes. (08 Marks)

b. A centrifugal compressor runs at 15000 rpm and produces stagnation pressure ratio of 4.0 between the inpeller inlet and outlet. The stagration conditions of the air at the compressor in take are 1 bar and 298 k respectively. The absolute velocity at the compressor intake is axial. If the compressor has radial blades at the exit such that $Vr_2 = 135\ m/s$ and the total-to-total efficiency of the compressor is 0.78, draw the velocity triangle at the exit of the rotor and compute the slip as well as the slip co-efficient. The rotor diameter at outlet is 58 cm. (12 Marks)

6 a. Show that the pressure rise in an impeller of a centrifugal pump is given by

$$\frac{1}{2g}\left[Vm_1^2 + u_2^2 - Vm_2^2\, Co\sec^2 \beta_2\right]$$

where Vm_1 and Vm_2 are velocities of flow at inlet and outlet, u_2 is tangential velcocity of impellar at outlet and β_2 blade angle at blade exit. (10 Marks)

b. The outer diameter of the impeller of centrifugal pump is 40cm and the width of the impellar at outlet is 5 cm. The pump is running at 800 rpm and is working against a head of 15m. The vane angle at outlet is 40° and manometric efficiency is 75%. Determine :

i) The velocity of flow at out let

ii) The angle made by the absolute velocity at outlet with the direction of motion at out let

iii) Discharge. (10 Marks)

7 a. Explain the necessity of compounding of steam turbines and discuss the following two methods of compounding with neat sketches.

i) Velocity compounding.

ii) Pressure compounding. (10 Marks)

b. Steam issues from the nozzle of a DeLaval turbine with a velocity of 1200 m/s, the nozzle angle being 22°. If the rotor blades are equiangular and the rotor trangantial speed is 400 m/s compute.

i) The rotor blade angles

ii) The tangantial force on the blade ring

iii) The power developed if steam flowing through the turbine is 900 kg/hr

Assume $Vr_1 = Vr_2$ (10 Marks)

8 a. Classify hydraulic turbines. (04 Marks)

b. Show that when vane angle at the inlet of francis turbine is 90°, velocities of flow is constant and the dischanrge is radial at exit, The hydraulic efficiency is given by

$$\eta_h = \frac{2}{2 + \tan^2 \alpha}$$

α_1 = exit guide blade angle. (06 Marks)

c. A reaction turbine working under a head of 5.5m produces 2400 kw, when the dischanrge through the turbine is 63.5 m^3 of water/Sec. the draft tube for the turbine has an inlet diameter of 3.5m and an outlet diameter of 4m. The draft tube efficiency is 80%. Find the increment in hydraulic efficiency and power output that would result if the original draft tube had an efficiency of 100% instead of 80%. (10 Marks)

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