CBCS Scheme

USN | | | | | | | | | | 15ME53

Fifth Semester B.E. Degree Examination, Dec.2017/Jan.2018
Turbo Machines

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing one full question from each module.

Module-1

1 a. Define and give the significance of specific speed, head coefficient and power coefficient with respect to turbo machines. **(06 Marks)**

b. Explain the effect of Reynold number on the performance analysis of turbomachines. **(04 Marks)**

c. It is desired to deliver 5 m^3/sec at a head of 640 m in a single stage pump.
i) If the specific speed is not to exceed 40, what should be the speed of the impellers?
ii) If the speed is reduced to 1450 rpm, how many stages are required? **(06 Marks)**

OR

2 a. Explain static and stagnation state for a fluid. Obtain an expression relating static and stagnation temperature for a perfect gas. **(06 Marks)**

b. An axial flow compressor has eight stages of equal pressure ratio of 1.35 and the flow rate through the compressor and the overall efficiency are 50 kg/sec and 0.82 respectively. If the conditions of air at the entry are 1.0 bar and 300 K. Determine:
i) The state of air at the compressor exit
ii) Polytropic efficiency
iii) Efficiency of each stage
iv) Power required to drive the compressor assuming mechanical efficiency of 90%. **(10 Marks)**

Module-2

3 a. Draw the velocity triangles at inlet and outlet of a turbo machine and derive the Euler turbine equation with usual notations. **(08 Marks)**

b. In an inward flow water turbine, the water enters the runner through a guide vane at an angle of 30° and at a velocity of 30 m/sec. The inner diameter is 1.8 m and the outlet diameter is half the inlet diameter. The water leaves the runner at an absolute velocity of 3 m/sec at an angle of 130° to the wheel tangent with a slight positive whirl. Find the power developed by the turbine if the discharge is 0.4 m^3/sec and also the blade angles at inlet and outlet, if the speed of the turbine is 300 rpm. **(08 Marks)**

OR

4 a. A radial outward flow turbo machine has no inlet whirl. The blade speed at the exit is twice that at inlet. Radial velocity is constant throughout. Taking the inlet blade angle as 45°, show that the degree of reaction is given by $R = \frac{2+\cot\beta_2}{4}$ where β_2 is the blade angle at exit with respect to tangential direction. **(10 Marks)**

b. The impeller of a centrifugal pump has an outer diameter of 1.5 m. It lifts water at a rate of 2000 kg/sec. The blade is making an angle is 145° with the direction of motion at outlet and the speed being 3000 rpm. Radial velocity of flow is 3m/sec. Find the power required to drive the impeller. **(06 Marks)**

Module-3

5 a. Define and explain diagram efficiency and stage efficiency. **(04 Marks)**

b. A velocity compounded impulse wheel has two rows of moving blades with a mean diameter of 70 cm. The speed of rotation is 3000 rpm and the nozzle angle is 16° and the estimated steam velocity at the nozzle outlet is 610 m/sec. The mass of steam passing through the blades per second is 5.5 kg. Assuming that the energy loss in each row of blades (moving and fixed) is 24% of the kinetic energy of the steam entering the blades. The outlet angles of the blades are:

1. First row of moving blades = 18°
2. Intermediate guide blades = 22°
3. Second row of moving blades = 38°

Draw the diagram of relative velocities and derive the following:

i) Blade inlet angles

ii) Power developed in each row of moving blades

iii) Efficiency of the wheel as a whole. **(12 Marks)**

OR

6 a. For a 50% reaction steam turbine, show that $\alpha_1 = \beta_2$ and $\alpha_2 = \beta_1$ where β_1 and β_2 are the inlet and outlet blade angles, α_1 and α_2 are the angles with respect to fixed blades. **(08 Marks)**

b. A certain stage of a Parsons turbine consists of one row of fixed blades and one row of moving blades. The details of the turbine are as follows:

Mean blade speed = 107 m/sec

Mass of steam passing per second = 13.5 kg

Steam velocity at exit from fixed blades = 143.7 m/sec

Nozzle inlet angle = 20°

Calculate the power developed in the stage and gross efficiency, assuming carry over coefficient as 0.74 and the efficiency of conversion of heat energy into kinetic energy in the blade channels as 0.92. **(08 Marks)**

Module-4

7 a. Derive an expression for the hydraulic efficiency of a Pelton wheel turbine interms of jet velocity, V_1, blade velocity, U and blade angles. **(08 Marks)**

b. The supply to a single jet pelton wheel is from a reservoir 310 m above the nozzle centre (C_V of nozzle = 0.97) through a pipe 67.5 cm diameter, 5.6 km long. Take friction coefficient for the pipe = 0.008. Jet diameter = 9 cm. The blade speed ratio = 0.47 and buckets deflect the water through 170°. The relative velocity of water is reduced by 15% in passing over the buckets. If the mechanical efficiency = 85%. Determine the power given to runner, hydraulic efficiency and overall efficiency. **(08 Marks)**

OR

8 a. With a neat sketch, explain the working of a Kaplan turbine. Draw the velocity triangles at inlet and outlet of the turbine. Also explain the function of draft tube. **(08 Marks)**

b. The following data is given for a Francis turbine. Net head = 70 m, speed = 600 rpm, shaft power = 368 KW, overall efficiency, η_0 = 85% and hydraulic efficiency, η_h = 95%, flow ratio = 0.25, breadth ratio = 0.1, outer diameter of runner = 2 x inner diameter of runner, velocity of flow is constant at inlet and outlet and the thickness of the vanes occupy 10% of the circumferential area of the runner and discharge is radial at outlet. Determine:

i) Guide blade angle

ii) Runner vane angles at inlet and outlet

iii) Diameter of the runner at inlet and outlet

iv) Width of wheel at inlet. **(08 Marks)**

Module-5

9 a. Show that the pressure rise in the impeller of a centrifugal pump when frictional and other losses in the impeller are reflected is given by

$$\frac{1}{2g}\left[V_{f_1}^2 + U_2^2 - V_{f_2}^2 \operatorname{cosec}^2\beta_2\right]$$

where V_{f_1} and V_{f_2} are the velocity of flow at inlet and outlet, U_2 = tangential velocity of impeller at outlet, β_2 = vane angle at outlet. **(06 Marks)**

b. A three stage centrifugal pump has impeller 40 cm in decimeter and 2.5 cm wide at outlet. The vanes are curved back at an angle of 30° and reduces the circumferential area by 15%. The manometric efficiency = 85% and overall efficiency = 75%. Determine the head generated by the pump when running at 1200 rpm and discharges 0.06 m^3/sec. Find the shaft power also. **(10 Marks)**

OR

10 a. Explain the phenomenon of (i) surging (ii) chocking in the centrifugal compressor. **(06 Marks)**

b. Define work done factor for an axial flow compressor. **(02 Marks)**

c. An axial flow compressor of 50% reaction design has blades with inlet and outlet angles with respect to axial direction as 45° and 10° respectively. The compressor is to produce a pressure ratio of 6:1 with an overall isentropic efficiency of 0.85 when the inlet static temperature is 37°C. The blade speed and axial velocity are constant throughout the compressor. Assuming a value of 200 m/sec for blade speed find the number of stages required if the work done factor is 0.87 for all stages. **(08 Marks)**

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