CBCS Scheme

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15AE46

Fourth Semester B.E. Degree Examination, June/July 2017
Turbomachines

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Differentiate between a positive displacement machine and a turbomachine. **(04 Marks)**

b. With usual notations, using dimensional analysis derive an expression for power and capacity coefficients of a turbomachine. **(06 Marks)**

c. A centrifugal pump delivers 1 m^3/s against a pressure of 40 m of water at a speed of 1200 rpm. Calculate the (i) Speed of rotation (ii) The specific speed of the machine (iii) The power of the motor required for delivering 50% more discharge. Take impeller diameter 0.5 m and overall efficiency 33%. **(06 Marks)**

OR

2 a. Derive an alternate form of Euler's turbine equation and explain the significance of each energy components. **(08 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 at inlet? The following data may be used. Inlet dia = 16 cm; Outlet dia = 50 cm; Speed = 3000 rpm; Blade angle at inlet = 45°. **(08 Marks)**

Module-2

3 a. Define the following for a compression process using h-S diagram:(i) Total–to–Total efficiency (ii) Polytropic efficiency (iii) Preheat factor. **(08 Marks)**

b. A low pressure air compressor develops a total pressure change of 1400 mm WG. If the initial and final states of air are $p_1 = 1.01$ bar, $T_1 = 305$ K, $T_2 = 320$ K, determine compressor efficiency and infinitesimal stage efficiency. **(08 Marks)**

OR

4 a. Starting from fundamentals show that the polytropic efficiency for expansion in a turbomachine is given by, $\eta_P = \left(\frac{n-1}{n}\right)\left(\frac{\gamma}{\gamma-1}\right)$. **(08 Marks)**

b. The pressure ratio across a gas turbine is 2.2 and efficiency is 88%. The temperature of gas at inlet is 1500 K. Determine polytropic efficiency. **(08 Marks)**

Module-3

5 a. With a schematic diagram, explain the working of a centrifugal compressor. Clearly show the variation of pressure in the inlet casing, impeller and diffuser. **(06 Marks)**

b. Define power input factor and relate it to Euler's work and slip factor. **(06 Marks)**

c. Explain the phenomenon of surging with the help of a P-Q or H-Q diagram. **(04 Marks)**

OR

6 a. Draw velocity triangles for an axial compressor stage clearly showing upstream guide vanes and diffuser blades section. Further, derive an expression for work input to compressor in terms of blade angles. **(08 Marks)**

b. An axial flow compressor of 50% reaction design has blades with inlet and outlet angles of 45° and 10° respectively. The compressor is to produce a pressure ratio of 5 : 1 with an overall isentropic efficiency of 0.83, when the inlet static temperature is 36°C. The blade speed and axial velocity are constant throughout the compressor. Find the number of stages required if workdone factor is (i) unity (ii) 0.87 for all stages. Take blade speed as 200 m/s, C_P for air as 1005 J/kg.K. **(08 Marks)**

Module-4

7 a. Define degree of reaction (R) and utilization factor $(\in)$. For an axial flow turbine show that the utilization factor is given by,

$$\in = \frac{v_1^2 - v_2^2}{v_1^2 - Rv_2^2}$$ **(08 Marks)**

b. A fluid flows through one stage of a turbomachine. The velocity diagram is shown in figure.

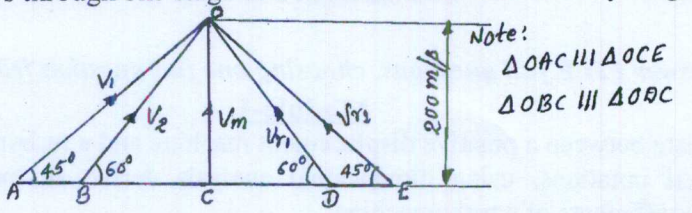

Fig. Q7 (b)

(i) Is this a power absorbing or power generating turbomachine?
(ii) What is the change in total enthalpy of fluid across the stage?
(iii) Value of degree of reaction and
(iv) Utilization factor. **(08 Marks)**

OR

8 a. Sketch and explain the working of a 90° inward radial flow turbine (IFR). **(06 Marks)**

b. Define the following terms and write the expression for the same:
(i) Nozzle loss coefficient. (ii) Rotor loss coefficient. **(04 Marks)**

c. A single stage 90° IFR fitted with an exhaust diffuser has the following data:
Overall stage pressure ratio = 4 ; Temperature at entry =557 K;
Diffuser exit pressure = 1 bar; Mass flow rate = 6.5 kg/s;
Flow coefficient = 0.3 ; Speed = 18000 rpm; Rotor tip dia = 42 cm;
Enthalpy losses in nozzle and rest of the stages are equal. Assuming negligible velocities at the nozzle entry and diffuser exit, find (i) the nozzle exit air angle (ii) power developed. **(06 Marks)**

Module-5

9 a. Define with reference to a centrifugal pump the following:
(i) Net positive suction head (ii) Manometric head
(ii) Manometric efficiency (iv) Volumetric efficiency. **(08 Marks)**

b. Calculate the blade angle at outlet, the power required and overall efficiency of a centrifugal pump having 700 mm impeller diameter, delivering 1.5 m^3/s against a head of 80 m. The impeller runs at 1000 rpm and the width at outlet is 7 cm. The leakage loss is 3% of the discharge, external mechanical loss is 10 kW and the hydraulic efficiency is 80%. **(08 Marks)**

OR

10 a. Show that the hydraulic efficiency of Pelton wheel is maximum when peripheral wheel velocity is half the absolute velocity of jet at inlet. Further deduce that $\eta_{b\,max} = \left(\frac{1+K\cos\beta_2}{2}\right)$, where K is friction coefficient and β_2 is outlet blade angle. **(08 Marks)**

b. What do you mean by a draft tube? Explain its function. **(03 Marks)**

c. The linear blade velocity at the inlet of an inward flow Francis turbine is 40 m/s. The hydraulic efficiency is 85%. Net head is 120 m. Discharge is radial at outlet. Calculate the velocity of whirl at inlet. **(05 Marks)**

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