CBCS SCHEME

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15AE46

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

Time: 3 hrs. Max. Marks: 80

Note: ***Answer any 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 co-efficients of a turbomachines. **(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. Combustion product approaches an axial flow turbine rotor with an absolute velocity of 550 m/s and at a direction of 18° from the wheel tangent. The mass flow rate is 60 kg/s. If the absolute velocity at the rotor exit is axially directed, find the power output and degree of reaction when the blade speed is 300 m/s. Assume axial velocity is constant throughout. **(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 of 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 turbo machine 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 work done factor is (i) Unity (ii) 0.87 for all stages.
Take blade speed as 200 m/s, C_P for air as 1005 J/kgK. **(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,

$$E = \frac{V_1^2 - V_2^2}{V_1^2 - RV_2^2}$$ **(08 Marks)**

b. In an axial flow impulse turbine, the gas enters at 5.2 bar and leaves at 1.03 bar. The turbine inlet temperature is 1000 K and isentropic efficiency of the turbine is 0.88. If mass flow of gas is 28 kg/s nozzle. Angle at outlet is 33° with the wheel tangent absolute velocity of gas at inlet of the nozzle is 140 m/s, determine the gas velocity at nozzle exit, whirl velocity at rotor inlet and turbine work output. Take $\gamma = 1.33$ and $C_{pg} = 1.147$ KJ/kg-K. **(08 Marks)**

OR

8 a. Sketch and explain the working of a 90° inward radial flow turbine (IFR). **(08 Marks)**

b. 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 co-efficient = 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. **(08 Marks)**

Module-5

9 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 $\eta_{t\,max} = \left(\frac{1 + K\cos\beta_2}{2}\right)$, where K is friction co-efficient and β_2 is outlet blade angle. **(08 Marks)**

b. What do you mean by 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)**

OR

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

b. A centrifugal pump has its impeller diameter 30 cm and a constant area of flow 210 cm^2. The pump runs a 1440 rpm and delivers 90 liters per second against a head of 25 m. If there is no whirl velocity at entry. Compute (i) The rise in pressure across the impeller and hydraulic efficiency of pump. The vanes at exit are bent back at 22° with reference to tangential speed. **(08 Marks)**

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