CBCS SCHEME

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15AE46

Fourth Semester B.E. Degree Examination, Dec.2023/Jan.2024
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 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. With the help of h – s diagram, define the following with refer to compressor :
Static – to – static efficiency
Static – to – total efficiency
Total – to –total efficiency. **(04 Marks)**

b. Derive an expression for polytrophic efficiency of a compression process. **(06 Marks)**

c. A nine stage centrifugal compressor has an overall pressure ratio of 2.82. Air enters the compressor at a pressure of 1 bar and 17°C. The stage efficiency is 90%. Determine :
i) pre – heat factor ii) polytrophic efficiency iii) overall efficiency. **(06 Marks)**

OR

4 a. Obtain an expression for the overall isentropic efficiency in terms of stage efficiency, pressure ratio per stage, number of stages and adiabatic index (γ) for a turbine. **(08 Marks)**

b. The overall pressure ratio across a three stages gas turbine is 11 and its efficiency is 88%. If the pressure ratio of each stage is same and the inlet temperature is 1500K. determine :
i) pressure ratio in each stage ii) polytropic efficiency iii) stage efficiency iv) reheat factor v) exit temperature vi) total power output for a mass flow rate of 50 kg/s. **(08 Marks)**

Module-3

5 a. Define: i) Power input factor ii) Slip factor with reference to a centrifugal compressor. Derive an equation for Euler work in terms of power input factor and slip factor, assuming a radial vaned impeller for no slip. **(08 Marks)**

b. A centrifugal compressor has to deliver 30kg of air per second, the impeller is 70cm diameter revolving at 11000rpm with an adiabatic efficiency of 80%. If the pressure ratio is 4.2:1, calculate the probable axial width of the impeller at the impeller tip, if the radial velocity is 120m/s. The inlet conditions are 1 bar and 47°C. **(08 Marks)**

OR

6 a. With the help of a schematic diagram explain the working of an axial flow compressor. **(06 Marks)**

b. An 8-stage axial flow compressor provides an overall pressure ratio of 6:1 with an overall isentropic efficiency of 89%, when the temperature of air at inlet is 19°C. The work is divided equally between stages. A 50% reaction is used with a mean blade speed of 190m/s and a constant axial velocity of 100m/s through the compressor. Assuming a work done factor of unity, estimate the power required and the blade angles. **(10 Marks)**

Module-4

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

$$\epsilon = \frac{v_1^2 - v_2^2}{v_1^2 - Rv_2^2}$$

(08 Marks)

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

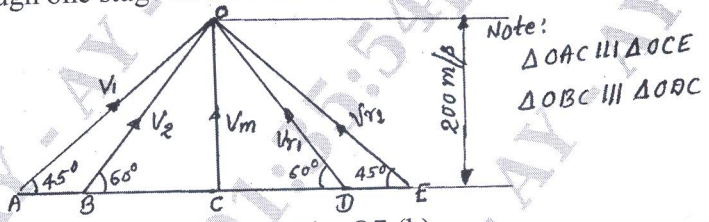

Fig. Q7 (b)

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. Derive an expression for minimum starting speed of a centrifugal pump. **(05 Marks)**

b. With neat sketch explain working of centrifugal pumps when connected in : i) series ii) parallel. **(05 Marks)**

c. A centrifugal pump has its impeller diameter 30cm and a constant area of flow 210cm^2. The pump runs a 1440 rpm and delivers 90 liters per second against a head of 25m 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. **(06 Marks)**

OR

10 a. A pelton wheel has a tangential velocity of buckets 15 m/s. The water is being supplied under a head of 36m at the rate of 0.02m^3/s. The bucket deflects the jet through an angle of 160°. If the nozzle coefficient is 0.98, find the power developed by the wheel. **(06 Marks)**

b. What are the functions of a draft tube? Sketch the different types of draft tubes. **(04 Marks)**

c. A Kaplan turbine working under a head of 15m develops a power of 7350KW. The outer diameter of the runner is 4m and hub diameter = 2m. The guide blade angle at the extreme edge of the runner is 30°. The hydraulic and overall efficiency of the turbine are 90% and 85% respectively. if the whirl velocity is zero at outlet, determine : i) runner angle at a inlet and outlet at the extreem edge of the runner ii) speed of the turbine iii) specific speed of the turbine. **(06 Marks)**

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