CBCS SCHEME

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18AE46

Fourth Semester B.E. Degree Examination, Jan./Feb. 2023
Turbomachines

Time: 3 hrs. Max. Marks: 100

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

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Apply dimensional analysis to fluid flow and state significance of each π term obtained consider the following variables discharge (Q), speed (N), size (D), energy per unit mass flow (gH), power (P), density (ρ) and dynamic viscosity of fluid (μ). **(10 Marks)**

b. A quarter scale turbine model is tested under a head of 30 m. The full-scale turbine is required to work under a head of 130 m and to run at 450 rpm. Calculate:
   (i) The speed of the model if it produces 130 KW when the discharge is 0.6 m^3/sec and
   (ii) The power produced by the prototype if its efficiency is 6% more than that of the model. **(10 Marks)**

OR

2 a. Obtain Euler's turbine equation in its fundamental form, with a neat sketch, for power absorbing and developing machine. **(10 Marks)**

b. For symmetrical velocity triangle, inlet and outlet angles are 45° and 60° with flow velocity 200 m/s, of a fluid flowing through one stage of a turbomachine:
   (i) Check for power developing or power absorbing
   (ii) Calculate total enthalpy of fluid
   (iii) Calculate degree of reaction
   (iv) Calculate utilization factor **(10 Marks)**

Module-2

3 a. Obtain polytropic efficiency for an infinitensional compressor stage and show that $\eta_p = \left(\frac{\gamma-1}{\gamma}\right)\left(\frac{n}{n-1}\right)$. **(10 Marks)**

b. The total pressure, static pressure and the total temperature of Helium at a certain point in a flow are 10 bar, 5 bar and 400 K respectively. Assuming Helium as a perfect with γ 5/3, evaluate the mach number and velocity of the Helium. **(10 Marks)**

OR

4 a. Show that, for expansion process the overall isentropic turbine efficiency is greater than the stage efficiency. **(10 Marks)**

b. Air flows through an air turbine where its stagnation pressure is decreased in the ratio 5:1. The total-to-total efficiency is 0.8 and the air flow rate is 5 kg/s. The inlet total temperature is 280 K. Calculate:
   (i) The actual power output
   (ii) The actual exit total temperature
   (iii) The actual exit static temperature if the exit flow velocity is 100 m/s
   (iv) The total to static efficiency of the device. **(10 Marks)**

Module-3

5 a. Discuss :

(i) The variations of pressure and velocity in a centrifugal compressor.

(ii) Principle of operation with h-s diagram for a centrifugal compressor. **(10 Marks)**

b. A centrifugal compressor rotor has inlet radius of 30 cm and exit radius of 60 cm. Entry is radial with a component of 60 m/s which is constant throughout. The compressor requires 700 KW of power to handle 20 kg of air per second. Find the blade angles at inlet and outlet if the compressor runs at 5100 rpm. Calculate the width at inlet and outlet, if specific volumes at inlet and outlet are respectively 0.85 m^3/kg and 0.71 m^3/kg. What is degree of reaction? **(10 Marks)**

OR

6 a. Apply Aerofoil theory to axial flow turbomachines and discuss nomenclature of cascade. **(10 Marks)**

b. A single stage axial flow machine with no inlet guide vanes, but a row of stationary vanes after, the rotor runs at 3600 rpm. The rotor hub and tip diameter are 20 cm and 12.5 cm. Mass flow rate of air is 0.5 kg/s. The turning angle of the rotor is 20° towards the axial direction during the air flow over the blade. If the atmospheric temperature and pressure are 25°C and 1 atm, for a constant axial velocity through a machine find:

(i) Total pressure rise of the air if $\eta_{tt} = 0.9$

(ii) Power required

(iii) Degree of reaction **(10 Marks)**

Module-4

7 a. With variation of pressure and velocity through a two stage impulse turbine:

(i) Discuss multi-stage velocity compounded impulse

(ii) Discuss multi-stage pressure compounded impulse **(10 Marks)**

b. Show that $\in_{max}$ of an axial flow turbine with degree of reaction $\frac{1}{4}$, the relationship of blades speed 'U' to absolute velocity at rotor inlet V_1 should be $\frac{U}{V_1} = \frac{2}{3}\cos\alpha_1$, α_1 is nozzle angle at inlet. Assume flow velocity as constant. **(10 Marks)**

OR

8 a. Discuss the following for radial turbine stage:

(i) Spouting velocity (ii) Stage efficiency **(10 Marks)**

b. An IFR turbine impulse stage with cantilever blades has a flow coefficient of 0.4 and develops 100 KW with total-to-total efficiency of 90% at 12000 rpm. If the flow rate of air is 10 kg/s at an entry temperature of 400°K, determine the rotor diameters and air angles at the entry and exit, the nozzle exit air angle and the stagnation pressure ratio across the stage, take $d_3 = 0.8\, d_2$, zero exit swirl and constant Meridional velocity. **(10 Marks)**

Module-5

9 a. Discuss the terminology of centrifugal pump. **(05 Marks)**

b. Obtain the expression for minimum starting speed fir centrifugal pump. **(05 Marks)**

c. A centrifugal pump ha its impeller diameter 30 cm and constant area of flow 210 cm^2. The pump runs at 1440 rpm and delivers 90 LPS against a head of 25 m. If there is no whirl velocity at entry, compute the rise in pressure head across the impeller and hydraulic efficiency of pump. The vanes at exit are bent back at 22° with respect to tangential speed. **(10 Marks)**

OR

10 a. Discuss the following:

(i) Classification of hydraulic turbines

(ii) Head and efficiency of hydraulic turbine **(10 Marks)**

b. Pelton wheel has to designed for the following data:
Power to be developed = 5880 KW, net head available = 300 m, speed = 550 rpm, ratio of jet diameter to wheel diameter = 1/10 and overall efficiency = 85%. Find the number of jets, diameter of jet, diameter of the wheel and the quantity of water required. Take $C_v = 0.98$, $\phi = 0.46$. **(10 Marks)**

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