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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: V**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 20ME5DCTUM / 16ME6DCTUM **Max Marks: 100**
Course: Turbo Machines **Date: 16.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may suitably be assumed.
3. Use of steam tables is permitted.

UNIT - I

1 a) Define Turbomachine from the energy transfer perspective? How do you identify a Turbomachine. **04**

b) Discuss hydraulic efficiency, mechanical efficiency, volumetric efficiency, and total efficiency of a power-producing and a power-absorbing turbomachine from the viewpoint of the second law of thermodynamics. **08**

c) A radial flow hydraulic turbine is required to be designed to produce 20 MW under a head of 16 m at a speed of 90 rpm. A geometrically similar model with an output of 30 kW and a head of 4 m is to be tested under dynamically similar conditions. At what speed must the model be run? What is the required impeller diameter ratio between the model and the prototype and what is the volume flow rate through the model, if its efficiency can be assumed to be 90%? **08**

UNIT - II

2 a) With the help of velocity triangles, demonstrate that the work done expression for a centrifugal compressor with a radial inlet and exit using a backward curved vane is given by **06**

$$W = u_2^2 - (u_2 Q \cot \beta_2 / A_2)$$

where u_2 is the blade velocity at exit, Q is the discharge, β_2 is the exit blade angle and A_2 is the exit area.

b) Air at a temperature of 27°C flows into a centrifugal compressor at 20000 rpm. The following data are given: Slip factor = 0.8, Power input factor = 1, Isentropic efficiency = 80%, Outer diameter = 0.5 m. Assuming the absolute velocities of air entering and leaving the compressor are same, find Static temperature rise of air passing through the compressor, and Static pressure ratio. Take C_p of air as 1.005 kJ/kg-K. **06**

c) A centrifugal compressor runs at 14900 rpm and produces a stagnation pressure of 4 between the impeller inlet and outlet. The air stagnation conditions at the compressor intake are 1 bar and 300 K respectively. The **08**

absolute velocity at the inlet is axial and the blades are radial at the exit with the exit relative velocity equal to 140 m/s and the total to total efficiency of the compressor is 80%. Draw the velocity triangles and compute the slip and slip coefficient, if the outer diameter of the compressor is 0.6 m.

OR

3	a)	Discuss the challenges an Engineer would face, when an axial flow compressor is to be replaced by any other type of compressor at a given application point, to get the same discharge and pressure ratio.	**04**
	b)	Obtain the equation for the stagnation pressure ratio considering the work done factor for an axial flow compressor.	**08**
	c)	Air enters a three-stage axial flow compressor at 1 bar and 300K. The energy input is 25 kJ/kg per each stage. The stage efficiency is 0.86. Show the process on the T-S diagram. Calculate the exit static temperature, compressor efficiency and the static pressure ratio.	**08**

UNIT - III

4	a)	Define the different pressure heads related to centrifugal pumps using a line diagram.	**06**
	b)	At the inlet and output of a centrifugal pump, the impeller has diameters of 300 mm and 600 mm respectively. If the working head of the pump is in between 30 and 50 meters to lift the water. If the pump runs at 800 rpm can it deliver the water for both the cases, comment on it.	**06**
	c)	The impeller of a centrifugal pump is 0.5m in diameter at exit and rotates at 1200 rpm. The blades of the pump are backward curved at an angle of 30^o to the tangent at outlet tip. If the measured velocity of flow at the outlet is 5 m/s. Calculate the work input per kg of water per sec. Find the theoretical maximum lift to which the water can be raised, if the pump is provided with a whirlpool chamber which reduces the velocity of the water by 50%.	**08**

UNIT - IV

5	a)	Explain how pressure compounding works in steam turbines using the pressure-velocity diagram.	**04**
	b)	Derive the expression for maximum work done and efficiency of a single stage impulse steam turbine.	**08**
	c)	A single-stage impulse steam turbine has a diameter of 1.5 m and running at 3000 rpm. The nozzle angle is 20^o, speed ratio is 0.45, ratio of relative velocity at the outlet to inlet is 0.9. The outlet angle of the blade is 3^o less than inlet angle and steam flow rate is 6 kg/s. Draw the velocity diagram and find the Velocity of whirl, Axial thrust, Blade angles and the Power developed.	**08**

UNIT - V

6	a)	Define the Hydraulic turbine and classify them.	**04**

b) Draw necessity velocity triangles and derive an expression for maximum work done for a Pelton wheel. Show that for maximum work done condition, the peripheral bucket velocity is half the absolute fluid velocity at the inlet.V **08**

c) A Pelton wheel works at the foot of a dam because of which the head available at the nozzle is 400 m, the nozzle diameter is 160 mm, the coefficient of velocity is 0.98, the diameter of the bucket wheel is 1.75 m and the buckets deflect the jet by 150^{o}. The wheel to jet speed ratio is 0.46. Neglecting the friction, calculate: **08**

(i) Power developed by the turbine.
(ii) Speed of the turbine.
(iii) Hydraulic efficiency.

OR

7 a) What is a draft tube and discuss its purpose. With the help of sketches explain the conical and elbow draft tubes. **05**

b) Get an expression for the pressure head at a conical draft tube's entry in terms of draft tube efficiency by using Bernoulli's principle. **06**

c) The following data refers to an elbow type draft tube: Area of the circular inlet is 25 m^2, Area of the rectangular outlet is 116 m^2, Velocity of the water at the inlet to draft tube is 10 m/s. The frictional head loss in the draft tube is equal to 10% of the inlet velocity head. Elevation of inlet plane above tail race level is 0.6 m. Determine **08**

(i) Vacuum or Negative head at the inlet, and
(ii) Power thrown away in to the rail race.

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