CBCS SCHEME

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17AE46

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

Time: 3 hrs. Max. Marks: 100

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

Module-1

1 a. Distinguish between a turbomachine and a positive displacement machine. **(06 Marks)**

b. What is a Turbomachine? With a neat sketch, explain the principal components of turbomachine. **(06 Marks)**

c. From the performance curve of a turbine, it is seen that a turbine of 1m diameter acting under a head of 1m develops a speed of 25RPM. Determine the diameter of the prototype, if it develops 10,000kW, working under a head of 200m with a specific speed of 150RPM. **(08 Marks)**

OR

2 a. Derive the basic Euler energy equation for a turbomachine. **(10 Marks)**

b. A model of Francis turbine of 1:5 scale ratio is tested under a head 1.5m. It develops 3kW at 360RPM. Determine the speed and power developed under a head of 6m. **(05 Marks)**

c. An output of 10kW was recorded on a turbine, 0.5m diameter, revolving at a speed of 800RPM, under a head of 20m. Determine the diameter and output of another turbine which works under a head of 180m at a speed of 200RPM, when their efficiencies are same. **(05 Marks)**

Module-2

3 a. What is polytropic efficiency in the compression process? Formulate the corresponding equation. **(08 Marks)**

b. An air compressor has the following data: Inlet pressure = 1.02 bar, Exit pressure = 1.5 bar, Inlet temperature = 300K, Exit temperature = 340K. Determine: i) The isentropic compression efficiency ii) Polytropic efficiency. **(06 Marks)**

c. An air compressor has six stages of equal pressure ratio of 1.4. The overall isentropic compression efficiency is 84%. Entry pressure is 1 bar and $T_1 = 40°C$. Determine the state of air at the exit [r = 1.4, R = 0.287kJ/kg.K, c_p = 1.005kJ/kg.K]. **(06 Marks)**

OR

4 a. With reference to a compression process, explain stage efficiency, represent the same on separate T-S or h-s diagram. **(06 Marks)**

b. A jet of gas has the following data. Temperature = 593K, r = 1.3, R = 469J/kg.K, Mach Number = 1.2. Determine for static and stagnation conditions i) Velocity of sound, ii) Enthalpy. **(08 Marks)**

c. Define reheat factor and explain the same. **(06 Marks)**

Module-3

5 a. Explain the phenomenon of surging and choking in a compressor. **(08 Marks)**

b. What is a diffuser? Explain with a neat sketch. **(06 Marks)**

c. Free air delivered by a compressor is 20kg/min. The inlet conditions are 1bar and 20°C, static. The velocity of air at the inlet is 60m/s. The isentropic efficiency of the compressor is 0.7. The total head pressure ratio is 3. Determine the total head temperature at the exit. **(06 Marks)**

OR

6 a. A two stage centrifugal compressor delivers 500m^3 of free air per min. The suction conditions are 1 bar and 15°C. The compression ratio and isentropic efficiency of each stage are 1.25 and 80% respectively. Determine the isentropic efficiency for the entire compression process. **(10 Marks)**

b. Air at a temperature of 290K, flows in a centrifugal compressor running at 20,000rpm, slip factor = 0.8, $\eta_{t\text{-}t}$ = 0.8, d_2 = 0.6m. Assume that the absolute velocity at the inlet and outlet are same. Determine the temperature rise of air passing through the compressor. **(10 Marks)**

Module-4

7 a. Mention different types of losses in a radial flow turbine and define nozzle loss coefficient. **(10 Marks)**

b. The output of a 3 stage gas turbine is 30MW at the shaft coupling at an entry temperature of 1500K. The overall pressure ratio across the turbine is 11 and efficiency 88%. If the pressure ratio of each stage is same, determine, i) Pressure ratio of each stage, ii) Polytropic efficiency. Assume γ = 1.4, c_p = 1.005kJ/kg.K. Assume an efficiency of 91% to take into account shaft losses due to disc and bearing friction. **(10 Marks)**

OR

8 a. With reference to flow passage, write a brief description of subsonic, transonic and supersonic turbines. **(10 Marks)**

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

Module-5

9 a. Explain the working of Kaplan Turbine with neat sketch. **(10 Marks)**

b. An axial flow pump is required to discharge 1.25m^3/s of water while running at 500RPM, the total head is 3.9m. If the speed ratio is 2.3, flow ratio = 0.51, hydraulic efficiency = 0.87 and the overall pump efficiency is 0.82, determine:

i) Power delivered to the water and the power input

ii) The impeller hub diameter and tip diameter. **(10 Marks)**

OR

10 a. Draw the inlet and exit velocity triangles for a Pelton wheel turbine. Formulate an expression for the maximum hydraulic efficiency. **(10 Marks)**

b. A Pelton wheel has a water supply rate of 5m^3/s at a head of 256m and runs at 500RPM. Assuming a turbine efficiency of 0.85, a coefficient of velocity for nozzle as 0.985, nozzle speed ratio of 0.46, determine:

i) Power output

ii) Specific speed

iii) Number of jets

iv) Diameter of the wheel

v) Jet diameter. **(10 Marks)**

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