CBCS Scheme

USN | | | | | | | | | | | 15AE46

Fourth Semester B.E. Degree Examination, Dec.2017/Jan. 2018
Turbo-Machines

Time: 3 hrs. Max. Marks: 80

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

Module-1

1 a. Compare the turbo-machines with positive displacement machines. **(06 Marks)**

b. Define specific speed of a turbine and derive an expression for it. **(06 Marks)**

c. From a performance curves of turbines, it is seen that a turbine of one meter diameter acting under a head of one meter develops a speed of 25 rpm. What diameter should be the prototype have if it develop 10000 KW working under a head of 200m with a specific speed of 150. **(04 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 products approaches an axial flow turbine rotor with an absolute velocity of 550m/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 300m/s. Assume axial velocity is constant throughout. **(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. Prove that the pressure coefficient is given by $\phi_P = \eta_C \Psi \mu$.
Where η_C = isentropic efficiency of compressor, Ψ = power input or work done factor, μ = slip coefficient. **(04 Marks)**

b. With appropriate sketches, explain the following :
i) surging ii) choking iii) pre-rotation with refer to centrifugal blower. **(04 Marks)**

c. A centrifugal compressor rotor has inlet radius of 30cm and exit radius of 60cm. Entry is radial with a component of 60m/s which is constant throughout. The compressor requires 700KW of power to handle 20kg of air per second. Find the blade angles at inlet and exit if the compressor runs at 5100 rpm. Calculate the width of blades at inlet and outlet if specific volumes at inlet and outlet are $0.85m^3/kg$ and $0.71m^3/kg$ respectively. What is the degree of a reaction? **(08 Marks)**

OR

6 a. Draw a h-s diagram for a single stage axial flow compressor showing clearly the pressure rise in rotor and diffuser. Hence derive an expression for overall pressure ratio in terms of isentropic efficiency, actual temperature change and adiabatic index. **(04 Marks)**

b. Show that the degree of reaction (R) for an axial flow compressor is given by :

$$R = \frac{V_f}{u}\left[\frac{\tan\gamma_1 + \tan\gamma_2}{2}\right]$$

Where V_f = flow velocity, u = tangential speed of the rotor, γ_1 and γ_2 are air angles of the blades at inlet and outlet respectively. **(04 Marks)**

c. An axial flow compressor of 50% reaction design has blades with inlet and outlet angles with respect to axial direction of 45° and 10° respectively. The compressor is to produce a pressure ratio of 6 with an overall isentropic of 0.85 when inlet static temperature is 37°C. The axial velocity of flow is constant throughout. If the blade speed is 200m/s find the number of stages required if the work done factor is : i) unity ii) 0.87 for all stages. **(08 Marks)**

Module-4

7 a. Sketch the T – S diagram for an axial flow gas turbine for a complete stage consisting of a nozzle and a rotor. Also write down the expression for :i) total – to – static nozzle efficiency ii) static – to – static rotor efficiency iii) total – to – total stage efficiency. **(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 1000K 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 and 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. A small inward radial flow gas turbine operates at its design point with total - to – total efficiency of 0.9. The stagnation pressure and temperature of the gas at nozzle inlet is 310 PKa and 1145K respectively. The flow leaving the turbine is diffused to a pressure of 100 KPa and velocity of flow is negligible. Find the impeller tip speed, WD from stage and flow angle at the nozzle exit. Assume that the gas enter the impeller radially flow velocity of 100 m/s and there is no whirl velocity at the impeller exit. Take $\gamma = 1.33$ and $C_P = 1.147$ KJ/kg – K. **(10 Marks)**

b. Explain briefly : i) spouting velocity ii) turbine efficiency iii) specific speed for 90° inward flow radial gas turbine. **(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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