Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V • EXAMINATION – WINTER • 2014

Subject Code: 150102 Date: 28-11-2014

Subject Name: Fundamentals of Turbo machines

Time: 10.30 am - 01.00 pm Total Marks: 70

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Air at the rate of 2Kg/s enters the impeller of a centrifugal compressor in axial direction. The stagnation temperature and stagnation pressure at inlet are 300K and 1bar. The rotor has 20 radial vanes and rotates at 15000rpm. The stagnation pressure ratio between diffuser outlet and impeller inlet is 4.2 and the overall efficiency is 83%. Mechanical efficiency is 96%, density at impeller outlet is $2Kg/m^3$, calculate power required to drive the compressor and the impeller tip radius. Width at impeller exit is 12mm. determine absolute Mach number at that point. Slip factor is 0.88. **09**

(b) Classify the turbomachines and list the differences between axial and radial turbomachines. **05**

Q.2 **(a)** Draw the velocity triangles for forward swept blades, radial swept blades and backward swept blades for the centrifugal compressor impeller. **07**

(b) The first stage of an axial flow compressor is designed on free vortex principle, with no inlet guide vanes. The rotational speed is 6000rpm and stagnation temperature rise is 20K. The hub tip ratio is 0.6, the work done factor is 0.93 and isentropic efficiency of the stage is 0.89. Assuming an inlet velocity of 140m/s and ambient stagnation conditions of 1 bar and 288K, relative Mach number at tip is limited to 0.95, compute: tip radius and corresponding rotor air angles, if the relative, mass flow entering the stage, stage stagnation pressure ratio and power required. Blade height is 6mm. **07**

OR

(b) Draw the complete h-s diagram for an axial compressor stage. **07**

Q.3 **(a)** Write a short note on surging and choking for turbomachines. **07**

(b) What is slip factor? What is its effect on flow and pressure ratio in the stage? Derive the Stodola's relation for slip factor **07**

OR

Q.3 **(a)** Define degree of reaction and derive the expressions for maximum utilization factor for the 50% reaction stage. **07**

(b) Draw and explain the h-s diagram for the complete axial turbine stage. **07**

Q.4 **(a)** Following data refers to mean section of free vortex axial turbine stage hub diameter 460mm, tip diameter 780mm, rotational speed 6000rpm, absolute velocity at rotor entry is 267 m/s, air angles at rotor entry and exit 75° and 45° respectively, axial velocity is constant and is 70m/s, calculate followings for the hub section. **07**

1. Air angles and blade angles,
2. Degree of reaction,
3. Flow coefficient,
4. Loading coefficient and
5. Work done by the turbine

(b) Explain the performance charts for an axial turbine stage. **07**

OR

Q.4 **(a)** List and explain the step wise procedure for to match compressor and turbines for the jet engine. **07**

(b) Explain the procedure to draw equilibrium running diagram for turbomachines. **07**

Q.5 **(a)** The flow of air at 20m/s enters to the nozzle with pressure 6bar and temperature 900K. The mass flow rate of air is 10Kg/s, find inlet Mach number, the stagnation and static pressure and temperature at nozzle exit if mach number at the exit is limited to 0.7. Calculate the area ratio and density ratio for such nozzle. **07**

(b) Draw and explain velocity triangle for two stage velocity compounded impulse turbine stage with maximum utilization factor. **07**

OR

Q.5 **(a)** Draw the entry and exit velocity triangles for a general inward flow radial turbine stage and for the ninety degree IFR turbine stage. **07**

(b) Define the followings: **07**

1. Utilization factor
2. Slip factor
3. Work done factor
4. Flow coefficient
5. Work loading coefficient
6. Total to total efficiency
7. Total to static efficiency

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