Seat No.: _____ **Enrolment No._____**

GUJARAT TECHNOLOGICAL UNIVERSITY

B.E SEM-V Examination-Nov/Dec.-2011

Subject code: 150102 **Date: 24/11/2011**

Subject Name: Fundamentals of Turbo-machines

Time: 02.30 pm-05.00 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)** Derive Euler's equation for turbo machine in the form of **07**

$$W = \frac{1}{2}\left(v_1^2 - v_2^2\right) + \frac{1}{2}\left(u_1^2 - u_2^2\right) + \frac{1}{2}\left(w_2^2 - w_1^2\right)$$

(b) Draw h-s diagram for (1) Centrifugal Compressor, (2) Axial Turbine **07**

Q.2 **(a)** Differentiate turbo-machines and positive displacement machines **07**

(b) What is equilibrium running of any gas turbine plant? Which are the conditions for equilibrium? Write procedure to find equilibrium points. **07**

OR

(b) 1) How performance of axial compressor is evaluated? (4 marks) **07**

2) Which are the basic assumption made for matching trends of components for single spool turbojet engine (3 marks)

Q.3 **(a)** What is degree of reaction? Obtain relations between different velocities and angles in 50% degree of reaction stages of an axial turbine. Also draw h-s diagram and velocity triangles for the same. **07**

(b) Air at 1 bar and 288˚K enters in an axial flow compressor stage rotating on 6000rpm with an axial velocity of 150m/s. There are no guide vanes in the compressor stage. The air enters the stage in an axial direction. Air is turned 30˚ when it passes through rotor. Hub and tip diameter are 50cm and 60cm respectively. Obtain **07**

1) construct velocity diagram for the stage at mean diameter
2) mass flow rate
3) power required
4) Degree of reaction.

OR

Q.3 **(a)** Write a short note on supersonic and transonic compressor stages. **07**

(b) An axial turbine rotating with the speed 6000RPM and having tip and hub diameter 750mm and 450mm respectively. Air angle at nozzle exit is 75º and relative angles at rotor entry and exit are 45 º and 76 º respectively. **07**

Draw velocity triangles for mean flow and determine

a) degree of reaction
b) blade to gas speed ratio
c) specific work

Q.4 **(a)** Derive expressions for spouting velocity and stage efficiencies for radial turbine. **07**

(b) A centrifugal compressor compresses 30kg of air per second as a rotational speed of 15000rpm. The air enters the compressor axially, and the condition at the exit section are radius 0.3m,relative velocity of air at tip 100m/s at an angle of 80° with respect to plane of rotation. Take p_0=1bar and T_0=300K **07**

Find the torque and power required to drive the compressor and also the ideal head developed.

OR

Q.4 **(a)** Explain: *Elements of Centrifugal compressor stage*. **07**

(b) A ninety degree IFR turbine stage has the following data. **07**

Total to static pressure ratio: 3.5,
Exit pressure: 1bar
Stagnation temperature at entry:650°C
Blade to gas sped ratio σ=0.66
Rotor diameter ratio: 0.45
Rotor speed :16000rpm
Nozzle exit angle: 20°
Calculate:

1) Rotor diameter
2) Rotor blade exit air angle
3) The mass-flow rate

Q.5 **(a)** Draw velocity triangles at entry and exit for 2-stage Pressure compounded impulse turbine, also explain variation in pressure and velocity while flow passing through the stages. **07**

(b) The conditions of air at the entry of an axial compressor stage are p_1=768mm Hg and T_1=314K. Air angles are **07**

$$\beta_1 = 51°, \beta_2 = 90°, \alpha_1 = \alpha_2 = 7°$$

The mean diameter and peripheral speed are 50cm and 100m/s, respectively. Mass flow rate through the stage is 25kg/s; the work done factor is 0.95 and mechanical efficiency 92%. Assuming a stage efficiency of 88% determine

a) air angle at the stator entry
b) blade height and hub tip diameter ratio
c) stage pressure ratio
d) Power required to drive the stage.

OR

Q.5 **(a)** Explain the phenomenon of *slip* in centrifugal compressor. What is slip factor? How it affects the actual work done and efficiencies of the centrifugal compressor. **07**

(b) At a designed speed, gas turbine is applied compressor having pressure ratio of 6:1. Effectiveness of the compressor is 0.87. Turbine inlet temperature is 950K. Combustion chamber pressure loss is 0.1kg/cm^2. Temperature and pressure at inlet are 300K & 1bar. Calorific value of fuel is 43kJ/kg. Calculate compressor work, turbine work and net work for the given gas turbine. **07**

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