Seat No.: ________ Enrolment No.___________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–V(New) • EXAMINATION – WINTER 2016

Subject Code:2150102 Date:17/11/2016

Subject Name:Fundamentals of Turbo Machines

Time:10:30 AM to 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.**

			MARKS
Q.1		**Short Questions**	**14**
	1	What is degree of reaction for the rotating machine?	
	2	What is isentropic efficiency of the turbine?	
	3	What is turbomachines?	
	4	Does energy transfer is positive or negative? In case of turbine	
	5	Explain the terms stagnation pressure and stagnation temperature.	
	6	What is Euler's energy equation?	
	7	What is continuity equation in differential form?	
	8	What is choking?	
	9	What is flow coefficient?	
	10	What is loading coefficient?	
	11	Define need of multistaging in turbomachines.	
	12	What is energy transfer and energy transformation?	
	13	Which process is take place for combustion in a gas turbine?	
	14	What is Mach number?	
Q.2	**(a)**	Show the entry and exit velocity triangles for a general inward –flow radial turbine(IFR) stage. Redraw them for a ninety degree IFR turbine stage.	**03**
	(b)	Derive degree of reaction formula for radial turbine stage.	**04**
	(c)	Describe briefly the various losses occurring in an inward flow radial turbine stage.	**07**
		OR	
	(c)	Draw the entry and exit velocity triangles for a general stage and a stage with maximum energy transfer.	**07**
Q.3	**(a)**	What is the use of inlet guide vanes? Explain with proper sketch.	**03**
	(b)	What is the principle of operation of centrifugal compressor?	**04**
	(c)	A centrifugal compressor runs at 10000 rpm and delivers 600 m^3/min of free air at a pressure ratio of 4:1. The isentropic efficiency of compressor is 82%. The outer radius of impeller (which has radial blades) is twice the inner one and neglect the slip coefficient. Assume the ambient air conditions are 1 bar and 293 K. The axial velocity of flow is 60 m/s and is constant throughout. Determine (a) Power input to the compressor,	**07**

(b) Impeller diameter at inlet and outlet and width at inlet, and
(c) Impeller and diffuser blade angles at inlet.

OR

Q.3 **(a)** Draw an illustrative diagram of a centrifugal compressor stage indicating the names of its principal parts. **03**

(b) Draw sketches of the three types of impellers and the velocity triangles at their entries and exits. **04**

(c) Air enters the inducer blades of a centrifugal compressor at P_{01} = 1.02 bar, T_{01} = 335 K. The hub and tip diameters of the impeller eye are 10 and 25 cm respectively. If the compressor runs at 7200 rpm and delivers 5.0 kg/s of air, Determine the air angle at the inducer blade entry and the relative mach number. If IGVs are used to obtain a straight inducer section, determine the air angle at the IGVs exit and the new value of the relative mach number. **07**

Q.4 **(a)** Explain working principle of axial flow compressor. **03**

(b) Prove the following relation of axial flow compressor: **04**
$(\tan\alpha_1 + \tan\beta_1) = (\tan\alpha_2 + \tan\beta_2)$

(c) An axial flow air compressor of 50% reaction design has blades with inlet and outlet angles of 45^0 and 10^0 respectively. The compressor is to produce a pressure ratio of 6:1 with an overall isentropic efficiency of 0.85 when inlet static temperature is 37^0 C. The blade speed and axial velocity are constant throughout the compressor. Assuming a value of 200 m/s for blade speed find the number of stages required if the work done factor is (a) unity and (b) 0.87 for all stages. **07**

OR

Q.4 **(a)** What is rotating stall? **03**

(b) What is surging? **04**

(c) Explain enthalpy vs entropy diagram of axial flow compressor for 50% reaction stage. And prove $\alpha_1 = \beta_2$ **07**

Q.5 **(a)** How do you differentiate between an impulse and a reaction turbine? With neat sketch explain working of an impulse and reaction stage. **03**

(b) With a neat sketch explain a single stage velocity triangle for axial turbine and derive an expression for the work output. **04**

(c) A gas turbine having single stage rotates at 10000 rpm. At entry to the nozzles the total head temperature and pressure of the gas is 700^0 C and 4.5 bar respectively and at outlet from the nozzle the static pressure is 2.6 bar. At the turbine outlet annulus the static pressure is 1.5 bar. Mach number at outlet is limited to 0.5 and gas leaves in an axial direction. The outlet nozzle angle is 70^0 to the axial direction and the nozzle friction loss may be assumed to be 3% of the isentropic temperature drop from total head at entry to static conditions at outlet nozzle pressure. Calculate **07**

(a) The gas angles at entry and outlet from the wheel showing them on velocity diagrams for mean blade section,
(b) Output power developed by the turbine shaft.

Assume the mean blades diameter as 64 cm, gas mass flow rate as 22.5 kg/s, turbine mechanical efficiency = 99%, C_p= 1.147 kJ/ kg K

OR

Q.5	**(a)**	For axial turbine stage prove following relation: $\Psi = \Phi(\tan \alpha_2 + \tan \alpha_3)$.	**03**
	(b)	Draw the velocity triangles for aaxial turbine stage. Prove the following relation: $(\tan \alpha_2 + \tan \alpha_3) = (\tan \beta_3 + \tan \beta_2)$	**04**
	(c)	Define degree of reaction for axial turbine stage and derive an expression for the same.	**07**

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