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

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII (old) - EXAMINATION – SUMMER 2017

Subject Code:181904 **Date:09/05/2017**

Subject Name: Thermal Engineering

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.**
4. **Mollier chart and steam table are permitted.**

Q.1 **(a)** Describe the changes which occur in a convergent divergent nozzle as the back pressure is slowly increased from the design pressure up to the pressure at entry. **07**

(b) A Convergent nozzle is supplied with steam at 10 bar and 270ºC. The diverging portion of the nozzle is 3.2 cm long and throat diameter is 6 mm. Find the semicone angle of the divergent section so that the steam leaves the nozzle at 1.2 bar. The loss in the nozzle due to friction is 15% of the total enthalpy drop. Assume that the loss takes place only in divergent part of the nozzle. **07**

Q.2 **(a)** What are the different methods of compounding of steam turbine stages? List the advantages and limitations of velocity compounding. **07**

(b) Define the term Degree of reaction used in reaction turbines and prove that it is given by $R_d = \left(\frac{V_f}{2U}\right)\left(\cot\beta_2 - \cot\beta_1\right)$ *when* $V_{f1} = V_{f2} = V_f$ **07**

Further prove that the moving and fixed blades should have the same shape for 50% reaction.

OR

(b) What are the different sources of losses in steam turbines? Explain the nature of each loss and indicate approximate values. **07**

Q.3 **(a)** Explain the reason of not using more than two stages in velocity compounded steam turbines. **07**

(b) In a stage of impulse reaction turbine, steam enters with a speed of 250m/sec at an angle of 30º in the direction of blade motion. The mean speed of the blade is 150m/sec when the rotor is running at 3000r.p.m. The blade height is 10 cm. The specific volume of steam at nozzle outlet and blade outlet are 3.5 m^3/kg and 4 m^3/kg respectively. The turbine develops 250 kW. Assuming the efficiency of nozzle and blades combined considered are 90% and carry over coefficient is 0.8, find (a) The enthalpy drop in each stage, (b) Degree of reaction, and (c) Stage efficiency. **07**

OR

Q.3 **(a)** Show that the maximum discharge of steam through the nozzle takes place when the ratio of steam pressure at the throat to the inlet pressure is given by $\frac{p_2}{p_1} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}}$ where, n is the index of expansion. **07**

(b) What are the conditions which produce supersaturation of steam? How does the area of the throat of a turbine-nozzle for supersaturated flow compare with the area determined for normal flow? **07**

Q.4 **(a)** Draw the schematic diagram of a simple gas turbine plant cycle with intercooled, heat exchange and reheat and explain briefly the working principle. Draw also the p-V and T-s diagrams of cycle. **07**

(b) Derive the expression for specific work output and the efficiency of a simple gas turbine plant cycle with intercooled, heat exchange and reheat. Draw their trends as a function of pressure ratio. **07**

OR

Q.4 **(a)** Prove that the efficiency corresponding to the maximum work done in a Brayton cycle is given by the relation **07**

$$\eta_{w\max} = 1 - \frac{1}{\sqrt{t}}$$

Where t is the ratio of the maximum and minimum temperatures of the cycle.

(b) An ideal gas turbine operates with m number of compressor stages and n number of turbine stages with a overall pressure ratio, r. The maximum temperature is T_{max} and the minimum temperature is T_{min}. Assume pressure ratios in compressor is same in all m stages and perfect intercooling and reheating. Also assume that pressure ratios in all n stages in turbine are same. Show that **07**

$$t = t_{exit} \times \left(r^{a} \right)^{\frac{m+n}{mn}}$$

$$t = \frac{T_{\max}}{T_{\min}},\ a = \frac{\gamma - 1}{\gamma},\ and\ t_{exit} = \frac{T_4}{T_2}$$

Where T_4 and T_2 are the exit temperatures of the turbine and compressor respectively.

Q.5 **(a)** Write a short note on methods of attachment of blades to turbine rotors. **07**

(b) A gas turbine unit operates at a mass flow of 30 kg/s. Air enters the compressor at a pressure of 1 bar and temperature 15°C and is discharged from the compressor at a pressure of 10.5 bar. Combustion occurs at constant pressure and results in a temperature rise of 420 K. if the flow leaves the turbine at a pressure of 1.2 bar, determine the net power output from the unit and also the thermal efficiency. Take C_p=1.005 kJ/kg K and γ=1.4. **07**

OR

Q.5 **(a)** Explain the working difference between propeller-jet, turbo-jet and turbo-prop. **07**

(b) Draw a schematic diagram of a "Pulse Jet Engine" and describe its operation. What are the advantages and disadvantages of Pulse Jet Engine? **07**

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