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10MTP22

Second Semester M.Tech. Degree Examination, June 2012
Steam and Gas Turbines

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions.***

1 a. Show, by analytical method that for isentropic flow of steam through a convergent divergent nozzle, the throat velocity is the local acoustic velocity. **(10 Marks)**

b. An adiabatic steam nozzle is to be designed for a discharge rate of 10 kg/s of steam from 10 bar and 400°C to a back pressure of 1 bar. The nozzle efficiency is 0.92 and the frictional loss is assumed to take place in the diverging portion of the nozzle only. Assume a critical pressure ratio of 0.5457. Determine the throat and exit area. **(10 Marks)**

2 a. Obtain an expression for maximum blade efficiency in a single stage impulse turbine. What is the maximum efficiency if $\alpha = 20^o$, $\beta_1 = \beta_2$ and K = 0.83 where α is the nozzle angle and K-blade velocity coefficient. **(10 Marks)**

b. In a stage of an impulse turbine provided with a single row wheel, the mean diameter of the blade ring is 80cm and the speed of rotation is 3000 rpm. The steam issues from the nozzles with a velocity of 300 m/s and the nozzle angle is 20^o. The rotor blades are equiangular and due to friction in the blade channels the relative velocity of steam at outlet from the blades is 0.86 times the relative velocity of the steam entering the blades, what is the power developed in the blades when the axial thrust is 140N. **(10 Marks)**

3 a. In a Curtis stage with 2 rows of moving blades, the rotors are equiangular. The first rotor has angle of 29^o each while second rotor has angle of 32^o each. The velocity of steam at the exit of the nozzle is 530 m/s and the blade coefficients are 0.9 in the first, 0.95 in the stator and in the second rotor, if the absolute velocity at the stage exit should be axial, find:
i) Mean blade speed; ii) Rotor efficiency; iii) Power output for a flow rate of 32 kg/s. **(10 Marks)**

b. Show that for a Parson's turbine $\eta_{b\max} = \dfrac{2\text{Cos}^2\alpha_1}{1+\text{Cos}^2\alpha_1}$. **(10 Marks)**

4 a. What is reheat factor? Why is it greater than unity? **(04 Marks)**

b. Define the terms i) internal efficiency; ii) relative efficiency. **(04 Marks)**

c. An impulse turbine installation, consisting of HP, IP and LP turbines, is required to work with initial steam condition of 17bar with 120°C of superheat and a condenser pressure of 0.07 bar. Allowing a reheat factor of 1.05 and a loss of available heat of 25 kJ/kg steam, determine the heat units to be allocated to each turbine in order that HP and IP may each develop 1/4 of the total power. Assume stage efficiency of 0.77, 0.75 and 0.72 in the HP, IP and LP respectively. **(12 Marks)**

5 a. Show that the degree of reaction (R) for an axial flow compressor $R = \dfrac{V_a}{2u}\left[\text{Cot}\beta_1 + \text{Cot}\beta_2\right]$. **(08 Marks)**

b. A centrifugal compressor delivers 20 kg/s of air with a total head pressure ratio of 4. The speed of the compressor is 12000 rpm. Inlet total temperature is $15^{o}C$. Stagnation pressure at inlet is 1.0 bar, slip factor is 0.9, power input factor is 1.04 and the total head isentropic efficiency is 80%. Calculate the outer diameter of the impeller. If the mach number at the exit of the impeller is limited to unity, calculate the depth of the impeller at the exit. **(12 Marks)**

6 a. For Brayton cycle prove that optimum pressure ratio for maximum net work done.

$$(r_p)_{opt} = \left(\frac{T_{max}}{T_{min}}\right)^{\frac{\gamma}{2(\gamma-1)}};\ W_{net_{max}} = Cp\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2.$$

T_{max} = max temperature in cycle and T_{min} = min temperature in cycle. A gas turbine works on Brayton cycle between $27^{o}C$ and $827^{o}C$. Determine the cycle efficiency. Also compare the Carnot efficiency with Brayton cycle efficiency for these temperature limits. **(10 Marks)**

b. With a neat sketch, explain turboset engine and derive an expression for thermal efficiency of a turboset engine. **(10 Marks)**

7 a. What are the desirable requirements of a liquid propellant for rockets? Compare the advantages and disadvantages of solid and liquid propellants. **(10 Marks)**

b. Explain with a neat sketch solid core nuclear heated hydrogen rocket. **(10 Marks)**

8 Write short notes on :

a. Shape of nozzle of uniform pressure drop.

b. Compounding of steam turbines.

c. Methods of blade cooling.

d. Overall blade loss coefficient. **(20 Marks)**

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