BE (Mech) Part III 6th Semester Final Examination 2012
Boiler and Steam Turbine (ME 602)

Time 3 hrs **Full Marks 70**

First Half
Answer any three questions from this half
Use of charts and tables is permitted

1. (a) What are the different types of nozzles? Describe different types of nozzles with neat sketch of each type.
(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 friction loss is assumed to take place in the diverging part of the nozzle only. Assume a critical pressure ratio of 0.5457. Determine the throat and exit areas.
2. (a) What is the difference of the theory of action in impulse turbine and impulse-reaction turbine?
(b) Steam flows from the nozzles of a single row impulse turbine with a velocity 450m/s at a direction which is inclined at an angle of 16° to the peripheral velocity. Steam comes out of the moving blades with an absolute velocity of 100m/s in the direction at 110° with the direction of blade motion. The blades are equiangular and steam flow rate is 6 kg/s. Determine the power loss due to friction.
3. (a) What is the difference between velocity compounding and pressure compounding of an impulse turbine, show by sketches.
(b) A velocity-compounded impulse wheel has two rows of moving blades with a mean diameter of 70 cm. The speed of rotation is 3000 rpm, the nozzle angle is 16°, and the estimated steam velocity at the nozzle outlet is 610 m/s. The mass of steam passing through the blades is 6.5 kg/s. Assuming that the energy loss in each row of blades (moving and fixed) is 24% of the kinetic energy of the steam entering the blades and referred to as the relative velocity, and that the outlet angles of blades are: (1) first row of moving blades 18° (2) intermediate guide blades 22° (3) second row of moving blades 38°, draw the velocity diagrams and calculate the following: (a) blade inlet angles (b) power developed in each row of blades (c) efficiency of wheel as a whole.
4. (a) What is a 50 % reaction turbine? Give the expression for the degree of reaction of an impulse-reaction turbine
(b) Steam flows into the nozzles of an impulse-reaction turbine stage from the blades of the preceding stage with a velocity of 100 m/s and issues from the nozzles with a velocity of 325 m/s at an angle of 20° to the wheel plane. Calculate the gross stage efficiency for the following data: mean blade velocity = 180 m/s, expansion efficiency for nozzles and blades =0.9, carry-over factor for nozzles and blades =0.9, degree of reaction =0.26 and blade outlet angle = 28°.
5. (a) Describe, with a neat sketch, the working of a low level counter flow jet condenser.
(b) For checking the air leakage into the condenser, the steam plant is run until conditions are steady and immediately steam supply to the engine is shut off and condensate extraction pumps are closed down. Now the condenser is isolated. At the time of shut down the temperature and vacuum in the condenser are observed to be 42°C and 680 mm Hg. After 10 minutes, the values are 30°C and 510 mm Hg. The barometer reads 756 mm Hg. The effective volume of the condenser is $0.4 m^3$. Determine (a) the amount of air leakage into the condenser during the observed period and (b) the mass of water vapor condensed in the same period.

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SECOND HALF (Attempt any three questions)

1 (a) What do you mean by circulation in case of a boiler? Classify it. With the help of a neat labeled diagram, explain in brief the working of natural circulation system of a boiler. Write the relevant mathematical formulations for assessment of heat transfer in case of convective and radiative super heaters.

(b) A natural circulation boiler operates at 100 bar and produces steam at 122 kg/s. Riser receives saturated water at velocity of 1.2 m/s. Estimate (i) the pressure head developed, (ii) void fraction, (iii) heat transfer per projected area and (iv) number of risers. The height of the furnace, inner diameter and outer diameter of the riser tube are 18 m, 60 mm and 65 mm respectively. The circulation ratio and slip ratio are 9 and 1.4.

2 (a) With the help of relevant flow diagrams, explain in brief the working of forced draught and induced draught systems. Also mention their relative merits and demerits.

(b) The average temperature of flue gas, in a chimney of height of 62 m, is 325^0c. The ambient pressure and temperature are 1.013 bar and 25^0c. Estimate (i) draught produced in N/m^2 and mm of water column, (ii) equivalent height of hot flue gas in meter, (iii) gas temperature at maximum discharge condition, (iv) draught produced in mm of water column at maximum discharge condition and (v) efficiency of chimney. Air-fuel ratio is 14:1. The minimum temperature of flue gas in chimney for artificial draught system is 125^0c. Cp of gases is 1.006 kJ/kg-K.

3 (a) What is the function of a cooling tower? Classify it. With the help of neat labeled diagrams discuss in brief the working of a hyperbolic and an induced draft cross flow cooling towers.

(b) Mention some typical industrial applications of cogeneration system. With the help of relevant flow and T-s diagrams, discuss in brief the working of back pressure turbine and pass-out turbine systems used for cogeneration purpose.

4 (a) Draw the flow and T-s diagrams separately of reheating cycle and regenerative feed heating cycle using two closed type heaters with dripping system. Mention the importance of the said cycles. Also write the energy balance equations for the heaters.

(b) In an ideal regenerative cycle, the steam enters the turbine at 100 bar, 520^0c. After isentropic expansion in the turbine, steam leaves at 0.01bar. Two open type heaters are used as feed water heaters at 10 bar and 2 bar respectively. Calculate the thermal efficiency, SSC and HR of the cycle. Use Molier chart and steam table.

5 Write short notes on <u>any three</u> of the following:-

(a) Natural draught system

(b) Air preheaters

(c) Economizer

(d) Water cooling method in cooling tower