BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR.

B.E. (Part IV) 7th Semester (Mech. Engg.) Final Examination, 2012

Branch: **Mechanical Engineering.** Subject: **Fluid Power Engineering.** Sub. Code: **AM701**

Time: 3 hrs. Full Marks: **70**

Use separate answerscript for each half

All questions carry equal marks.

Answer any **Six** questions, **taking three from each half**

Two marks are reserved for neatness from each half.

First Half

1. (a) A liquid jet of velocity V_j, density ρ and area A_j, strikes a fixed hollow cone, as shown in Fig.1(a), and deflects back as a conical sheet at the same velocity. Find the cone angle θ for which the restraining force $F = \frac{3}{2}\rho A_j V_j^2$ (4)

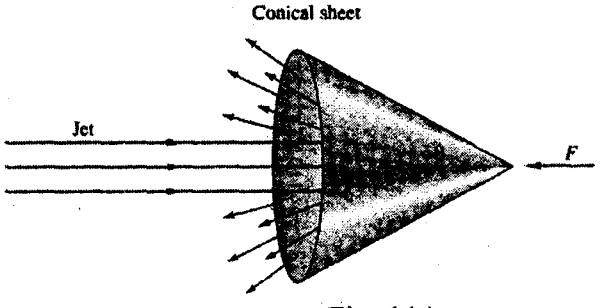

Fig. 1(a)

(b) Derive with neat sketch, the expression for minimum number of buckets required for a Pelton turbine in terms of jet ratio, speed ratio, co-efficient of velocity of nozzle and any other related constants. (7)

2. (a) Show that the specific speed of geometrically similar water turbines, of radial flow Francis type, can be expressed in the form: $N_s = CK_u\sqrt{K_f K\left(\frac{B}{D}\right)\eta}$

where, N_s is specific speed, K_u is speed ratio, K_f is flow ratio, η is overall efficiency, B is runner width, D is runner diameter and K is the factor considered for the effect of blade thickness. Determine the value of C for specific speed in r.p.m.-KW-m unit. (5)

(b) The maximum overall efficiency of a Pelton turbine is 82 % when the speed ratio (K_u) is 0.45, and the co-efficient of velocity (C_v) is 0.97 for the nozzle. Assuming that the loss due to windage and bearing friction is proportional to the square of the rotational speed , estimate the friction factor for the buckets, hydraulic efficiency and mechanical efficiency of the turbine, if the jet turns through 165^0. (6)

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3. (a) Explain with suitable sketch the change in shape and inlet velocity triangle of Francis turbine runner with the variation of specific speed. Identify slow, medium and fast Francis turbine runners from the velocity triangles. (4)

(b) A vertical shaft inward flow reaction turbine runs at 250 r.p.m. and uses 4.45 m^3/s. The runner diameter at inlet is 1.2 m and the runner blade angle at entry is 90 ^{0}.The diameter at entry to the spiral casing is 1.5 m and the pressure head at this point is 27 m. above atmospheric. The water enters the runner without shock at a pressure head of 12.2 m above atmospheric, passes through the runner with constant velocity of flow 5 m/sec and enters the draft tube without whirl at a pressure of 1.8 m below atmospheric. Discharge from the draft tube takes place below the tail-race level with velocity of 2.5 m/sec. The turbine entry and runner inlet are 1.8 m above the tail-race level and there is a fall of 30 cm through the runner. Find the loss of head due to fluid resistance as water passes: (i) from turbine entry to runner inlet (ii) through the runner (iii) through the draft tube (iv) obtain the power transmitted to the shaft and (v) the efficiency of the turbine. (7)

4. (a) An inward flow reaction turbine having radial discharges and velocity of flow is constant and equal to the velocity of discharge from the draft tube. Show the hydraulic efficiency can be expressed by : $$\frac{1}{1+\frac{\left(\frac{1}{2}\right)\tan^2\alpha}{1-\left(\frac{\tan\alpha}{\tan\theta}\right)}}$$

where α is guide blade angle and θ is runner vane angle at inlet. Neglect all possible losses. (6)

(b) A reaction turbine working under a head of 30 m produces 13500 KW power when running at 120 r.p.m. If at the site, atmospheric pressure is equivalent to 10.2 m of water head and vapour pressure is 0.22 m of water, calculate the safe height of the discharge end of the runner above tail race level. Thoma's cavitation factor $\sigma_c = 3.17\times10^{-6} N_s^2$. N_s is the specific speed of the turbine in r.p.m KW m unit. (5)

5. (a) A reaction turbine of axial flow type is fitted with 4 blades of aerofoil section. It runs at 120 r.p.m. The mean radius of blade circle is 1.5 m and the blade length in radial direction is 0.6 m. The chord of aerofoil section is inclined at 25 degrees to the direction of motion and the chord length is 2.5 m. If the coefficients of lift and drag for aerofoil section are 0.7 and 0.04 respectively and if the net head on turbine is 10 m and velocity of flow is 4.5 m/s, find the power and efficiency of turbine. (5)

(b) In a tidal power plant Kaplan turbine operates a 5 MW generator at 150 r.p.m. under a head of 5.5 m. The generator efficiency is 93 % and the overall efficiency of the turbine is 88 %. The tip diameter of the runner is 4.5 m and hub diameter is 2 m. Assuming hydraulic efficiency of 94 % and no exit whirl, determine the runner vane angles at inlet and exit at the mean diameter of the vanes. (6)

SECOND HALF

6. With the help of neat sketches and standard symbols describe the working principles of (a) Pressure Relief Valve and (b) Pressure Reducing Valve.

   In a 50-ton vertical hydraulic press, the workpiece is to be held tight against a horizontal force of 15 kN. Both holding cylinder of 50 mm bore and power cylinder of 200 mm bore have area ratio 1:2 each. Draw a suitable hydraulic circuit and estimate the set pressures for different pressure control valves in the circuit. Assume loss across each valve in each line to be 3 bar and negligible pipe friction losses.

7. With the help of an idealized configuration, deduce an expression for efficiency of a hydraulic motor in terms of pressure differential, speed, dynamic viscosity of oil and motor characteristic coefficients.

   The lock gate in a shipyard requires 800 Nm torque for operation. It is to be operated by a hydraulic motor. Find the capacity of the motor if its mechanical efficiency is to be 85% and the working pressure is limited to 250 bar.

8 How do you specify the performance characteristics of a centrifugal pump? Draw a neat sketch of the experimental set-up used for estimation of performance characteristics of a centrifugal pump in a laboratory and describe the procedure in brief.

   Two geometrically similar centrifugal pump are running at the same speed of 1000 r.p.m. One pump has an impeller of 300 mm diameter and lifts water at a rate of 20 lit/min against a head of 15 m. Determine the head and impeller diameter of the other pump if it is to deliver water at a rate of 10 lit/min.

9. What is 'Specifc Speed' of a centrifugal pump ? Deduce an expression for it.

   Prove that the manometric head of a centrifugal pump running at speed N and giving a discharge Q may be expressed as

$$H_{mano} = A N^2 + B N Q + C Q^2$$

   Where, A, B and C are constants.

10. With the help of neat sketch/standard symbol, write short notes on any three of the following :

    (i) Cavitation in pump , (ii) Draft Tube, (iii) Vane Pump, (iv) Pressure compensated Flow Control valve

    (v) Regenerative Circuit.