BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR.

B.E. (Part IV) 7th Semester (Mech. Engg.) Final Examination, 2013

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 lawn sprinkler shown in Fig. 1(a) has 0.8 cm diameter nozzle at the end of a rotating arm and discharges water at a rate of 10 m/s velocity. Determine the torque required to hold the rotating arm stationary. Also determine the constant speed of rotation of the arm, if free to rotate. (4)

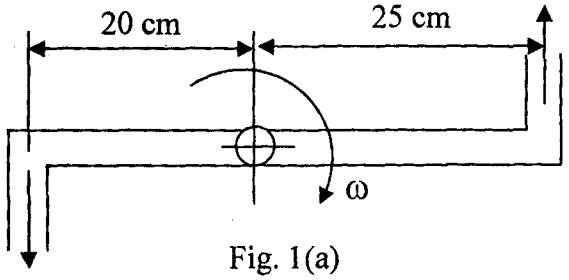

Fig. 1(a)

(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) 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 propotional 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)

(b)Assuming radial discharge at outlet and constant velocity of flow, deduce an expression for degree of reaction of a radial flow reaction turbine in terms of guide vane angle and runner vane angle at inlet. (5)

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 214 rpm and uses 10.3 m^3/sec when the net head is 24.4 m. The hydraulic efficiency is 90 %.The inlet edge angle of the runner blades is 112^0 measured from the direction of the runner velocity. Water enters the runner without shock with a velocity of flow 7.3 m/sec and enters the draft tube without whirl with a velocity of 6 m/sec. The discharge velocity from the draft tube is 2.4 m/sec. The mean height of the runner entry surface

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and entrance to the draft tube are 1.5 m and 1.2 m above the tail race level. The loss of head due to friction is 90 cm in the runner and 60 cm in the draft tube. Find (i) the diameter of the runner entry surface (ii) head loss in the guide passages (iii) the pressure heads at entrance to the runner and draft tube (iv) specific speed of the turbine, based on power output of the runner. (7)

4. (a) A vertical shaft Francis Turbine runs at 430 r.p.m. and the discharge is 15 m^3/sec. The velocity and pressure head at the entrance to the volute casing are 9 m/sec and 230 m, where the elevation above tail race is 5 m. The diameter of the runner is 2 m and width at inlet is 270 mm. The overall and hydraulic efficiencies are 92 % and 94%,respectively. Find (a) the power output, (b) the shape number (c) the guide vane angle (d) the rotor vane angle at inlet, and (e) Degree of reaction. (7)

(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 $\sigma_c = 3.17 \times 10^{-6} N_s^2$. N_s is the specific speed of the turbine in r.p.m KW m unit. (4)

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) A Kaplan Turbine develops 1471 KW under a head of 6 meters. The turbine is set 2.5 meters above the tail race level. A vacuum gauge inserted at the turbine outlet records a suction head of 3.1 meters. If the turbine efficiency is 85 %, what would be the efficiency of draft tube having inlet diameter of 3 meter? Find the reading of suction gauge if the power developed is reduced to 735.5 KW, the head, turbine and draft tube efficiencies, and speed remaining constant. (6)

SECOND HALF

6. Prove that the maximum efficiency of a jet propulsion device with inlet orifice fitted amidship and discharging astern is 50%.

   The head of water from the centre of orifice fitted at one side of a tank is maintained at 2 m. The orifice has a diameter of 100 mm. If the tank is fitted with frictionless wheels and allowed to move, determine (i) the propelling force, (ii) work done per second and (iii) efficiency of propulsion. Take $C_v = 0.97$ for the orifice.

7. With the help of a neat sketch, explain why the actual head-capacity curve of a centrifugal pump is somewhat parabolic although ideally it should be linear.

   A centrifugal pump has an impeller of 800 mm diameter and it delivers 1 m^3/sec of water against a head of 80 m. The impeller runs at 1000 r.p.m. and the width at outlet is 80 mm. If the leakage loss after the impeller is 3% of the discharge, external mechanical loss is 10 kW and the manometric efficiency 80%, calculate blade angle at outlet, the power required to drive the pump and the overall efficiency.

8a) Two geometrically similar centrifugal pumps 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/sec 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/sec.

b) A centrifugal pump is to deliver 1.88 m^3/sec of water against a head of 6 m. while running at 200 r.p.m. What should be the minimum diameter of its impeller if the ratio of its diameter at outlet to that at inlet is to be 2 : 1.

9a) What is the advantage of a hydraulic motor over an electric motor? Why a 'gear pump' cannot be used to control the speed of an actuator or hydraulic motor but a ' vane pump' can be used for the same? Deduce an approximate expression for capacity of a 'flat vane pump' in terms of its 'housing diameter','Number of vanes', 'vane thickness' and 'eccentricity'.

b) A 10 ton hydraulic cylinder of 100 mm diameter is operate at a speed of 150 mm/sec. The motion of the cylinder is controlled by a 4-way 3-position direction control valve in which pressure drop in each of pressure line and return line is 2 bar The pressure drop in the pipeline between the cylinder and the direction control valve is 3 bar and the leakage loss is 3 lit/min. Draw the hydraulic circuit and determine the pump capacity and relief valve set pressure. Also estimate the power required to drive the pump if it is to run at 1500 r.p.m and its overall efficiency is 75%.

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

   (i) Pressure Relief Valve, (ii) Direction Control Valve, (iii) Flow Control Valve, (iv) Surge Tank, (v) Cavitation in Pump.