B.E. 7th SEMESTER (MECHANICAL ENGG.) FINAL EXAMINATIONS, 2011

Fluid Power Engineering (AM701)

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

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 water tender coupled to a locomotive running at 100 km/hr scoops water from a tough between rails. A vertical delivery pipe of constant diameter is connected to the scoop with a right angle bend. Assume that there is no friction and water is at atmospheric pressure at both inlet and outlet. The outlet is 3 m above the water level in the trough. Calculate the water discharge rate through a delivery pipe of 150 mm diameter. Also determine the force on the tender due to scooping action.

   (b) A free water jet issues horizontally from a 4 cm diameter orifice, installed on the wall of a constant-level tank, the head of water being 2 m above the center of the orifice. The jet strikes a single curved vane mounted on smooth rails and held in position by externally applied force of 45 N opposite to the direction of the issuing jet. The jet is deflected through 120 ^{0} when the vane is held stationary. If the measured discharge is 5 lit/sec, estimate the co-efficient of contraction and velocity for the orifice. Also determine the magnitude and direction of velocity of water leaving the vane when it is allowed to move in the direction of the issuing jet at a speed of 3 m/sec. Neglect friction.

2. The velocity of the jet driving a Pelton wheel, which has a bucket circle diameter of 1 m and a speed of 'N' rev/min, is 47.5 m/s. The relative velocity at outlet is 0.85 times of that at inlet and this relative velocity is deflected through 160 ^{0} by the buckets. From first principles, deduce an expression for the hydraulic efficiency of the wheel. Calculate the hydraulic efficiencies when 'N' = 400 and 'N' = 800 and also find it's maximum value. What would be the runaway speed?

3. (a) 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.

   (b) A vertical shaft Francis turbine runs at 430 r.p.m. and the discharge is 15 m^3/sec. At the entrance to the volute casing, the velocity is 9 m/sec and pressure head is 230 m, where the elevation above the tail race is 5 m. The diameter of the runner is 2 m and it's width at inlet is 270 mm. The overall and hydraulic efficiencies are 92 % and 94%, respectively. Find (i) the power output, (ii) the shape number (iii) the guide vane angle (iv) the rotor vane angle at inlet, and (v) Degree of reaction. Assume no exit whirl.

4. 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 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.

5. (a) A propeller turbine runner has an outer diameter of 4.5 m and inner diameter of 2 m. It develops 28000 HP when working under a head of 20 m. The turbine is directly coupled to a 50 Hz alternator having 22 pairs of poles. The hydraulic efficiency is 94% and overall efficiency is 88 %. Find the (i) discharge through the turbine (ii) runner vane angles at inlet and outlet at the hub and at the edge of the blade. Assume no exit whirl and velocity of flow remains constant. Also consider free vortex flow distribution at the inlet side of the blade.

(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 remain constant.

SECOND HALF

6. With the help of an idealized configuration, deduce an expression for efficiency of a positive displacement pump in terms of pressure differential, speed, dynamic viscosity of oil and pump characteristic coefficients

   An asymmetric actuator of area ration 1:2 has to transmit a load of 150 kN at a speed of 100 mm/sec during forward stroke. The cylinder bore is 75 mm. The direction of motion of the actuator is controlled by a 4-way 3-position tandem centre solenoid valve, which causes a pressure drop of 2 bar in each of pressure and return line. Determine the pump capacity if it has a volumetric efficiency of 90% and runs at 1500 r.p.m. Also determine the relief valve set pressure.

7. Describe with a neat sketch the working principle of a simple pressure reducing valve. Mention one of its applications in practice.

   In a speed control hydraulic circuit the motor capacity is 33 ml/rev. The maximum pump capacity is 610 ml/rev while running at 960 r.p.m. with 3.75 kW being supplied from an electric motor. If the overall efficiency and mechanical efficiency for both pump and motor are 84% and 90% each respectively, determine (a) relief valve set pressure and (b) the maximum motor speed and torque at this speed.

8. What is specific speed of a rotodynamic pump? Starting from fundamental, deduce an expression for specific speed of a centrifugal pump.

   A centrifugal pump running at 750 r.p.m. discharges 56 lit/sec of water against a head of 20 m and consumes 20 kW of power. Find the discharge, head and power required to drive the pump if it is to run at 1500 r.p.m. under dynamically similar condition. Also determine its specific speed.

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

   A centrifugal pump is to deliver water against a head of 25 m at the design speed of 1200 r.p.m. The diameter and width of the impeller at outlet are 350 mm and 60 mm respectively, while the inlet diameter is 180 mm. The vanes are curved backwards at 30° to the tangent at outlet. The manometric efficiency is 90 %. Assuming radial flow at inlet and constant velocity of flow throughout the impeller, determine (i) width of impeller at inlet, (ii) vane tip an angle at inlet and (iii) the discharge from the pump.

10. With the help of neat sketches/ symbols, write short notes on any **three** of the following

    (a) Regenerative Circuit, (b) Meter-In and Meter-Out Circuit, (c) Draft Tube (d) Cavitation in pump,

    (e) Direction Cotrol Valve