EXERCISE

1) A quarter scale turbine model is tested under a head of 10.8m. The full-scale turbine is required to work under a head of 30 m and to run at 7.14 rev/s. At what speed must the model be run? If it develops 100 kW and uses 1.085 m^3 of water per second at the speed, what power will be obtained from the full scale turbine? The efficiency of the full-scale turbine being 3% greater than that of the model? What is the dimensionless specific speed of the full-scale turbine?

(Ans.17.14 rev/s,7.66MW,0.513 rev/s)

2) A Pelton wheel operates with a jet of 150mm diameter under the head of 500m. Its mean runner diameter is 2.25 m and and it rotates with speed of 375 rpm. The angle of bucket tip at outlet as 15^o coefficient of velocity is 0.98, mechanical losses equal to 3% of power supplied and the reduction in relative velocity of water while passing through bucket is 15%. Find (a) the force of jet on the bucket, (b) the power developed (c) bucket efficiency and (d) the overall efficiency.

(Ans. 165.15kN,7.3MW,90.3%,87.6%)

3) A pelton wheel works at the foot of a dam because of which the head available at the nozzle is 400m. The nozzle diameter is 160mm and the coefficient of velocity is 0.98. The diameter of the wheel bucket circle is 1.75 m and the buckets deflect the jet by 150^o. The wheel to jet speed ratio is 0.46. Neglecting friction, calculate (a) the power developed by the turbine, (b) its speed and (c) hydraulic efficiency.

[Ans. (a) 6.08 MW,(b) 435.9rpm,(c) 89.05%]

4) A Powerhouse is equipped with impulse turbines of Pelton type. Each turbine delivers a power of 14 MW when working under a head 900 m and running at 600 rpm. Find the diameter of the jet and mean diameter of the wheel. Assume that the overall efficiency is 89%, velocity coefficient of jet 0.98, and speed ratio 0.46.

(Ans.132mm. 191m)

5) A Francis turbine has a wheel diameter of 1.2 m at the entrance and 0.6m at the exit. The blade angle at the entrance is 90^0 and the guide vane angle is 15^0. The water at the exit leaves the blades without any tangential velocity. The available head is 30m and the radial component of flow velocity is constant. What would be the speed of wheel in rpm and blade angle at exit? Neglect friction.

(Ans. 268 rpm, 28.2^0)

6) In a vertical shaft inward-flow reaction turbine, the sum of the pressure and kinetic head at entrance to the spiral casing is 120 m and the vertical distance between this section and the tail race level is 3 m. The peripheral velocity of the runner at entry is 30m/s, the radial velocity of water is constant at 9m/s and discharge from the runner is without swirl. The estimated hydraulic losses are (a) between turbine entrance and exit from the guide vanes 4.8 m(b) in the runner 8.8m (c) in the draft tube 0.79 m (d) kinetic head rejected to the tail race 0.46m. Calculate the guide vane angle and the runner blade angle at inlet and the pressure heads at entry to and exit from the runner.

(Ans.14.28^0 , 59.22^0 , 47.34m, -5.88m)

7) The following data refer to an elbow type draft tube:

Area of circular inlet = $25m^2$

Area of rectangular outlet = $116m^2$

Velocity of water at inlet to draft tube = 10 m/s

The frictional head loss in the draft tube equals to 10% of the inlet velocity head.

Elevation of inlet plane above tail race level = 0.6m

Determine:

a) Vacuum or negative head at inlet

b) Power thrown away in tail race

(Ans.4.95 m vac, 578kW)

8) Show that when vane angle at inlet of a Francis turbine is 90 o and the velocity of flow is constant, the hydraulic efficiency is given by $2/(2+\tan^2\alpha)$, where α is the guide blade angle.

9) A conical type draft tube attached to a Francis turbine has an inlet diameter of 3 m and its area at outlet is $20m^2$. The velocity of water at inlet, which is 5 m above tail race level, is 5 m/s. Assuming the loss in draft tube equals to 50% of velocity head at outlet, find (a) the pressure head at the top of the draft tube (b) the total head at the top of the draft tube taking tail race level as datum (c) power lost in draft tube.

(Ans. 6.03 m vac, 0.24m, 0.08m)