Energy Resources and Policy

Tutorial:
Hydro power

Density of water is 1000 kg/m^3 unless otherwise stated

1. A pipeline 450 mm in diameter and 3.6 km long discharges water at the rate of 295 litres per second when open to the atmosphere at the lower end, which is situated 38 m below the water level in the supply reservoir. Calculate the friction coefficient for the pipeline, and the power in the flow at exit from the pipe.

   A nozzle with velocity coefficient 0.98 is to be fitted to the pipe exit, with the aim of increasing the power in the flow to the maximum possible. Calculate the required nozzle diameter and the resulting maximum power.

   [0.0067; 507W; 100 mm; 40.7 kW]

2. In a proposed hydro-electric scheme, an output of 200 MW is required. The turbines discharge water at a level 180m below the reservoir free surface. The flow passage from reservoir to turbine house is to be a single tunnel of circular cross-section, 2.5 km long, and it is intended that the transmission efficiency be 90%. Assuming a friction factor of 0.0052, calculate the required tunnel diameter. Take the efficiency of the turbo-generators as 79%.

   The tunnel is then drilled to this specification, and the turbine and generators installed. During initial testing, it is found that a flow rate of 168 m^3/s is required to obtain a 200 MW output. Calculate the actual tunnel friction factor and transmission efficiency. Also determine the maximum power output obtainable from the system.

   Illustrate by means of a sketch the power/flow rate characteristic curves for the system, as designed and as actually produced. Indicate the approximate position of the operating point in each case.

   [5.708m; 0.853; 0.00686; 235.6 MW]

3. A small hydro power plant uses a single-jet impulse turbine running under a head of 31m. The supply pipeline is 145m long and 0.15m in diameter, and has a friction factor of 0.008. The turbine nozzle can be adjusted to give a range of jet diameters, and has a velocity coefficient of 0.95.

   If the system is set to run at a pipeline transmission efficiency of 0.92, what power is produced at the nozzle exit, and what jet diameter is required?

   [5.595 kW; 35.4 mm]