Energy Conversion Lab, IIT Kanpur

Lab Manual for Pelton Turbine

Learning Objectives:-

- Design and function of a Pelton Turbine.
- To determine characteristics curves of a Pelton Turbine.

Apparatus required:- Pelton turbine setup, stopwatch and tachometer.

Theory:-Water turbines are important components of hydroelectric power stations. Their task is to convert the potential energy of the water in reservoirs, canals, and rivers into mechanical energy, normally to power electric generators. Pelton turbines are the preferred turbine for hydro-power when the available water source has relatively high hydraulic head at low flow rates. In Pelton turbine, the water jet is accelerated in a nozzle and emerges with atmospheric pressure. After free flight, water jet strikes the blades of the impeller tangentially, and diverted by almost 180° which creates a change in angular momentum. The energy available at the turbine is only kinetic energy and it works under atmospheric pressure.

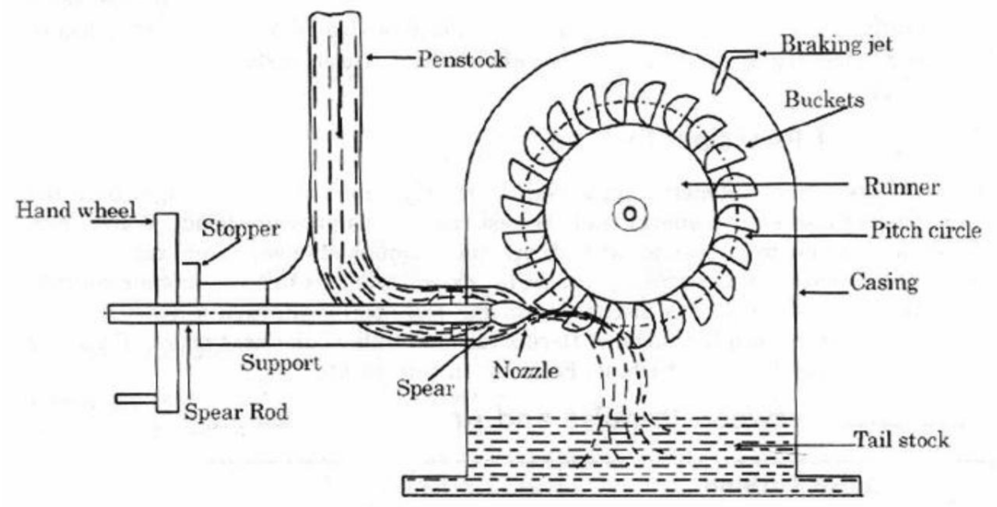


Figure 1- Schematic Diagram of Pelton wheel

1. **Nozzle with Spear**: –

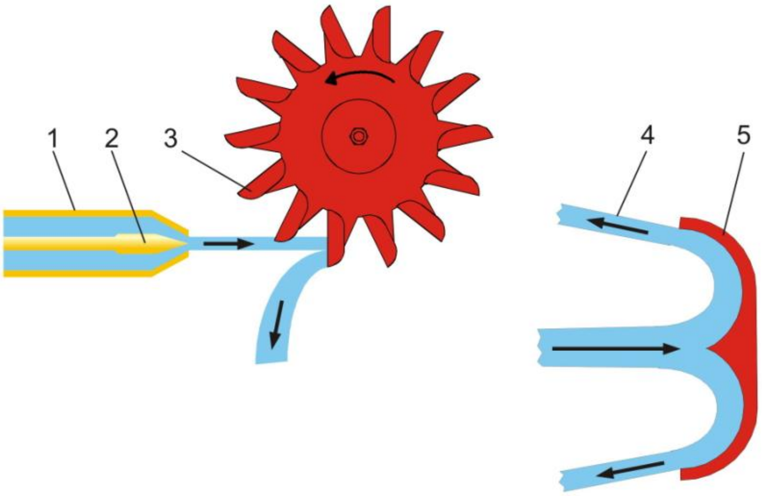
- Nozzle is used to increase the kinetic energy of the water that is going to strike the buckets or vanes attached to the runner.
- The quantity of water that strikes the buckets is controlled by spear. The spear is installed inside the nozzle and regulates the flow of water that is going to strike on the vanes of the runner. A nozzle containing spear is shown in the figure 1.
- The spear is a conical needle present in the nozzle. It is operated by a hand wheel or automatically in an axial direction. When the spear is moved backward the rate of flow of water increases and when it is pushed forward the rate of flow of water decreases.

2. **Runner and bucket**: –

- Runner is a rotating part of the turbine. It is a circular disc on the periphery of which a number of buckets evenly spaced are fixed.
- The buckets are made by two hemispherical bowl joined together. Each buckets have a wall in between two hemispherical bowl called splitter.
- The splitter splits the jet of water striking the buckets into two equal parts and the jet of water comes out at the outer edge of the bucket.

- The buckets are designed in such a way that the jet of water strike the buckets, deflected through 160 degree to 170 degree.

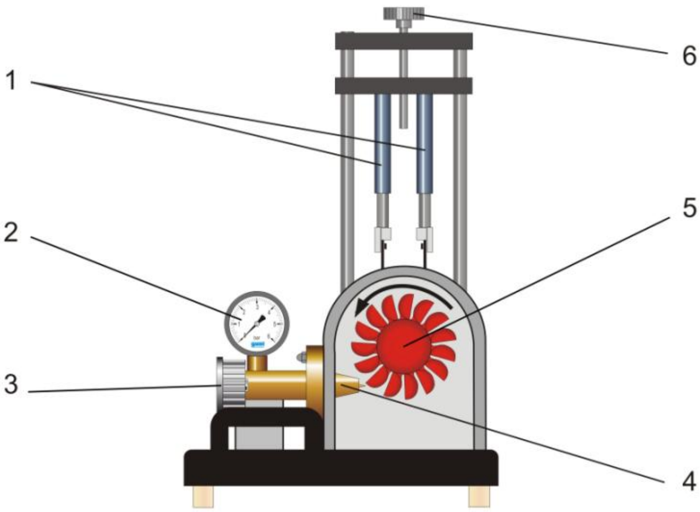
3. **Casing**: – Casing is to prevent the splashing of the water and to discharge water to tail stock.
4. **Breaking jet**: – In order to stop the runner in the shortest possible time a small nozzle is provided which directs the jet of water at the back of the vanes. This jet of water used to stop the runner of the turbine is called breaking jet.



1.Needle nozzle
2. Spear
3. Blades
4. Redirected water jet
5. Profile of a blade

Figure 2- The rotor and nozzle arrangement

Experimental Setup:-



1. Spring balance
2. Manometers
3. Adjustment of the nozzle cross-section
4. Needle Nozzle
5. Impeller
6. Adjustment of the band brake.

Fig. 3 Schematic diagram of experimental setup.

The experimental unit consists of an impeller, a needle nozzle used as control device, a band brake for loading the turbine. The impeller is housed in a transparent front panel so as to see the water flow through impeller and the nozzle during operation. The diameter of the nozzle is 10 mm. The cross-section of the nozzle and the flow rate are modified by adjusting the needle. The blades have the shape of a double cup.

Measurements:-

1. To determine the volumetric flow rate (Q) calculate time to fill the tank from 20 to 30 litres.
2. Use digital Tachometer to determine rotational speed (n).
3. Read the pressure (P) from manometer.
4. To determine the Torque (M) find out how much is braking force (F in N).

Sample Calculation

1. **Input Hydraulic power P_{hyd} :**

The hydraulic power is a function of volumetric flow rate and head- $P_{hyd} = f\,(Q, H)$

Thus the hydraulic power is given by,

$$P_{hyd} = \rho . g . H . \dot{Q}$$

The head can be written in terms of pressure and hence the formula becomes,

$$P_{hyd} = \frac{p . \dot{Q}}{1000 * 60} * 10^5 \quad [W]$$

Where p is pressure at inlet in bar and Q (volume flow rate) in l/min

2. **Torque M at the Shaft:**

Torque (M) = Force (F) * Lever arm radius

Force (F) = $(T_1 - T_2)$ [N]

Where Lever arm D = 0.05 m

3. **Power P_{av} at the turbine shaft:**

Power = Torque * angular velocity

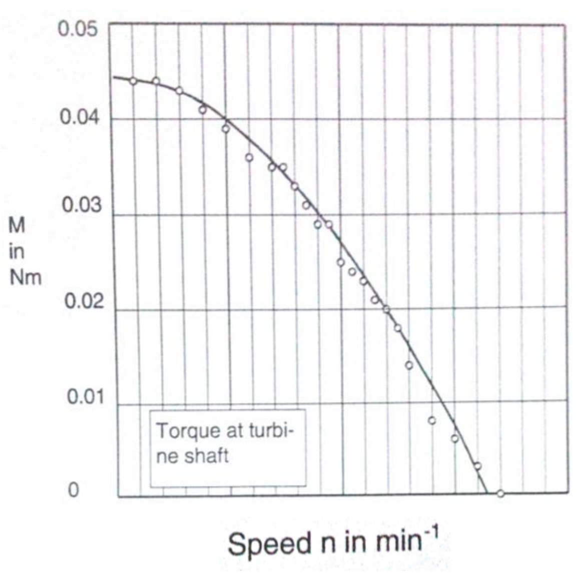
$$P_{av} = \frac{M * 2\pi N}{60} \quad [W]$$

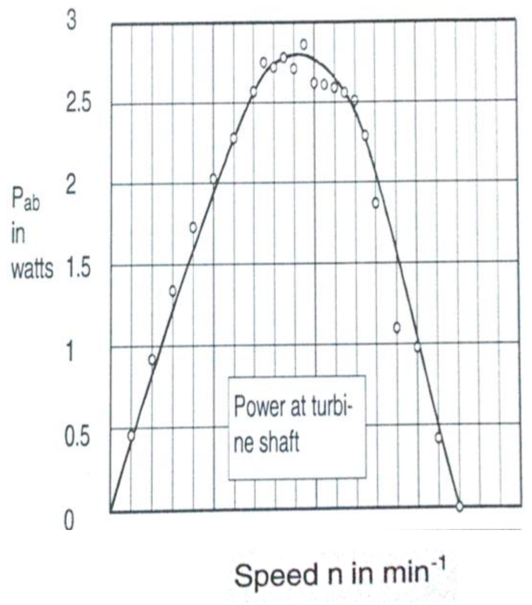
4. **Efficiency:**

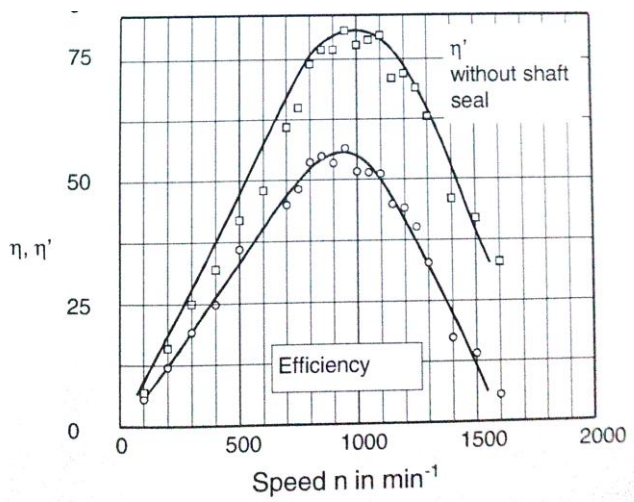
$$\eta = \frac{Shaft\ Power\left(P_{av}\right)}{Hydraulic\ Power(P_{hyd})} = \frac{T . \omega}{\rho g \dot{Q} H}$$

Efficiency can be enhanced still further if allowance is made from the outlet for the internal friction torque of approximately 0.012 N-m.

Performance Curves:







REPORT

In your laboratory reports must have the followings;

- Cover page (Exp. Name, Exp. Performance and Report Submission date, Group details)
- Objectives
- Working principle
- Experimental setup discussion
- All the necessary calculations using measured data
- Discussion of your results and a conclusion
- Source of error

Data Sheet

Title: Pelton Wheel

Group No. : **Date : / /**

Name and Roll No. :

1.
2.
3.
4.
5.

Observation Table:

Nozzle Position:

Pressure:

Volume:

Time:

Hydraulic Power:

Reading	F_1 (N)	F_2 (N)	Speed (RPM)	Force F (N)	Torque M (N-m)	Power (W)	Efficiency (%)	
							η	η'
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
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T.A. Sign.