Impact of free jet

Introduction: Water turbines are widely used throughout the world to generate power. In the type of water turbine referred to as a Pelton† wheel, one or more water jets are directed tangentially on to vanes or buckets that are fastened to the rim of the turbine disc. The impact of the water on the vanes generates a torque on the wheel, causing it to rotate and to develop power. Although the concept is essentially simple, such turbines can generate considerable output at high efficiency. Powers in excess of 100 MW, and hydraulic efficiencies greater than 95%, are not uncommon. It may be noted that the Pelton wheel is best suited to conditions where the available head of water is great, and the flow rate is comparatively small. For example, with a head of 100 m and a flow rate of 1 m3 /s, a Pelton wheel running at some 250 rev/min could be used to develop about 900 kW. The same water power would be available if the head were only 10 m and the flow were 10m3 /s, but a different type of turbine would then be needed. To predict the output of a Pelton wheel, and to determine its optimum rotational speed, we need to understand how the deflection of the jet generates a force on the buckets, and how the force is related to the rate of momentum flow in the jet. In this experiment, we measure the force generated by a jet of water striking a flat plate or a hemispherical cup, and compare the results with the computed momentum flow rate in the jet.

The jet of water is directed to hit the vanes of a particular shape a force is exerted on the vane by the jet.The amount of force depends on the diameter of the jet shape and the fluid flow rate it also depends on whether the vane is moving or stationary. In this experiment we are concerned about the stationary vane. The force on vane is given by the following formulas:

Flat Plate: Ft =ρ a v 2

Hemispherical Ft=2 ρa v 2

Where a = area of jet in m2

ρ = density of water = 1000 kg/ m3

v=velocity of jet in m/s

Ft = Force acting parallel to the direction of jet



**Impact of jet**

The liquid comes out in the form of a jet from the outlet of a nozzle which is fitted to a pipe

through which the liquid is flowing under pressure.A **jet** is a stream of fluid that is projected into

a surrounding medium, usually from some kind of a nozzle, aperture or orifice.[1] Jets can travel

long distances without dissipating.

Jet fluid has higher momentum compared to the surrounding fluid medium. In the case that the

surrounding medium is assumed to be made up of the same fluid as the jet, and this fluid has

a viscosity, the surrounding fluid is carried along with the jet in a process called entrainment.

**Force Exerted By Fluid Jet On Stationary Flat Plate**

The following cases of the impact of jet, i.e. the force exerted by the jet on a plate will be

considered considered:‐

1. Force exerted by the jet on a stationary plate

a) Plate is vertical to the jet

b) Plate is inclined to the jet

c) Plate is curve

2. Force exerted by the jet on a moving plate

a) Plate is vertical vertical to the jet

b) Plate is inclined to the jet

c) Plate is curved

**Force exerted by the jet on a stationary vertical plate**

Consider a jet o f water coming out from the nozzle strikes the vertical plate



V = velocity of jet, d = diameter of the jet, a = area of x – section of the jet

The force exerted by the jet on the plate in the direction of jet.

Fx = Rate of change of momentum in the direction of force

Rate of change of momentum in the direction of force = initial momentum – final momentum /

time

= mass x initial velocity – mass x final velocity / time

= mass/time (initial velocity – final velocity)

= mass/ sec x (velocity of jet before striking mass/ sec x (velocity of jet before striking – final

velocity of jet after striking)

Force of Jet Impinging On An Inclined Fixed Plate**:**

Consider a jet of water impinging normally on a fixed plate as shown in fig-2.





Force Of Jet Impinging On A Moving Plate***:***

Consider a jet of water imping normally on a plate. As a result of the impact of the jet, let the plate move

in the direction of the jet as shown in fig-3.



Let, v= Velocity of the plate, as a result of the impact of jet A little conversation will show that the relative

velocity of the jet with respect to the plate equal to **(V-v)** m/s. For analysis purposes, it will be assumed

that the plate is fixed and the jet is moving with a velocity of **(V-v)** m/s. Therefore force exerted by the jet,



**Force Of Jet Impinging On A Moving Curved Vane*:***

Consider a jet of water entering and leaving a moving curved vane as shown in fig-4.



Let,

• V = Velocity of the jet (AC), while entering the vane,

• V1 = Velocity of the jet (EG), while leaving the vane,

• v1, v2 = Velocity of the vane (AB, FG)

• α = Angle with the direction of motion of the vane, at which the jet enters the vane,

• β = Angle with the direction of motion of the vane, at which the jet leaves the vane,

• Vr = Relative velocity of the jet and the vane (BC) at entrance (it is the vertical difference

between V and v)

• Vr1 = Relative velocity of the jet and the vane (EF) at exit (it is the vertical difference between

v1 and v2)

• Ɵ = Angle, which Vr makes with the direction of motion of the vane at inlet (known as vane

angle at inlet),

• β = Angle, which Vr1 makes with the direction of motion of the vane at outlet (known as vane

angle at outlet),

• Vw = Horizontal component of V (AD, equal to ). It is a component parallel to the direction of

motion of the vane (known as velocity of whirl at inlet),

• Vw1 = Horizontal component of V1 (HG, equal to ). It is a component parallel to the direction

of motion of the vane (known as velocity of whirl at outlet),

• Vf = Vertical component of V (DC, equal to ). It is a component at right angles to the direction

of motion of the vane (known as velocity of flow at inlet),

• Vf1 = Vertical component of V1 (EH, equal to ). It is a component at right angles to the

direction of motion of the vane (known as velocity of flow at outlet),

• a = Cross sectional area of the jet. As the jet of water enters and leaves the vanes tangentially,

therefore shape of the vanes will be such that Vr and Vr1 will be a long with tangents to the

vanes at inlet and outlet. The relations between the inlet and outlet triangles (until and unless

given) are: (i) V=v1 , and

(ii) Vr=Vr1 We know that the force of jet, in the direction of motion of the vane,

