EXPERIMENT NO. 01

Study of Impulse momentum principle and its application to fixed flat, moving, inclined, and curved plates/vanes.

Date of Experimentation	**:**	
Date of Submission	**:**	
Signature of Batch Incharge	**:**	

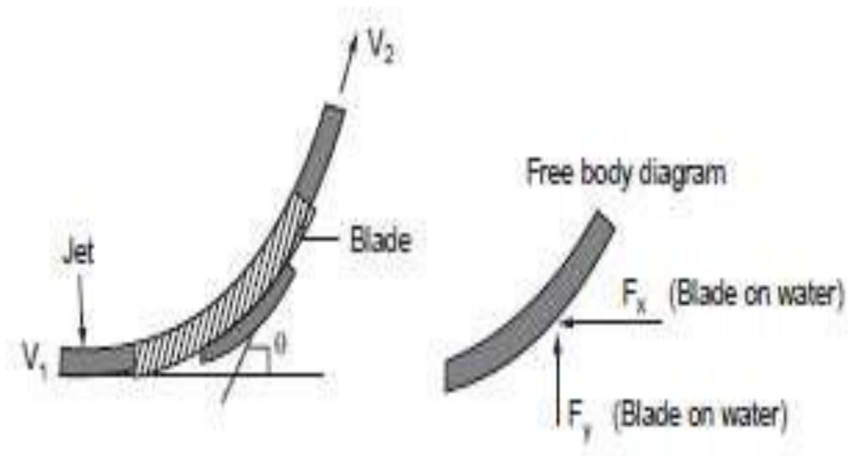

Figure 1

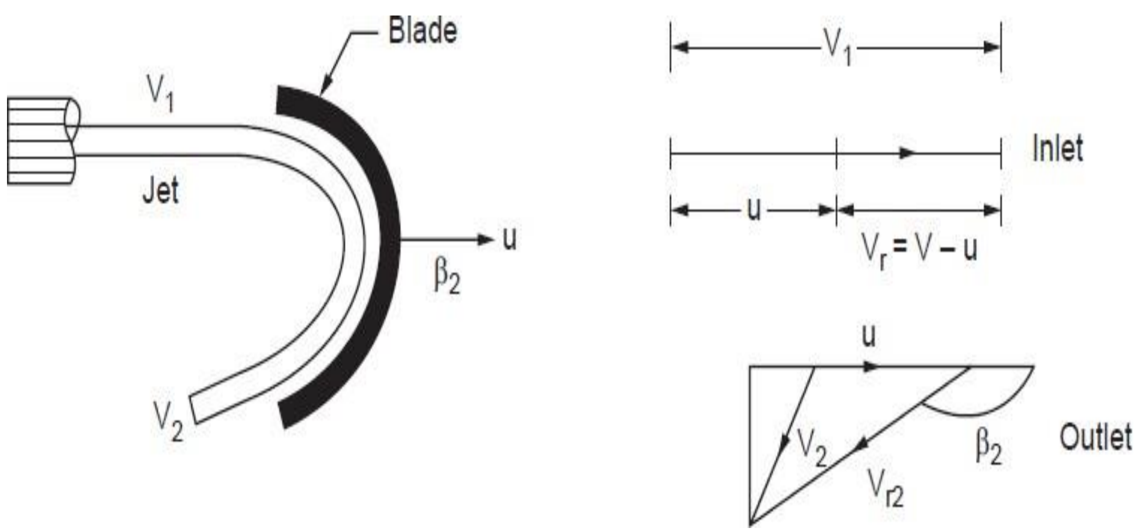

Figure 2

EXPERIMENT NO. 01

Study of Impulse momentum principle and its application to fixed flat, moving, inclined, and curved plates/vanes.

1. OBJECTIVE

i) Study of the Impulse Momentum Principle

ii) Application of the Impulse Momentum Principle to fixed and moving flat, inclined plates and vanes, and curved plates and vanes

2. THEORY AND PRINCIPLES

High velocities possess considerable energy. High-velocity fluid in the form of a jet exerts a force on the obstruction. This can be utilized in the generation of power when a jet of the fluid impacts the surface of the bucket and linked system for giving turbine. Thus, it becomes important to know the value of force to design the buckets and linked system. It is also known how jet deflection causes a force on turbine vanes that can be used to predict the output of the turbine.

2.1 A Study of the Impulse Momentum Principle

The impulse-momentum principle says that when you push or pull on someone, their momentum change equals the force you use. In other words, this principle is a modified form of Newton's second law, which states that the r**esultant external force acting on anybody in any direction is equal to the rate of change of momentum of the body in that direction.** Then, for any arbitrarily chosen direction 'x', t may be expressed as,

$$Fx = d(Mx)/dt$$

Where Fx denotes the resultant external force in the x-direction.

The above equation can also be written as Mx = momentum in the x-direction.

$$F_X *(dt) = d(Mx);$$

$$F_X (dt) = \text{impulse}$$

Calculate the theoretical force acting on the vane from the jet's velocity and the nozzle opening's area.

d(Mx) = Momentum change as a result of Mx.

From the above discussion, the above equation applies to finite or discrete bodies. Which force action can take place and be completed in a finite amount of time?

The water jet is allowed to strike the stationary vane. A lever mechanism and sliding weight measure the actual force acting on the vane.

2.2. Application of the Impulse Momentum Principle to fixed and moving plates and vanes

2.2.1 FORCE EXERTED ON A STATIONARY VANE OR BLADE

In the case of turbomachines fluid passes over blades and in this context, the force on a vane due to the fluid flowing over it is discussed. In turbomachines the blades are in motion. To start the analysis force on stationary vane is considered as shown in figure 1. Here the direction of the velocity is changed. There is negligible change in the magnitude. In the case considered pressure forces are equal both at inlet and outlet. The flow is assumed to occur in the horizontal plane.

Force along x direction by the blade on fluid, with the assumed direction:

Assuming $V_2 = V_1$ as no other energy transfer occurs,

$$-F_x = m(V_{2u} - V_1)$$
$$= m(V_2 \cos\theta - V_1)$$
$$= m(V_1 \cos\theta - V_1)$$
$$F_y = m(V_{2y} - V_{1y})$$
$$= m V_1 \sin\theta$$

2.2.1 FORCE ON A MOVING VANE OR BLADE

The force on a single moving vane is rarely met with. But this forms the basis for the calculation of force and torque on a series of moving vanes fixed on a rotor. There are two main differences between the action of the fluid on a stationary vane and a moving vane in the direction of the fluid motion. In the case of the moving vane it is necessary to consider both the absolute and relative velocities. The other difference is that the amount of fluid that strikes a moving vane at any time interval differs from that which strikes the stationary vane. If a jet of area A with a velocity V_1 strikes a stationary vane, the mass impinging per unit time on the vane equals 8 AV_1 kg/s. But when the vane moves away from the direction of the jet with a velocity of u, the mass of water striking the vane equals $\rho A(V_1 - u)$ kg/s. $(V - u)$ is the relative velocity between the jet and the vane. This can be realised when the consider the velocity of the vane to be equal to that of the jet. In this case no water will strike the vane, obviously. Consider the flow as shown in figure 2.

The velocity diagram with as inlet and outlet are shown in the figure. Considering the force on the fluid in the direction of blade velocity (can be considered as x direction)

$$Fu = \rho A\,(V_1 - u)\,(V_{u2} - V_{u1})$$

$$V_{u2} = (V_r \cos u)\,2\,\beta_2 \text{ , denoting Vr as relative velocity}$$

$$\therefore\ F_u = \rho A\,(V_1 - u)\,(V_r \cos u\ V_u)\,2\,\beta_2 - - 1$$

In the case shown, $V_{u1} = V$ itself, It is possible that $(V_{r2} \cos \beta_2 - u)$ or V_{u2} is negative depending upon the relative values of u and V_r i.e. $u > V_{r2} \cos \beta_2$.

It is to be noted that the vane angle at the inlet should be in the direction of the relative velocity of the water when it touches the vane. Otherwise loss will occur due to the jet hitting the vane at an angle and then turning the follow on the vane surface.

It was assumed that the relative velocity at inlet and at outlet are equal as no work was done by the vane on the fluid. In case of friction, $V_{r2}= cV_{r1}$ where c is a friction. In case the vane moves at a direction different from that of the jet velocity say at an angle α, then force on the fluid on the vane will be at an angle.

In such a case,

$$Fx = \rho A\,(V_1 \cos \alpha_1 i - V_{r2} \cos \beta_2 - u)\,(V_1 \cos \alpha_1 - u)$$

$$= \rho A\,(V_1 \cos \alpha_1 - V_2 \cos \alpha_2)$$

As it was already mentioned, a single moving vane is not of practical importance when a series of vanes fixed on the periphery of a well is struck by the jet, then the mass of fluid striking the when will be ρAV itself.

Work or energy transfer between the fluid and the water will be F × u .