

## Experiment 4

### IMPACT OF JET (I)

#### INTRODUCTION:

Impact of jets apparatus enables experiments to be carried out on the reaction force produced on vanes when a jet of water impacts on to the vane. The study of these reaction forces is an essential step in the subject of mechanics of fluids which can be applied to hydraulic machinery such as the Pelton wheel and the impulse turbine.

#### OBJECTIVE:

To investigate the reaction force produced by the impact of a jet of water on to various target vanes (flat and semispherical)

#### APPARATUS:

- The F1-10 Hydraulic Bench
- F1-16 equipment
- Stopwatch
- Flat and semispherical plates.

#### THEORY:

When a jet of water flowing with a steady velocity strikes a solid surface (target plate), the water is deflected to flow along the surface. Then the jet velocity can be calculated from the measured flow rate and the nozzle exit area:

$$v = \frac{Q}{A}$$

If the friction is neglected, also assuming that there are no losses due to shocks and the magnitude of the water velocity remains having the same value but only its direction changes. The pressure exerted by the water on the solid surface will everywhere be at right angles to the surface (for a flat surface).

In the absence of friction,

- Magnitude of the velocity across the surface = Incident velocity,  $v_i$
- The impulse force exerted on the target = opposite to the force which acts on the water to impart the change in direction.

Applying Newton's second law in the y-direction of the incident jet

$$F_y = Q_m v (\cos\theta - 1)$$

Where

$F_y$  = force exerted by deflector on fluid

$Q_m$  = mass flow rate and

$$Q_m = \rho Q_t = \rho A v$$

So,

$$F_y = \rho A v^2 (\cos\theta - 1)$$

For a static equilibrium,  $F_y$  is balanced by the applied load,  $W = Mg$  ( $M$  is the applied mass) hence,

$$W = \rho A v^2 (\cos\theta - 1)$$

Graphically representing the results also will show how accurate the experimental data is. Thus, the slope,  $s$ , of a graph of  $W$  plotted against  $v^2$  is obtained from a regression line and this is compared to the value from:

$$s = \rho A (\cos\theta - 1)$$

### **PROCEDURE:**

1. Position the weight carrier on the weight platform and add weights until the top of the target are clear of the stop and the weight platform is floating in mid position. Move the pointer so that it is aligned with the weight platform. Record the value of weights on the weight carrier.
2. Start the pump and establish the water flow by steadily opening the bench regulating valve until it is fully open.
3. The vane will now be deflected by the impact of the jet. Place additional weights onto the weight carrier until the weight platform is again floating in mid position.
4. Measure the flow rate and record the result on the test sheet, together with the corresponding value of weight on the tray. Observe the form of the deflected jet and note its shape.

5. Reduce the weight on the weight carrier in steps and maintain balance of the weight platform by regulating the flow rate in about three steps, each time recording the value of the flow rate and weights on the weight carrier.
6. Close the control valve and switch off the pump. Allow the apparatus to drain.
7. Replace the flat vane with semispherical vane and repeat the test

**TABLE OF OBSERVATIONS AND CALCULATIONS:**

- Nozzle diameter,  $d=0.008\text{m}$
- Nozzle cross sectional area,  $A=5.0265 \times 10^{-5}\text{m}^2$
- Density of Water,  $\rho=1000\text{kg/m}^3$

Reading No	Plate type	Volume of water collected $\text{m}^3$	Time (sec)	Mass applied(Kg)
1	Flat plate $\alpha=90^\circ$			
2				
3				
4				
5				
1	semispherical plate $\alpha=180^\circ$			
2				
3				
4				
5				

**GRAPHICAL RELATIONSHIP:**

Plot force on vane  $F$  (N) against the velocity squared values for both flat plate and a hemispherical cup for theoretical and experimental values on the same plot.

**CONCLUSION AND RECOMMENDATIONS:**

- Comment on the agreement between your theoretical and experimental results and give reasons for any differences
- Compare between theoretical slope for flat and semispherical plate and what does it mean?
- Comment on the significant of any experimental errors