Impact of a Jet

Objective

To compare the momentum in a fluid jet with the force generated when it strikes a flat plate and a hemispherical cup.

Apparatus

The following equipment is required for the experiment:
(a) Impact of a Jet Apparatus
(b) Steady water supply with a flow control valve
(c) Flow meter
(d) A flat plate and a hemispherical cup
(e) Set of calibrated weights

The impact of a jet is depicted in Figure 6.1. The jet and the plate are located inside the transparent casing.
Theory

Applying the momentum equation in x direction

\[-F_x = \rho Q [V_{x,out} - V_{x,in}]\]
\[= \rho Q [V \cos \beta - V]\]
\[F_x = \rho Q V [1 - \cos \beta]\]

For flat plate, $\beta = 90$ deg.

\[F_x = \rho Q V\]

For a hemispherical cup, $\beta = 180$ deg

\[F_x = 2 \rho Q V\]

The exit velocity $u$ can be obtained from the rate $Q$ as follows:

\[U = \frac{Q}{\text{area of nozzle}}\]

The jet at the nozzle is vertically displaced from the point of contact on the plate therefore an adjustment can be made to relate the exit velocity $u$ to the impact velocity $v$.

Applying the Bernoulli’s equation between nozzle and plate:
\[ \frac{P_n}{\gamma} + \frac{u^2}{2g} + Z_n = \frac{P_p}{\gamma} + \frac{V^2}{2g} + Z_p \]

Now:

\[ \frac{P_n}{\gamma} - \frac{P_p}{\gamma} = 0 \quad \text{Since the nozzle is at atmosphere.} \]

And

\[ Z_n - Z_p = s \]

Therefore:

\[ V^2 = U^2 - 2gs \]

**Experimental Procedure**

The following procedure is to be performed during this experiment:

1. Install the flat plate in the apparatus
2. Note the no load position of the weigh tray by aligning the pointer on top of the apparatus to the weigh pan.
3. Add the appropriate masses to the way tray until it returns to the no load position.
4. Record the flow rate and mass.
5. Reduce the water supply and repeat procedure (steps 4-5) for each flow rate.
6. Replace the flat plate with an hemispherical cup and repeat procedure.

**Report**

In the report

1. For each flow rate determine the force on the plate for each flow rate.
2. Compute the force on the flat plate by the rate of delivery of momentum \((\rho QV)\) of jet at impact.
3. Plot force on the flat plate against delivery of momentum jet. Derive an equation for force on flat plate by means of this graph.
4. Compare results with analytical solution for force on flat plate assuming no fluid friction
5. Discuss your results.

**Data sheet for Impact of a jet**

Diameter of the nozzle =
Cross sectional area of nozzle =
Height of impact above nozzle tips =
<table>
<thead>
<tr>
<th>Mass</th>
<th>Q</th>
<th>U</th>
<th>V</th>
<th>F</th>
<th>ρQV</th>
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</thead>
<tbody>
<tr>
<td>(gr.)</td>
<td>(liter/min)</td>
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<tr>
<td>Hemispherical cup</td>
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