OBJECTIVE 1

TO DETERMINE THE COEFFICIENT OF IMPACT FOR VANES AND COMPARE WITH THEORETICAL VALUE

APPARATUS REQUIRED:

- Scale
- Collecting tank
- Nozzle
- Transparent cylinder
- Vane of different shapes
- weights

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THEORY:

Momentum equation is based on Newton's second law of motion which states that the algebraic sum of external forces applied to control volume of fluid in any direction is equal to the rate of change of momentum in that direction. The external forces include the component of the wt. of fluid & the force extended externally upon the boundary surface of control volume.

If a vertical water jet moving with velocity is made to strike a target which is free to move in the vertical direction, then a force will be exerted on the target by the ~~and~~ impact of jet, according to momentum eqn this force must be equal to rate of change of momentum of the jet flow in that direction.

Formula used:

$$F = \rho Q (v_{in} - v_{out})$$
$$= \rho Q (v - v\cos 180^\circ)$$
$$= \rho Q v (1 - \cos 180^\circ)$$
$$\therefore F = 2\rho Q v$$

Here,
F = force
ρ = density of water
v = velocity of jeat
Q = discharge

PROCEDURE:

(i) Relevant dimensions or area of collecting tanks, dia of nozzle was measured.

(ii) The position of upper disk, when jet was not running was noted down.

(iii) The initial reading of water level in the collecting tank was measured.

(iv) When the jet striked the vane, the position of upper disk changed & the reading in the scale to which vane raised was noted.

(v) The weights of various values were added one by one in the weight carrier to bring vane to initial position.

(vi) At this position, the discharge was also found out.

~~(vii)~~

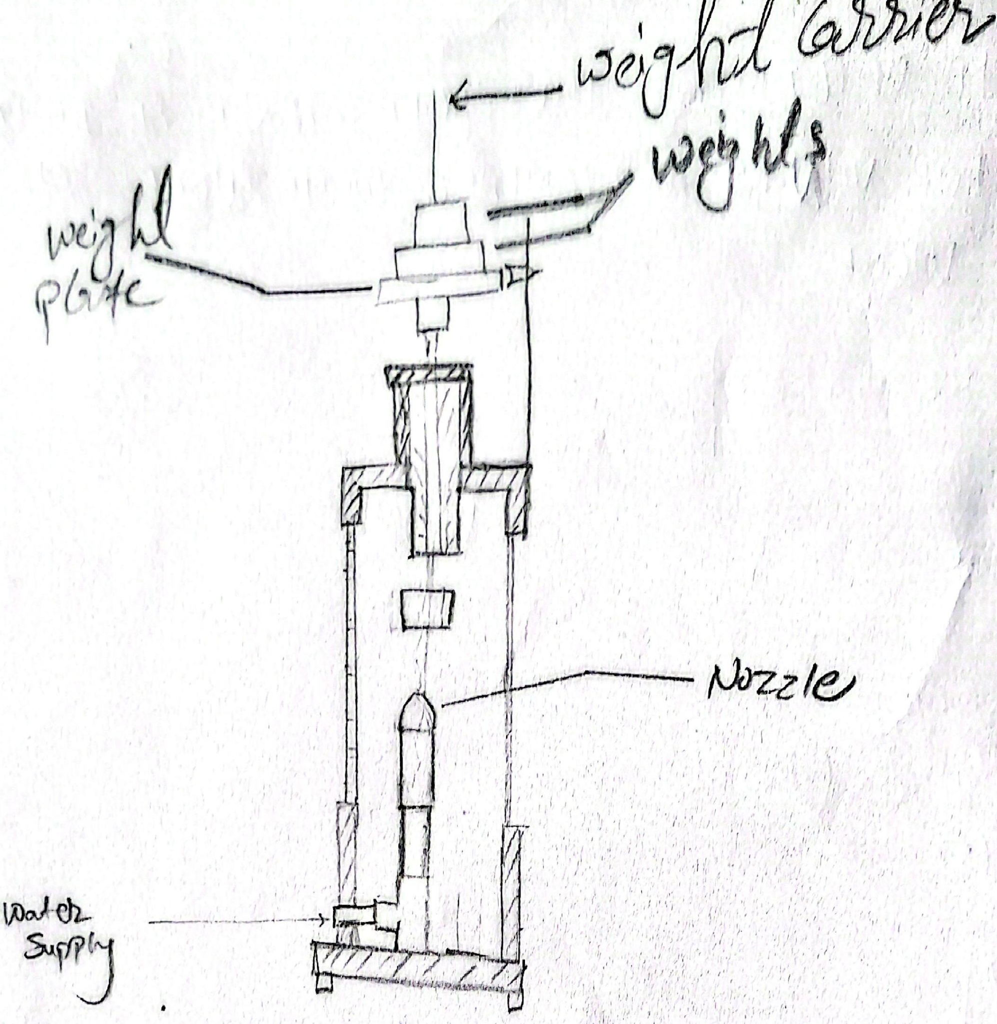

fig. Illustrative figure of impact of jet apparatus

OBSERVATION & CALCULATION

diameter of nozzle = 10 mm = 10×10^{-3} m

Area of Nozzle (A) = $\frac{\pi}{4} \times (10 \times 10^{-3})^2 = 7.85 * 10^{-5}$ m^2

density of water (ρ) = 1000 kg/m^2

Area of collecting tank = length * breadth

= 42×30

= 1260×10^{-4} m^2

= 0.126 m^2

Initial water level = 15.1 cm

Final water level = 16 cm

Time taken = 9.4 s

~~Theoretical force~~ F — Total weight added = $0.2 \times 9.81 = 1.962$ N (= F) —— (1)

∴ Total volume of water collected in tank in 9.4 s = height * area of tank

$= [(16 - 15.1) \times 10^{-2}] * 0.126$

$= 1.134 * 10^{-3}$ m^3

So $Q = \frac{1.134 * 10^{-3}}{9.4} = 1.206 \times 10^{-4}$ m^3/s

Hence, force $(F_1) = 2 * \rho * Q * v$

$= \frac{2 \rho Q^2}{A}$

$= \frac{2 \times 1000 \times (1.206 \times 10^{-9})^2}{7.85 \times 10^{-5}}$

= 0.373 N —— (2)

Error % = $\frac{1.962 - 0.373}{\cancel{1.962}\ 0.373}$ ~~= 0.809 = 80.9%~~

= 4.260

= 426 %

RESULT :

The force exerted on the vane by the impact of jet was found to be 0.373 N & the force (or weight) required to bring back the target in its original position was found to be 1.962 N.

CONCLUSION :

To balance the impact of jet on vane, way more (exactly 426 %) of force was applied whereas it should be equal to force exerted by jet. This might have happened due to various reasons like non-standard conditions of pressure, temperature, influence of external forces, carelessness in taking measurements & so on.

PRECAUTION :

(i) Laboratory code should be followed by all participants.

(ii) While taking measurements, ~~there~~ observer should be ~~focus~~ ~~maintaine~~ careful and focused.

(iii) water collection time should be measured precisely.

OBJECTIVE 2

DETERMINATION OF HYDRAULIC COEFFICIENTS FOR CIRCULAR ORIFICE [EXPERIMENTALLY]

MATERIALS REQUIRED:

- Supply tank with orifice
- Measuring tank
- Circular orifice plate
- Measuring scale
- Water supply with motor
- Stopwatch
- Needle setup (for jet trajectory tracing)

THEORY:

When water flows through an orifice, it form a jet whose properties deviate from ideal theoretical behavior due to contraction, friction & turbulence.

The following three coefficients quantify these deviations:

→ **Coefficient of Contraction (C_c):**

- ratio of area of jet at vena contracta to the area of orifice.

i.e., $C_c = \dfrac{A_{vc}}{A_0}$

→ **Coefficient of velocity (C_v):**

- ratio of actual velocity of jet to theoretical velocity

i.e., $C_v = \dfrac{V_{actual}}{V_{th}}$

→ **Coefficient of Discharge (C_d):**

ratio of actual discharge to theoretical discharge.

$$C_d = \frac{Q_{act}}{Q_{th}} = C_c \times C_v$$

Also,

$$V_{th} = \sqrt{2gH}$$

$$Q = A \times V = \frac{\text{Volume}}{\text{time}}$$

$$A_0 = \frac{\pi d^2}{4}$$

PROCEDURE:

1) ~~Fill~~ the supply tank was filled with water using pump until a desired steady head (H) is maintained above the orifice centre.
2) ~~Measure~~ the head of water above the orifice centre was measured.
3) Allow the water flow through orifice & collect the discharged water in measuring tank for known time using a stopwatch
4) The volume of collected water was measured
5) The jet trajectory was traced to measure horizontal distance (x) and vertical distance (y).
(6) Finally, the hydraulic coefficients were measured.

OBSERVATION & CALCULATION:

Head of water $(H) = 21.5\ cm$

$x = 22.2\ cm$

$y = 6\ cm$

Area of orifice $(A_o) = \frac{\pi \times 1^2}{4} = 0.785\ cm^2$

$V_{th} = \sqrt{2gH}$

$= \sqrt{2 * 981 * 21.5}$

$= 205.38\ cm/s$

$x = Vt \quad ; \quad t = \frac{x}{V}$

$y = \frac{1}{2} gt^2$

$= \frac{1}{2} * g * \frac{x^2}{V^2}$

$\Rightarrow V^2 = \frac{1}{2} * \cancel{9.81}\ 981 \times \frac{(22.2)^2}{6}$

$\Rightarrow V = 200.72\ cm/s$

$\therefore$ Coefficient of velocity $(C_v) = \frac{V}{V_{th}} = \frac{200.72}{205.38} = 0.98$

For C_d:

Area of measuring tank (A) = 1200 cm^2

Time (t) = 30 s

$h_1 = 4.1 cm$

$h_2 = 7.1 cm$

$h = 3 cm$

∴ Volume of water collected = 1200 × 3 = 3600 cm^3

~~So~~ Actual discharge (Q_{act}) = $\frac{3600}{30}$ = 120 cm^3/s

$Q_{th} = 0.785 * V_{th} = 0.785 * 205.38 = 161.22\ cm^3/s$

Hence, $C_d = \frac{Q_{act}}{Q_{th}} = \frac{120}{161.22} = 0.74$

Finally, $C_c = \frac{C_d}{C_v} = \cancel{\frac{0.98}{0.74}}\ \frac{0.74}{0.98} = 0.75$

RESULT:

→ coefficient of discharge (C_d) = 0.74

→ coefficient of velocity (C_v) = 0.98

→ coefficient of contraction (C_c) = 0.75

PRECAUTIONS:

→ Maintain constant head during the experiment.

→ Stopwatch reading should be accurate.

→ Take multiple reading to minimize human/instrumental error.

→ Avoid splashes or spillage while collecting water in measuring tank.