Al-Mustaqbal University
College of Engineering and Engineering Technologies
Department of Chemical Engineering and Petroleum Industries

EXPERIMENTS(2)

SECOND CLASS

1ND SEMESTER

FLUID FLOW LABORATORY

By

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Experiment No. (2): *(Impact Of Jet)*

Purpose of Experiment:

The objective of this experiment is to investigate the reaction forces produced by the change in momentum of a fluid flow when a jet of water strikes a flat plate or a curved surface, and to compare the results from this experiment with the computed forces by applying the momentum equation.

Introduction:

Moving fluid, in natural or artificial systems, may exert forces on objects in contact with it. To analyze fluid motion, a finite region of the fluid (control volume) is usually selected, and the gross effects of the flow, such as its force or torque on an object, is determined by calculating the net mass rate that flows into and out of the control volume. These forces can be determined, as in solid mechanics, by the use of Newton's second law, or by the momentum equation. The force exerted by a jet of fluid on a flat or curve surface can be resolved by applying the momentum equation. The study of these forces is essential to the study of fluid mechanics and hydraulic machinery.

METHOD

The momentum force is determined by measuring the forces produced by a jet of water impinging on solid flat and curved surfaces, which deflect the jet at different angles.

EQUIPMENT:-

The following equipment is required to perform the impact of the jet experiment:

- Hydraulics bench,
- Impacts of a jet apparatus with three flow deflectors with deflection angles of 90, 120 and 180 degrees, and
- Stopwatch for timing the flow measurement.

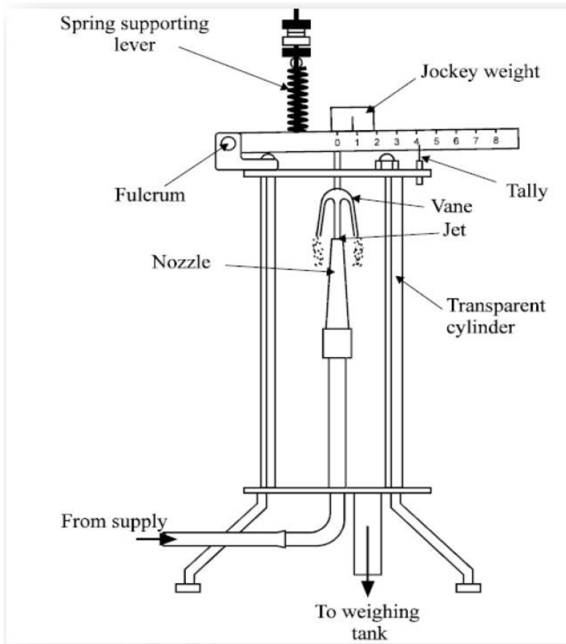


Fig 11.1 Impact of Jet Apparatus

EQUIPMENT DESCRIPTION

The jet apparatus is a clear acrylic cylinder, a nozzle, and a flow deflector (Figure 11.1). Water enters vertically from the top of the cylinder, through a nozzle striking a target, mounted on a stem, and leaves through the outlet holes in the base of the cylinder. An air vent at the top of the cylinder maintains the atmospheric pressure inside the cylinder. A weight pan is mounted at the top of the stem to allow the force of the striking water to be counterbalanced by applied masses.

Theory:

The velocity of the water (v) leaving the nozzle with the cross-sectional area (A) can be calculated by:

$$v = \frac{Q}{A} \qquad (1)$$

in which Q is the flow rate.

Applying the energy equation between the nozzle exit point and the surface of the deflector shows that the magnitude of the flow velocity does not change as the water flows around the deflector; only the direction of the flow changes.

Applying the momentum equation to a control volume encompassing the deflected flow results in:

$$\mathbf{F_x = 0}$$

$$\mathbf{F_y = \rho\, Q\, v\, (1 - \cos\theta)} \qquad \mathbf{(2)}$$ where:

F_y: force exerted by the deflector on the fluid

ρ : fluid density θ : the angle between the initial velocity of the jet V_1 and the velocity after striking the plate V_2.

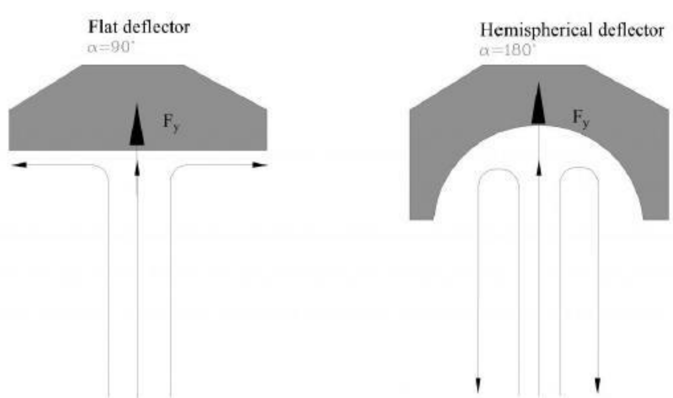


Fig 11.2 Examples of flow deflection angles for flat and hemispherical deflectors From equilibrium of forces in a vertical direction, F_y is balanced by the applied weight on the weight

pan, W (W = mg, where m is the applied mass), i.e., $F_y = W$.

Therefore:

Fy = the force exerted by weights on fluid ($F_{experiment}$) (N).

$F_{experiment}$ = mass x g (3)

Procedure:-

1. Switch on the power and start the motor.
2. Mark the position of vertical lever and horizontal arm when there is no weight on the pan.
3. Open the inlet valve so that jet of water strikes the flat plate at its center. The lever is deflected to one side.
4. Put a weight W on the pan so as to bring the lever in its original position as marked in step1.
5. Measure the discharge Q by volumetric method.
6. Repeat step 2 and 4 for various other discharges.

C_{i} = coefficient of impact

F – Force due to pressure of jet water.

ρ=Mass density of water = 1000 kg/m^3

A=Area of nozzle (A)= $\frac{\pi}{4}d^2$=0.785 × 10^{-4} m^2

F_{act} × 0.125 = mg × L …….(1)

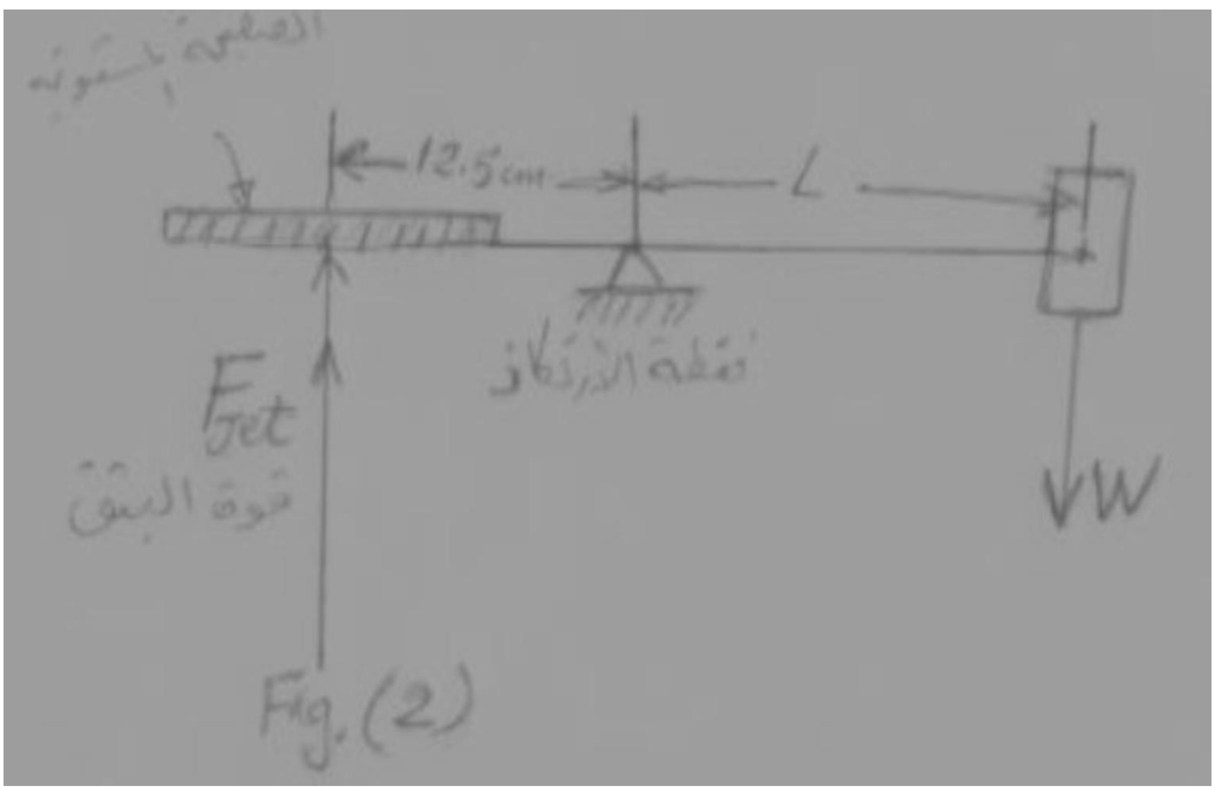
m =1.25 kg

F_{act} × 0.125 = 1.25 × 9.81 × L …….(2)

F_{theo} = ρ Q V

Q = AV

$C_i = \frac{Fact}{Ftheo}$



Calculate:-

1. F_{act}
2. F_{theo}
3. Ci (coefficient of impact)

NO.	Discharge(Q)(L/min)	Discharge(Q)(m^3/s)	Velocity (v)(m/s)	L (m)	Force (N)
1.	10			0.057	
2.	15			0.129	
3.	20			0.23	
4.	25			0.36	

Discussion:

1. **What are the applications of the impact of a jet?**
2. **What happens when the velocity of a fluid is increased? How does this affect the force?**