Practical work 3: Impact of a Water Jet on an Obstacle

1. Objective:

When a fluid jet strikes a solid surface, it exerts a force on the surface that depends on the velocity of the jet and the geometric shape of the solid. This experiment allows the study of the impact of a water jet on two different obstacles: a flat plate and a hemisphere. By directly measuring the force exerted by the water jet on an obstacle, the Euler momentum theorem is studied experimentally through the measurement of the impact force on the plates (flat and hemispherical).

2. Characteristics of the Measurement Setup

A vertical pipe supplied by the hydraulic bench ends with a nozzle that produces a water jet with variable flow rate. This jet strikes an obstacle and deflects at an angle α\alphaα relative to the direction of the incident jet. The nozzle and the obstacle are enclosed in a transparent cylinder, whose base has a hole for draining water into the balance. The main dimensions are:

- Jet diameter: 8 mm
- Impact surfaces: flat, curved, hemispherical
- Set of weights: 200 g, 400 g, 600 g, and 800 g

3. Theory:

Consider a water jet striking an obstacle. If friction and head losses are neglected, the only external force is the force exerted by the obstacle, F. The application of Euler's momentum theorem allows us to calculate the theoretical forces for different surfaces:

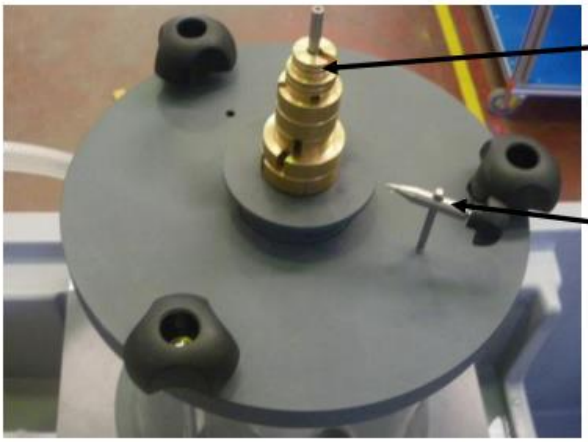
- Flat plate (α=90°) : $F_a = \rho Q^2 / S$
- Curved surface (α=120°): $F_a = \frac{3}{2} \rho Q^2 / S$
- Hemispherical cup (α=180°): $F_a = 2\, \rho Q^2 / S$

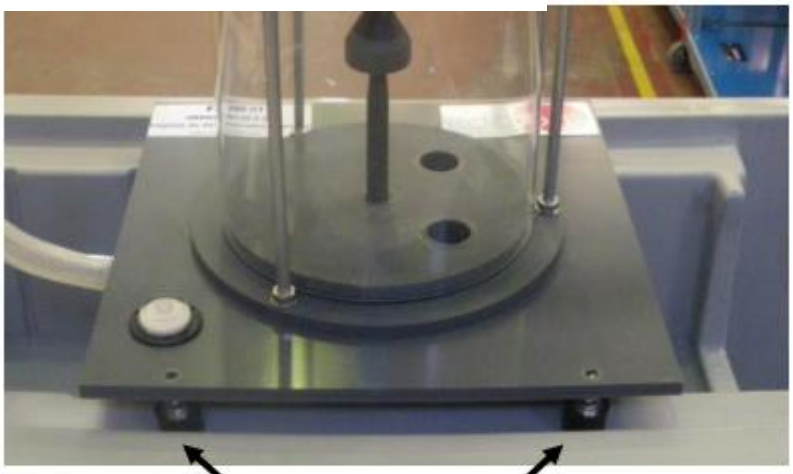
4. Procedure:

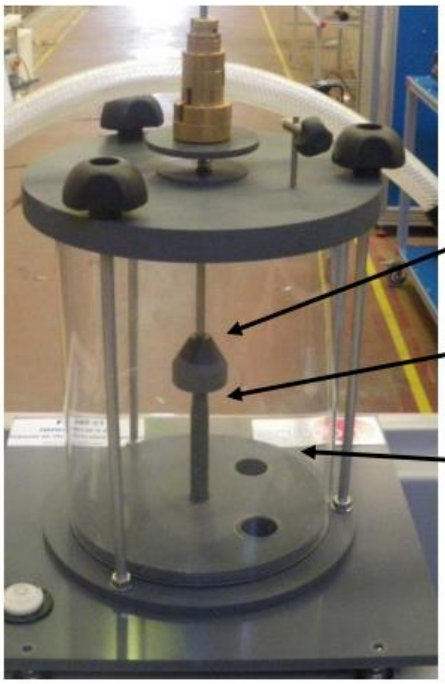
- Connect the device to the hydraulic bench and level it using the adjustable feet.
- Mount an obstacle on the device and set the pointer to zero.
- Place a mass on the platform and adjust the flow rate to bring the pointer back to zero.
- Record the flow rate and the mass value.
- Repeat the procedure for the other two obstacles.

5. Results and Calculations

Complete Table 1.


Calibrated weights (4)
Reference gauge (5)


Adjustable supports (6)


Test surface (3)
Nozzle (2)
Water tank (1)

FLAT IMPACT SURFACE (α = 90°)						
Weight (Kg)	F_m (N)	Volume (m^3)	Time (sec)	Q (m^3/s)	Q^2	F_a (N)
SEMISPHERICAL IMPACT SURFACE (α = 180°)						
Weight (Kg)	F_m (N)	Volume (m^3)	Time (sec)	Q (m^3/s)	Q^2	F_a (N)

- Using the graph, describe and comment on the forces that appear in the system.
- Analyze the behavior of the horizontal reaction of the impact surface.
- For guidance, note that for the hemispherical surface, the flow rate required to balance the system with a load of 330 g is 20±2 L/min.