AE 204 FLUID MECHANICS

STRIKING JET EXPERIMENT / EXP6

2024

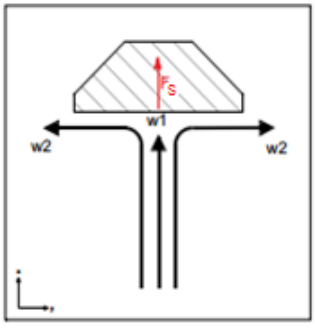
OBJECTIVE

This product shows students the force produced by a jet of water as it strikes a flat plate, a hemispherical cup, a 90-degree conical plate or a 120-degree (convex) conical plate. They can then compare this to the momentum flow rate in the jet.

THEORY

“Striking Jet” consists of a transparent cylinder containing a vertically tapered nozzle and a test plate. The cylinder is on legs and mounts on the top of the hydraulic bench. The nozzle, supplied by the hydraulic bench, produces a high-velocity jet of water which hits the test plate. The test plate connects to a strain gage which measures the jet force. A drain tube in the base of the cylinder directs water back into the hydraulic bench, allowing accurate flow rate measurement. The calculation methods of the jet force are summarized for each test plate as follows:

Flat plate:

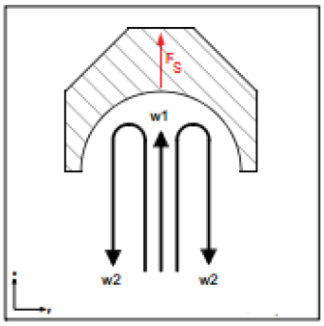


$$F_{s=V.\rho.(W_1-W_2)}$$

$$W_2 = 0$$

$$F_{s=V.\rho.W_1}$$

A hemispherical cup:

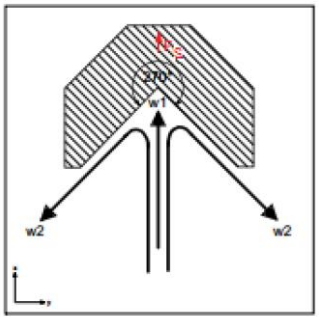


$$F_s = V.\rho.(W_1 - W_2)$$

$$W_2 = -W_1$$

$$\boxed{F_s = 2.V.\rho.W_1}$$

90-Degree conical plate:



$$F_s = V.\rho.(W_1 - W_{2x})$$

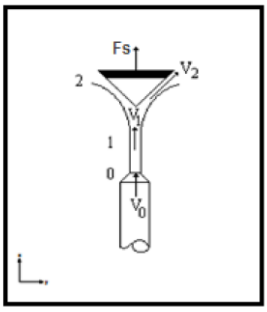
$$W_2 = -W_{1.}\cos\ \alpha$$

$\alpha = 45^{\circ}$

$$W_{2x} = W_2.\cos\ \alpha$$

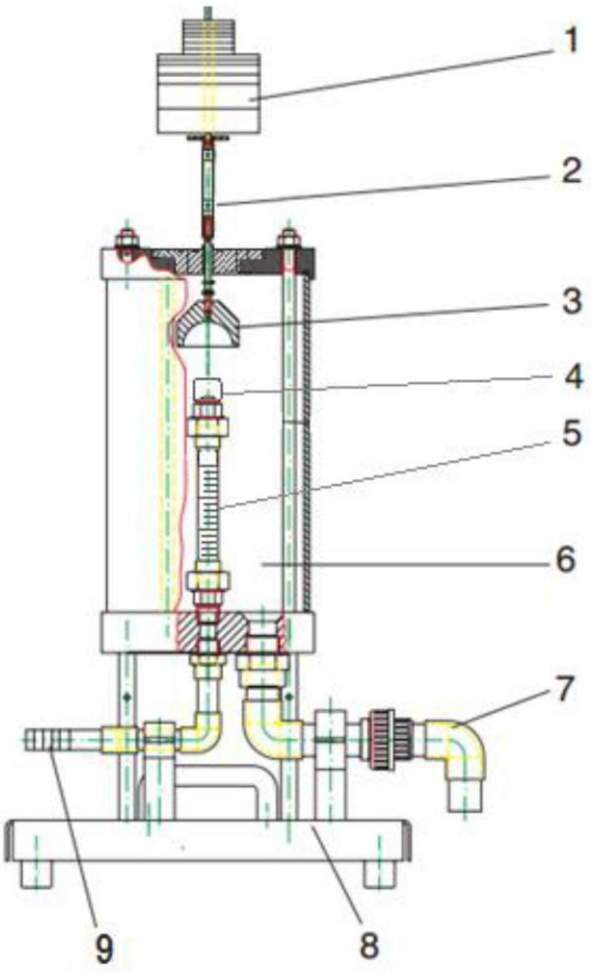
$$\boxed{F_s = V.\rho.W_1.(1 + cos^2\ \alpha)}$$

120-Degree (convex) conical plate:



$$\boxed{F_s = m\ (V1 - V_2\ cos\ a)}$$

DESCRIPTION OF APPARATUS



1. Strain gage
2. Connecting cylinder
3. Deflector plate
4. Nozzle
5. Rotameter
6. System section view
7. Drainage valve
8. Base plate
9. Water inlet valve

Figure 1. The "Striking Jet" Experimental Setup.

PROCEDURE

1. Place the jet impact test assembly on the hydraulic main unit if you do not have a main unit, connect it to any pressurized water source (Water pressure should be at least 4 bars and flow rate should be at least 1 m^3/h).
2. Select your deflector plate and unmounts the cover of the cylinder from its screws, place the selected deflector plate and mount it again with lock cap nuts.
3. Open the inlet valve after connecting the water inlet to the system.
4. Check for any water leaks.
5. After opening the water, the loading platform will rise with the effect of water impacting the deflector. Be sure that the platform effect is read by the strain gage force reading screen.
6. Note the water flow rate (m^3/h) versus force (N) on the table.
7. This experiment asks the student to measure the force on the plates for different flow rates and calculate the rate of delivery of momentum. The results should be linear, producing gradients that are unique to the design of the plate.

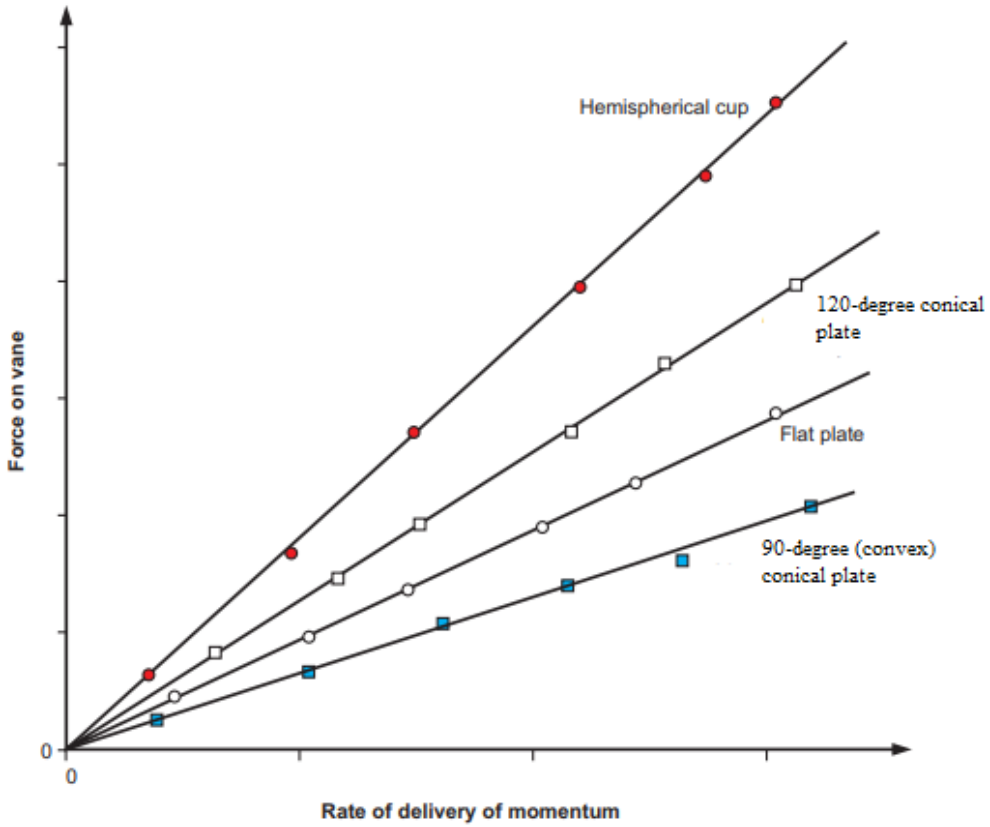


Figure 2. Rate of Delivery of Momentum (m^3/h) versus Force on Plates (N).

REFERENCES

1. https://www.tecquipment.com/impact-of-a-jet, Access date: 02.04.2024.

2. Munson, B.R. et al., Fundamentals of Fluid Mechanics, 7th Ed., 2013.

THE IMPACT OF A JET EXPERIMENT / LAB 6 DATA SHEET DATE:

STUDENT NAME, SURNAME: SIGNATURE:

TABLE 1

Data No	Q, Volumetric flow rate (m^3/s)	Force, F (N) MEASURED
1		
2		
3		
4		
5		
6		

Diameters of nozzles d = 6 and 10 mm
(Check out which nozzle type is used.)

Deflector plate weights

Flat plate: 0.105 N

Hemispherical cup: 0.055 N

30-degree conical plate: 0.050 N

90-degree conical plate: 0.060 N

120-degree (convex) conical plate: 0.065 N

Platform: 0.05 N

TABLE 2

Data No	Cross-sectional Area (m^2), A_D	Flow speed (m/s), $W_1 = Q / A_D$	Force, F (N) CALCULATED	Percentage error of Calculated Force wrt. Measured Force
1				
2				
3				
4				
5				
6				

Calculation steps:

1. During the experiment, fill in the Table 1.
2. After collecting the measured data, using given constant parameters (diameters, weights of the deflector plates), fill in Table 2.
3. Draw Free Body Diagram (FBD) of the jet striking the plate.
4. FIRST GRAPH: Draw flowrate (m^3/s) versus measured force (N) as in Figure 2.
5. SECOND GRAPH: Draw flowrate (m^3/s) versus calculated force (N) as in Figure 2.
6. Comment on the percentage error of calculated force with respect to measured force.

LAB RULES:
•Each group should submit one report.
•Each group should write each part by their own and get together with their group members to merge all of them.
•Reports are due to next Monday. They must be submitted to the corresponding assistant **till 17:00** on the next Monday.
•Students must sign the data sheet from the lab assistant at the end of each experiment and the signed sheet must be attached with the report. Reports without the signed data sheet will not be graded.
•Students are advised to read the detail of each experiment sheet before coming to the corresponding lab class.

LAB REPORT FORMAT (HANDWRITTEN EXCEPT COVER PAGE, TABLES AND PLOTS):
The lab report (no longer than 15 pages – all included –) should include the followings (unless otherwise specified):

1. Objective
2. Theory
3. Procedure
4. Results
5. Sample calculation
6. Necessary plots
7. Discussion on results, errors and graphs
8. Conclusion