LAB 4 – LINEAR MOMENTUN OF A WATER JET

LEARNING OUTCOMES

1. Describe the conservation of linear momentum
2. Measure the theoretical and experimental velocity for different types of angled plates

In this experiment, we will use the water jet apparatus connected to the Armfield Hydraulic Bench to study the principle of conservation of linear momentum. This apparatus (shown in Figure 1) consists of an upward pointing nozzle whose water jet strikes a target plate. The apparatus allows different types of target plates to be attached.

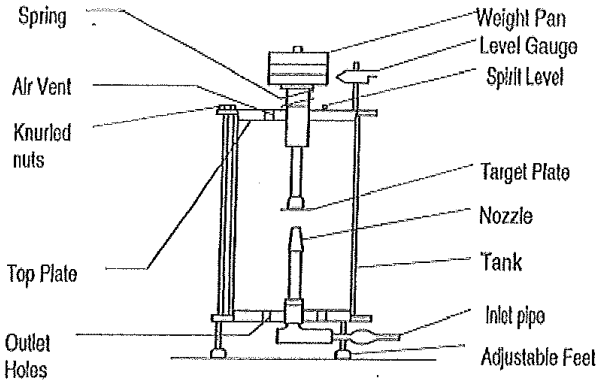

Figure 1. Schematic diagram of the water jet apparatus

EXPERIMENTAL PROCEDURE

1. For this experiment, an 8-mm diameter jet of water will impact upon three different types of shaped flow deflectors (90˚, 120˚ and 180˚) at a given steady flow rate
2. Ensure that the apparatus is level in the side channel of the hydraulic bench and check that the top-level gauge is aligned at the center line of the weight pan with no weights applied
3. Add weights in small increments (combination of 100, 50 and 20 grams)
4. Turn on the pump and adjust the bench valve to produce a flow that will re-align the level gauge with the center line
5. Measure the flowrate using the bench and a stopwatch. Repeat few trials for accuracy
6. Repeat the experiment for different flowrates and weights
7. Repeat the process for all three plates

DATA ANALYSIS

From Newton's Second Law, the expression for linear momentum of a steady, incompressible fluid in a control volume can be derived as follows

$$\sum F_{sys} = \rho Q (V_{out} - V_{in}) \quad (1)$$

For this experiment, Equation (1) simplifies to

$$F_y = \rho A V^2 (1 - cos\theta) \quad (2)$$

Where θ is the flow deflection angle, F_y is the balanced out by the applied load, W, which is the weight due to the mass (m) added.

If a straight line were fitted between F_y and V^2, its theoretical slope (S) can be calculated using Equation (2) as follows

$$S = \rho A(1 - cos\theta) \quad (3)$$

Where ρ is the density of fluid, A is the area of the nozzle, g is the gravitational constant.

The diameter of the nozzle is 0.008 m and the area (A) of the nozzle is 5.0265×10^{-5} m^2

DELIVERABLES

One team lab report containing the following

1. Letter of Transmittal (example: http://users.rowan.edu/~jagadish/resources/LoT_Example.pdf)
2. Introduction
3. Materials and Methods
    a. In paragraph format explain what materials you used
    b. Explain the procedure for collecting data in your own words in paragraph format
    c. Explain the method for analyzing the data collected in lab. Retype all the equations, screenshotting is not permitted. Use subscripts and superscript where necessary
4. Results and Discussion
    a. Present the figures for F_y vs V^2 for different types of plates with trendlines. Figure must show the trendline equation [Note: Figures must be referred to in-text]
    b. Present neatly formatted Table(s) for collected data. [Note: Tables must be referred in text]
    c. Compare the theoretical and experimental slope, show the percentage error.
    d. Compute the theoretical velocity using Eq (1) and compare with the experimental velocity
    e. All calculations must be included in appendix and should not be presented here
    f. Discuss your results. How do they compare? What is the reason for discrepancies?

4. Conclusions
    a. Briefly summarize your results and explain what you learned.
5. Appendix
    a. Show one sample calculation here