Experiment No. 6 : Vane Coefficient

Objective

To appreciate the linear momentum equation as applied to fluid system and to calculate vane coefficient for a flat plate or 180^o vane.

Practical Relevance

The momentum theorem has wide engineering application. The integral form of this equation is used in the quantitative analysis of many engineering problems eg flow through pumps, turbines, the Pelton wheel and other roto-dynamic machines, wind forces on structures.

Theoretical Background

When a liquid jet (usually water) strikes a solid surface without splashing, it is forced to move along the surface since it cannot penetrate it. For example when a jet strikes a flat plate normally it spreads radially in all directions (flower fountains). Thus even if the magnitude of the jet velocity does not change, its direction changes hence its momentum changes. This change in momentum of the flow results in a force results in a force on the solid object.

Consider the jet shown in figure below. The jet is being turned through an angle θ by a stationary vane. The forces on the vane may be obtained by applying the momentum equation to an appropriately chosen control volume. Let us make the following simplifying assumptions:

1. The jet fluid is inviscid and incompressible.
2. The velocity of the jet and its area remain constant.
3. The flow is steady and uniform at all sections.
4. Surface tensions effects are negligible.

The forces on the vane may then be easily obtained with the help of linear momentum principle as:

$$F_X = \rho A U^2 (1 - \mathrm{Cos}\,\theta) \qquad (6.1)$$

$$Fy = \rho A U^2 \mathrm{Sin}\,\theta \qquad (6.2)$$

Where, A and U is the jet area and velocity respectively for fluid of density, ρ.

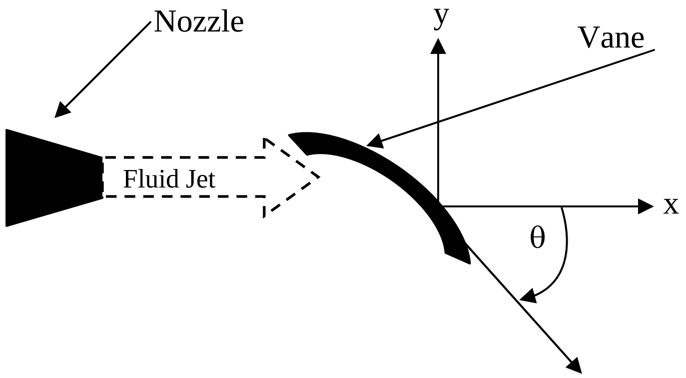

Figure 1 Schematic diagram of an impinging jet.

In actual practice the above assumptions are not valid, hence equation 6.1 and 6.2 are just a theoretical estimated value. Thus we define a vane co-efficient as:

$$K = \left(\frac{\text{Actual Force}}{\text{Theoratical Force}} \right) = \left(\frac{\left(F_X{}^2 + F_y{}^2\right)^{1/2}_{\text{Actual}}}{\left(F_X{}^2 + F_y{}^2\right)^{1/2}_{\text{Theoratical}}} \right) \tag{6.3}$$

Observations:

1. Cross sectional Area of the volumetric tank (A) =
2. Exit Diameter of the nozzle (D) =

Discussion

1. Discuss the physical significance of the experiment?