Verification of Momentum Equation by using Test Rig of Impact of Jet on Flat Plate

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Abstract— The liquid comes out in the form of a jet from the outlet of a nozzle which is fitted to a pipe through which the liquid is flowing under pressure. If some plate is placed in the path of the jet a force is exerted by the jet on the plate. The aim of impact of jet test rig is to practically determine the impact force of the jet deflected through a flat plate and to compare the experimental results to predictions from a control volume analysis of fluid (water), in this experiment we find the experimental force and then compare to the theoretical force using control volume method.

Key words: Momentum Equation, Flat Plate, Impact of Jet

I. INTRODUCTION

The study of force resulting from the impact of fluid jets involves the application of newton's second law in the form of F=m*a, the forces are determined by calculating the change of momentum of the flowing fluids. When the jet moves and strikes the obstruction like flat plate, inclined plate, vane in its path then the jet will exert the force on the obstruction is known as impact of jet. According to newton's second law of motion "The applied force is equal to rate of change in momentum.

- F= d/dt (m*V)
- F= m*dV/dt = m*a
- F= m/t*(V_2-V_1)

Product F*t is called impulse

Mass flow rate

- $\dot{m}$ = m/t = ρ*Q = ρAV = ρQ
- F=$\dot{m}$*(V_1-V_2)

For flat plate

- V_2 = 0
- F= ρQV

For Hemispherical curved plate

- V_2 = -V, V = V
- F= ρQ*[V + (-V)]
- F= 2 ρQV

Where Q= Discharge from the nozzle (Calculated by volumetric analysis)

- V= Velocity of jet
- V=Q/A

II. DESCRIPTION OF APPARATUS

The experimental apparatus is a closed circuit of water recirculating system consist of sump tank, pump set, jet/vane chamber, water nozzle, a flat plate, balancing lever, collecting tank as shown in fig 1.

Fig. 1: Impact of Jet Test Rig

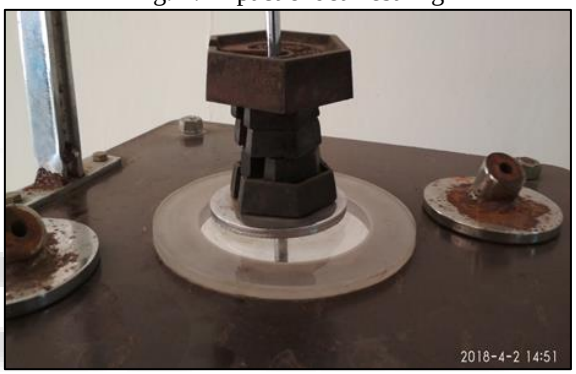

Fig. 2: Balancing Weight for Force Calculation

The balancing weight is used to balance the lever or arm is shown in fig.2 which is used to calculate force acting on flat plate.

The water is drawn from the sump tank by centrifugal pump and delivers it vertically to the nozzle. The flow control valve is also provided for controlling the water into the nozzle the water is issued out of nozzle as jet. The jet is made to strike on plate with force to the balancing lever attached to impact surface allows determination of the force required to deflect the water jet.

III. THEORY OF EXPERIMENT

"Impulse momentum principal state that the impulse exerted on anybody is equal to the resulting change in momentum of the body". This principal is modified from the Newton's second law of motion.

If a vertical water jet moving with a velocity 'V' made to strike a targeted vane which is free to move in vertical direction force will be exerted on the target by the impact of jet.

By momentum equation

- F= ρQ*(V_{out}-V_{in})
- For flat plate
- F= ρQ*(0-V)
- F= ρQV = ρAV^2

Where
Q= Discharge from the nozzle (Calculated by volumetric analysis)
V= Velocity of jet

IV. CALCULATION & RESULTS

Type of Vane	Trial No.	X_1	X_2	W_t	Time for 100mm rise
Flat plate	1	95	220	30	68
	2	95	215	50	52
	3	95	210	90	39

Table 1: Observation Table

V. OBSERVATIONS

Nozzle Diameter = 10mm
Density of water = 1000 kg/m^3
Arm Length = .28m
Tank Area =0 .3*0.5 = 0.15 m^2

VI. SAMPLE CALCULATION

For Flat Plate

- X_1 = 95 X_2 = 220 t = 68
- Q = (A*H)/t = (0.15*0.1)/68
- Q = 2.2058*10^{-4} m^3/s
- V = Q/A

Where A= Area of Nozzle

- A = π /4* d^2= $\frac{\pi}{4} * (0.01)^2$
- A = 7.8539*10^{-5} m^2
- V = (202058*10^{-4}) / (7.8539*10^{-5})
- V = 2.8085 m/s
- $F_{th = Wt}$ *(X_1/X_2)*9.81
- F_{th} = 30*10^{-3}*(220/95) *9.81
- F_{th} = 0.681N
- $C_f = F_{th} / F_{act}$ = 0.6195/0.651
- Cf = 0.9096

Where C_f = Coefficient of impact of flat vane.

VII. RESULT TABLE

Sr. No.	Discharge 10^{-4} (m^3/s)	Velocity of the jet (m/s)	F_{th} N	F_{ex} N
1	2.2058	2.8085	.6195	.681
2	2.8846	3.6728	1.0595	1.1100
3	3.8462	4.8972	1.8836	1.9517

Table 2:

VIII. CONCLUSION

Thus with this results we concluded that as the discharge increases the value of force exerted also increases.

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