Experimental investigation on impact of jet on flat and hemispherical vane

D.B. Jani[1], Mirza Juned[2], Bariya Bhargav[3], Nayka Samir[4], Bilwal Manav[5], Chndra KC Rohan R.[6]
[1,2,3,4,5,6]*GEC, Dahod-389151, Gujarat Technological University, GTU, Gujarat, India*

***Abstract*—The objectives of the paper are to conduct an experimental investigation into the impact force generated by the impact of a jet of water on flat plate and hemispherical plate vanes to compare between experimental and theoretical forces which are exerted by the jet. The procedure for this experiment is to bring the weight cup in the initial position by applying weight when the flow rate is varied. It can be possible to repeat the same experiment by changing different target vanes. Moreover, the effect of water jet impact can be seen at a constant flow rate by changing the type of target vanes and applying different amounts of weights to bring the weight cup in the initial position. Here, the theoretical forces are depended upon weights applied on the weight cup and the experimental forces are depended on flow rate, nozzle exit velocity, impact velocity and shape of the vanes.**

***Key words*—Impact of jet, flat vane, hemispherical vane, flow rate.**

I. INTRODUCTION

Water turbines are widely utilized throughout the world for hydraulic power generation. Here, fluid under pressure is allowed to strike the vanes of a turbine wheel. Mechanical work can be engendered from this impact provided by the water jet. Rotational motion is then engendered by the force generated as the jet strikes the vanes. One of the most conventional types of water turbine is the Pelton wheel. Here, water jets are tangentially directed on to buckets or vanes that can be fastened on the rim of the turbine disc. The impact of water on the vanes engenders a torque on the wheel causing it to rotate and to develop power. The output of a pelton wheel can be easily expressed and it is possible to determine its optimum rotational speed. Moreover, it is possible to understand how the deflection of the jet engenders a power on the vanes or buckets and how the force is related to the rate of momentum flow in the jet [1].

Qusai Waleed Al-Qudah [2] investigated the impact of jet by using flat plate and hemispherical cup. The objective of the investigation was to experimentally determine the force required to keep a flat plate at a datum level while it is subjected to the impact of jet and to compare the experimentally measured force with the analytically calculated force from the control volume form of the linear momentum equation. According to the investigation, when the volumetric flow rate was increased, the force resulted from the impact of the jet on both the flat plate and the hemispherical cup was increased. Some measured value of the jet force showed larger values than the predicted one due to errors in taking the reading and losses in the experiment apparatus.

Stephen Mirdo [3] experimentally investigated the impact of jet. The objective of the investigation was to determine the force exerted by a jet of water on a stationary vane and compare the experimental results to the theoretical results. By controlling the velocity vector of the fluid jet, the Pelton bucket was able to extract more energy from the moving fluid by changing its linear momentum. The theoretical and experimental forces had a significant percentage of error. Most of this error was due to the theoretical calculations neglecting the force of gravity on the jet of water. However, after the fluid obtained any height above the nozzle, the force of gravity acted on it.

Ravi Agarwal [4] investigated the impact of jet by using flat plate and hemispherical vane. The aim of the investigation was to determine the impulse momentum theorem as it applied to the impact of a water jet on vanes with different geometrical shapes. The force on the jet for different weights and shape of vanes was calculated theoretically and observed experimentally. It was found that the force for the hemispherical vane was more than that of the flat plate. Vrushiket Patil [5] also investigated the impact of jet by using flat plate and hemispherical vane. The aim of the investigation was to study the relation between the force produced and the change of momentum when a jet strikes a vane and to compare between force exerted by a jet on a flat plate and on a hemispherical surface.

A report uploaded by John Conor [6] shows the experimental investigation of impact of jet. The aim of the investigation was to study the jet forces impacting against stationary deflectors. Plate, hemisphere and slope deflectors were used for this investigation.
The aim of this paper is to determine the impulse momentum theorem as it applies to the impact of a water jet on vanes with different geometrical shapes.

II. EXPERIMENTAL SETUP

The experimental apparatus Consist of a chamber provided with Acrylic Sheets. A floating vane fixing rod is provided over the chamber to which the vane is fixed as shown in Fig. 1. An initial balance weight is provided for balancing the vane. Another sliding weight is provided to balance the vane fixing rod while the jet is striking the vane. A nozzle is fixed below the vane through which a vertical jet issues. A control valve provided controls the pressure at the jet and hence the flow rate and velocity of the jet. Different vanes are provided. The vanes can be inter changeably fixed to the rod. By adjusting the sliding weight, rod is balanced. When the jet is striking the vane. By taking the moment about the fulcrum, impact force can be calculated.
The experimental procedural steps are as follows:

1. Fix the vane to the fixing rod. Adjust the balancing weight so that vane fixing rod is in horizontal position.
2. Fill up sufficient water in the sump tank.
3. Open the control valve fully and start the pump.
4. Put the sliding weight over the rod and adjust it's distance such that the vane fixing rod is balanced.
5. Note down the discharge and distance of the sliding weight.
6. Repeat the procedure by changing the control valve position.
7. Repeat the procedure for another vane.

Fig. 1. Experimental set-up of impact of jet.

The following are the precautions taken while carrying out experiments on impact of jet apparatus.

- Never run the apparatus, if power supply is less than 180 volts and above 230 volts.
- Never fully close, the control valve line and by pass line valves simultaneously.
- To prevent the clogging of moving parts, run pump at least once in fortnight.
- Always use clean water.
- If the apparatus will now use for more than month, drain the apparatus completely.
- Always keep apparatus free from dust.
- If water is not lifted, the revolution of the AC motor may be reverse. Change the electric connection of motor to change the revolutions.
- If the panel is not showing input, check the fuse and main supply electricity.
- Do not run the pump at fully speed for the longer period to avoid leakages of water in discharge lines.

The following are the specifications of the apparatus:
Nozzle diameter – 0.006 meter
Types of vane – flat plate and hemispherical plate
DC motor with 1 HP power supply.

III. DATA REDUCTION

The force exerted by vane when deflection of jet 90°

$F_{th}= waV^2/g$ kg (1)

The force exerted by vane when deflection of jet 180°

$F_{th}= 2waV^2/g$ kg (2)

Experimentally, taking moments about the fulcrum

$$Fexp * l = m * L \quad (3)$$

Where, m = Mass of sliding weight Kg
L= Distance of sliding weight from fulcrum, m

IV. RESULTS AND DISCUSSIONS

The following are the observations obtained for the mass of the sliding weight 75 gm and 150 gram. The distance of vane from the fulcrum is l = 0.15 m.

Table -1. Observation table.

Sr. No.	Dia. Nozzle mm	Type of Vane	Time for 10 Liter (Sec)	Weight Added (gm)	Distance of sliding weight L (m)
1	6	Flat	30.82	150	0.40
2	10	Flat	24.63	75	0.50
3	6	Hemisp herical	123.52	150	0.40
4	10	Hemisp herical	105.35	75	0.50

The impact of water jet created on flat plat and hemispherical plate has been compared in Fig. 2

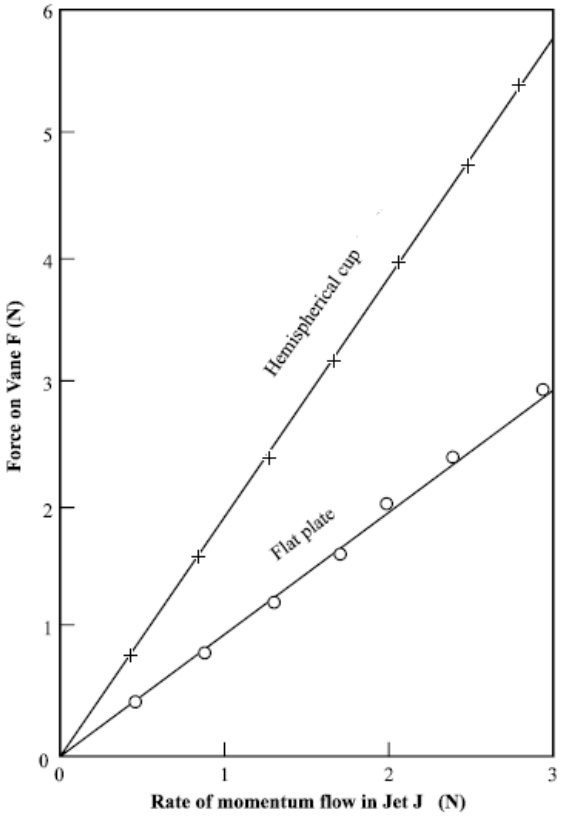

Fig. 2. Comparison of impact created by water jet.

The impact of jet principle is used in designing impulse turbine; part of the fluid energy is transformed to kinetic energy in a nozzle that issues a jet of fluid at high speed. The experiment was done successfully, even though the data collected were a little bit difference compared to the theoretical values as shown in Fig. 3 and Fig. 4 for flat vane and hemispherical vane respectively. These variations are due to human and servicing factors such as parallax error. Moreover, friction observed during flow also creates an error. Additionally, error may be introduced due to stop watch use and viscosity effects. In order to reduce the differences between the theoretical and experimental value of forces, some recommendations may be taken. The position of the observer's eye must be 90° perpendicular to the focusing object. It is necessary to ensure that the apparatus functioning perfectly in order to get an accurate result. It is necessary to ensure constant water supply of pump. The time should be measured very carefully with the help of stop watch. It is necessary to ensure that no bubble is present in the water. The jet must impinge at the center of the vane. The flow rate must be measured very carefully. It is necessary to record the weights very carefully [7-8].

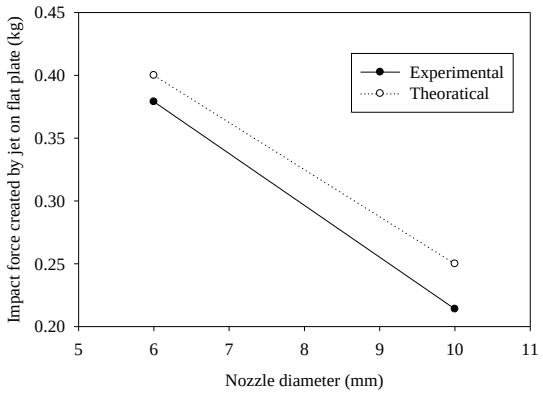

Fig. 3. Comparison between theoretical and experimental impact created by water jet on flat vane.

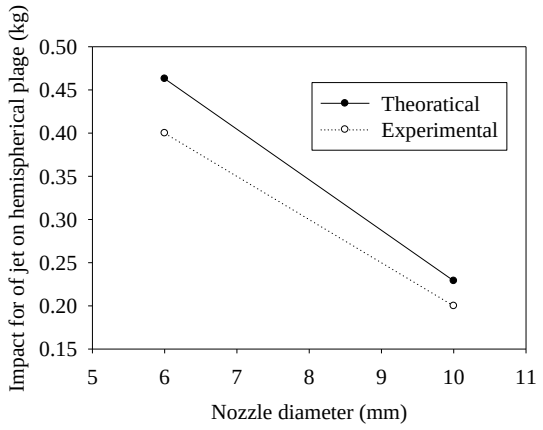

Fig. 4. Comparison between theoretical and experimental impact created by water jet on hemispherical vane.

V. CONCLUSIONS

The aim of the present investigation is to focus on the experimental analysis of the impact of water jet on different configurations of vanes. Impact of jet apparatus is utilized to demonstrate the way in which fluid force is being utilized for generating a force. The force can turn a turbine. Moreover, it is possible to convert the kinetic energy in a flowing fluid from a nozzle to a rotary motion of the turbine with the help of vanes fitted on shaft of the turbine. The maximum possible force is shown which occurs when the jet is deflected through 180° without energy loss. Thus, more impact with water jet at same water flow can be created by the hemispherical plate than the flat plat.

REFERENCES

[1] Roshane Nanayakkara, Impact of Jet, Scribd [internet], accessed: 01 December 2017, available from: https://www.scribd.com/doc/38008443/Impact-of-Jet.

[2] Quasi Waleed Al-Qudah, Impact of Jet, Hydraulics Laboratory [internet], The University of Jordan (Faculty of Engineering and Technology), accessed: 02 December 2017, available from: www.icivil-hu.com/Civil-team/Structures%20Section/Impact%20of%20jet.pdf.

[3] Stephen Mirdo, Impact of a Jet of Water, Scribd [internet], accessed: 03 December 2017, available from: https://www.scribd.com/doc/48248022/Impact-of-a-Jet-of-Water

[4] Ravi Agarwal, Impact of Jet Vanes, Scribd [internet], accessed: 04 December 2017, available from: https://www.scribd.com/doc/65108627/Fluid-Mechanics-Impact-of-Jet-Vanes-experiment

[5] Vrushiket Patil, Impact of Jet on Vanes, Scribd [internet], accessed: 05 December 2017, available from: https://www.scribd.com/doc/71242319/Impact-of-Jet-on-Vanes

[6] John Conor, Impact of a Jet Lab Report, Scribd [internet], accessed: 06 December 2017, available from: https://www.scribd.com/doc/51634941/Impact-Of-A-Jet-Lab-Report.

[7] Shaho Abdul Qadir, Impact of a Jet, Scribd [internet], accessed: 07 December 2017, available from: https://www.scribd.com/document/71328788/Impact-of-a-Jet.

[8] The Impact of Jet Apparatus, Project [internet], accessed: 08 December 2017, available from: https://www.iproject.com.ng/mechanicalengineering/the-impact-of-jet-apparatus/index.html.