e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
(Peer-Reviewed, Open Access, Fully Refereed International Journal)
Volume:07/Issue:04/April-2025 Impact Factor- 8.187 www.irjmets.com

PLC BASED TEST RIG FOR IMPACT OF JETS

Mr. Aman Sherkhan Khan[*1], Mr. Kamalesh Rajendra Parab[*2], Mr. Aaditya Prasad Kadam[*3], Mr. Rohan Radhakrishna Mestry[*4], Miss. Sharvari Santosh Amre[*5], Miss. Tanaya Vijay Dalvi[*6], Prof. Swapnil Sawant Sir[*7]

[*1,2,3,4,5,6]Department Of Mechanical Engineerng Polytechnic Wing, Yashwantrao Bhonsale Institute Of Technology Charathe, Vazarwadi, Sawantwadi, Dist. Sindhudurg, India.

[*7]Professor, Department Of Mechanical Engineerng Polytechnic Wing, Yashwantrao Bhonsale Institute Of Technology Charathe, Vazarwadi, Sawantwadi, Dist. Sindhudurg, India.

ABSTRACT

The objective of our project is to design and develop "PLC Based Test Rig for Impact of Jets". This work provides a lot of benefits like easy understanding of how such machines works how measurements are been made regarding fluids also students will gain an exposed to PLC, they will get a clear idea that how to use PLC what is ladder logic, also our project system is very useful in future since India is moving forward towards automated industrialization. With the help of this technology, we can yield significant financial benefits which will prove beneficial for the country

Keywords: PLC, Ladder logic, Stepper motor, Mass flow sensor, Position sensor.

I. INTRODUCTION

1.1 Impact of jet

jet of water issuing from a nozzle has a velocity and hence it possesses a kinetic energy. If this jet strikes a plate, then it is said to have an impact on the plate. The jet will exert a force on the plate which it strikes. This force is called a dynamic force exerted by the jet. This force is due to the change in the momentum of the jet as a consequence of the impact. This force is equal to the rate of change of momentum i.e., the force is equal to (mass striking the plate per second) x (change in velocity). We will consider some particular cases of impact of a jet on a plate or vane. 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 if flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of the jet, a force is exerted by the jet on the plate. This force is obtained from Newton's second law of motion or from impulse- moment equation. Thus, impact of jet means the force exerted by the jet on a plate which may be stationary or moving. In this chapter, the following cases of the impact jet i.e., the force exerted by the jet on a plate, will be considered.

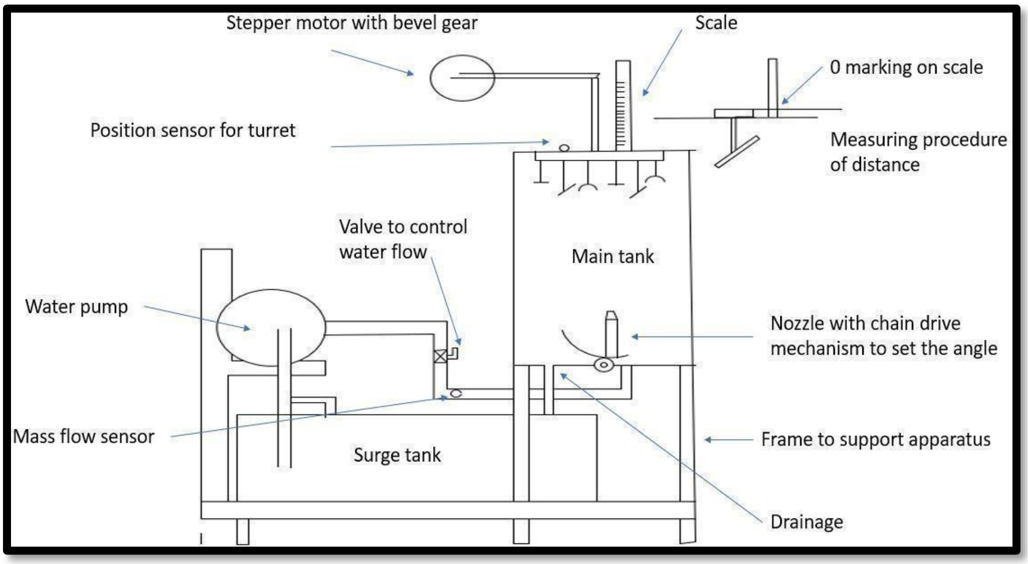
Impacts of jet is to understand correctly how a turbine (a Pelton wheel for example) works, students need to understand how jet deflection produces a force on turbine vanes. They also need to know how this force affects the rate of momentum flow in the jet.

The Impact of a Jet apparatus shows students the force produced by a jet of water as it strikes a flat plate, angled plate, 120-degree plate, or hemispherical cup. They can then compare this to the momentum flow rate in the jet. For use with Tec Equipment's Digital Hydraulic Bench (HIF, available separately), the equipment comprises 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 weigh beam assembly with jockey weight 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.

All test plates are all easily interchangeable, taking only a few seconds and needing no tools.To perform experiments, students level the apparatus and zero the weigh beam assembly. They set the flow from the hydraulic bench to maximum, and measure the jet force. They reduce the flow from the hydraulic bench in several increments. At each increment they record the force of the jet on the plate and the

II. METHODOLOGY

EXPERIMENTAL SETUP



EXPERIMENTAL PROCESS

Step 1

Switch on the test rig Step 2

Feed the condition of test on control panel (manually) Step 3

Position sensor will be on and it will sense the position of the turret plate (which is required for the test) Step 4 Stepper motor will start and it will rotate the turret

Step 5

Once the position of plate matches the feed condition the sensor will sense it and the motor will stop Step 6 Water pump will start

Step 7

Valve will be operated manually (to control the flow of water) Step 8

Mass flow sensor will sense the mass flow rate and display the readings on the display board Step 9

Water will get out of the nozzle inside the tank and the water will impact its force on the plate Step 10

Force sensor which is placed on the plate will sense the impact force and convert it into digital single and it will be displayed on display board

Step 11

Determination of forces will be done

VARIOUS CONDITIONS OF IMPACT OF JET

1. **Jet Impact on a Stationary Flat Plate (Perpendicular)**

The plate is flat and at 90° to the jet. Jet comes to rest after hitting the plate. Maximum force is generated.

Force (F) = ρAV^2

2. **Jet Impact on a Stationary Flat Plate (Inclined at θ)**

Plate inclined at angle θ.

Jet is deflected along the plate.

Force (F) = $\rho AV^2 \sin\theta$

3. **Jet Impact on a Moving Flat Plate (Perpendicular)** Plate moves in the same direction as the jet at velocity u. Relative velocity = (V - u).

Force (F) = $\rho A(V - u)^2$

4. **Jet Impact on a Moving Inclined Plate**

Plate inclined at angle θ and moving at velocity u. Deflection occurs with reduced force due to motion. Force (F) = $\rho A(V - u)^2 \sin\theta$

5. **Jet Impact on a Series of Flat Vanes (Stationary)** Jet hits curved vanes and deflects by 180° ideally. Force (F) = $2\rho AV^2$

6. **Jet Impact on a Series of Curved Vanes (Moving)** Vanes are moving at velocity u, and jet deflects by an angle β. Used in turbines.

Force (F) = $\rho A(V - u)^2 (1 + \cos\beta)$

III. RESULTS AND DISCUSSION

The rig could evaluate how effectively a jet stream removes contaminants (e.g., dirt, grease, paint) from a surface. The PLC could control the duration and intensity of the jet impact, while the cleaning effectiveness is monitored by residue measurements (e.g., after wiping a surface clean).

Results might indicate that higher jet pressures lead to more efficient cleaning but also cause more surface damage.

Jet Flow Rate and Pressure Correlation

Observation: The correlation between jet pressure, flow rate, and impact force could be studied. Result:

As jet pressure and flow rate increase, the force exerted on the test material will likely increase, causing more significant impact effects.

The PLC-based system can record the force data, which can then be analyzed to establish the relationship between these variables and their effect on material deformation or erosion.

Jet Impingement on Heat Transfer

Observation: If the test rig involves thermal systems, the jet's effect on heat transfer efficiency can be evaluated. Result:

Jets can enhance cooling rates due to forced convection, leading to a more efficient heat transfer process.

Data collected by the PLC can be used to determine the optimal jet velocity and pressure for improving heat dissipation in applications such as electronics cooling or industrial heat exchangers.

IV. CONCLUSION

The PLC based test rig would help generate precise data on how different jet configurations (pressure, velocity, flow rate) affect materials or surfaces. The real-time monitoring and control capability of the PLC system would allow for detailed analysis of erosion, cooling efficiency, structural integrity, and other parameter. This data is crucial for optimizing processes in industries like material testing, surface cleaning, aerospace, automotive and heat management system

V. REFERENCES

[1] Masuda H., Gotoh K., Fukada H., and Banba Y. (1994) The removal of particles from flat surfaces using a high-speed air jet, Advanced Powder Technology 5:205–217.

[2] Mccreery G. E., and Stoots C. M. (1996) Drop formation mechanisms and size distributions for plate nozzles, Int. J. Multiphase Flow Vol. No. 3, pp:431-452

[3] Parbhu A. N., Lee A. N., Thomsen S. J., and Siew D. C. W. (2002) Atomic force microscopy applied to monitoring initial stages of milk fouling on stainless steel, In Wilson D. I., Fryer P. J., and Hasting A. P. M. (Eds.), Fouling, cleaning and disinfection in food processing, pp:33-40, Department of Chemical Engineering, University of Cambridge, UK.

[4] Sertore D., Fusetti, M., Michelato P., and Pagani C., (2006) High pressure rinsing water jet characterization, Proc. EPAC06, INFN Milano-LASA, Segrate (MI), Italy.

[5] Sertore D., Fusetti, M., Michelato P., and Pagani C. (2008) Study of the high-pressure rinsing water jet interactions, Proc. EPAC08, INFN Milano-LASA, Segrate (MI), Italy

[6] Tsouknidas P., and Zhang X. (2010) Dishwasher improvement at ASKO, Developing a simplified test method to determine the influence of spray arm speed and pressure, Chalmers University of Technology, Göteborg, Sweden.

[7] Wright D., Wolgamott J., and Zink G., (1999) Nozzle performance in rotary applications, WJTA, StoneAge, Durango, Colorado, U.S.A.

[8] Klavenes A., Stalheim T., Sjovold O., Josefson K., and Granum P. E. (2002) Attachment of Bacillus cereus spores with and without appendages to solids surfaces of stainless steel and polypropylene, In Wilson D. I., Fryer P. J., and Hasting A. P. M. (Eds.), Fouling, cleaning and disinfection in food processing, pp:69-76, UK: Department of Chemical Engineering, University of Cambridge.

[9] A. Kibar, H. Karabay, K. S. Yiğit, I. O. Uçar, H. Y. Erbil, Experimental Investigation of Inclined Liquid Water Jet Flow onto Vertically Located Superhydrophobic Surfaces, Exp Fluids (2010) 49:1135–