Effect of Rotating Surface on Hydraulic Jump Profile Formed due to Two Parallel Impinging Jets.

[1]P.M. Mane, [2]R.S. Gorde, [3]G.D. Gosavi, [4]A. A. Wankhede, [5]R.T. Dhanore

[1-5]Assistant Professor
[1-5]Mechanical Engineering Department,
[1-5]Imperial college of Engineering and research wagholi, Pune, India.

Abstract: Hydraulic jump is a sudden drop in water level caused by a decrease in speed when flowing over a surface or in a passage. The flow field caused by two normal liquid jets differs from the flow field associated with one jet of normally falling liquid. In this study, an attempt was made to analyze the effect of a double jet of water falling on a flat rotating surface, which may have different flow rates. Depending on the mutual arrangement of the jets and their relative strength, various types of hydraulic jump curves can be determined. Jump profile is largely influenced due to effect of rotation of surface and studied to provide convenient experimental flow visualization.

***Keywords* – Hydraulic jump, jet impingement, rotating surface, twin jet.**

I. INTRODUCTION

When the water flows to a horizontal surface, it is easy to observe hydraulic jump, commonly noticeable in the kitchen and bathroom sinks. When a vertical jet hits a horizontal plate, it first spreads into a thin layer. However, at some distance from the jet, the height of the liquid level suddenly increases to a higher value [1]. The location of this jump depends primarily on the flow of water from the tap. Examples of hydraulic jumps can be seen downstream of hydraulic structures, such as spillways, gates and ventur. In practice, double jets are widely used, such as (a) obtaining uniform cooling and (b) coating in the coating industry. (c) evaporation of the concentrated solution [2]. A hydraulic jump is a rapidly changing area of hydrodynamic properties that connects supercritical and subcritical free surfaces or interfacial flows. Hydraulic jumps are a typical feature of rivers, natural flows in the ocean and the spread of normal jets.

In an open channel, when a fast flow suddenly becomes a slow flow, the height of the surface of the liquid increases significantly or increases sharply, this is called a hydraulic jump [1]. A hydraulic jump cause by a abrupt raise in water level due to a decrease in speed. Water before a jump moves much faster than water after a jump. When the water velocity drops to a critical flow rate, a jump occurs [3]. Previous experimental on various case of inclined and double jets, investigates jump-jump interaction on a flat non rotating surface. Similar flow fields also been studied to provide convenient experimental flow visualization [5, 6, and 8].

The flow field caused by two usually normal liquid jets differs from the flow field associated with one normal liquid jet [7], even differs from the flow field surrounding two usually normal jets of compressible fluid. Depending on the distance between the two jets of fluid and their relative strength, various types of hydraulic jump interactions can be performed to create different flow patterns

II. EXPERIMENTAL SETUP

The schematic diagram of the experimental setup is shown in Fig.1. The device consists of a closed water jet system. The experimental setup is implemented using a suitable instrument for monitoring and measuring various variables affecting the phenomenon. A centrifugal pump is used to supply water in the form of a spray with the desired flow rate. The flow rate was measured using two flow meters.

The flow meter is connected to a nozzle device by a pipe. Steel and copper round pipes with an internal diameter of 4 mm, 5 mm and 6 mm were used as nozzles. These tubes have an length to diameter ratio of 50-150 to ensure fully developed outlet flow conditions. The jet ejected from the nozzle landed on a round acrylic plate having a thickness of 5 mm and a diameter of 500 mm. A round plate is mounted on a support frame, a support frame based on a 600mm × 600 mm size, 16 mm thick square glass plate, mounted on four screws to adjust the alignment of a perfectly horizontal rotating circular acrylic plate.

The jet falling on a flat horizontal plate diffuses in the radial direction and then freely falls from the edge of the plate into the collection container. The entire unit is mounted on a heavy frame so that there is no noticeable effect of any external vibrations. Measures were also taken to change the longitudinal and vertical position of the nozzle relative to the horizontal plate.

During the experiment, the glass plate was supported by four set screws. Perfect horizontal alignment of the target plate is always ensured throughout the experiment. In addition, fluid discharge is uniform from all edges of the plate, which implicitly guarantees the absence of a noticeable error due to the lack of flatness of the target panel.

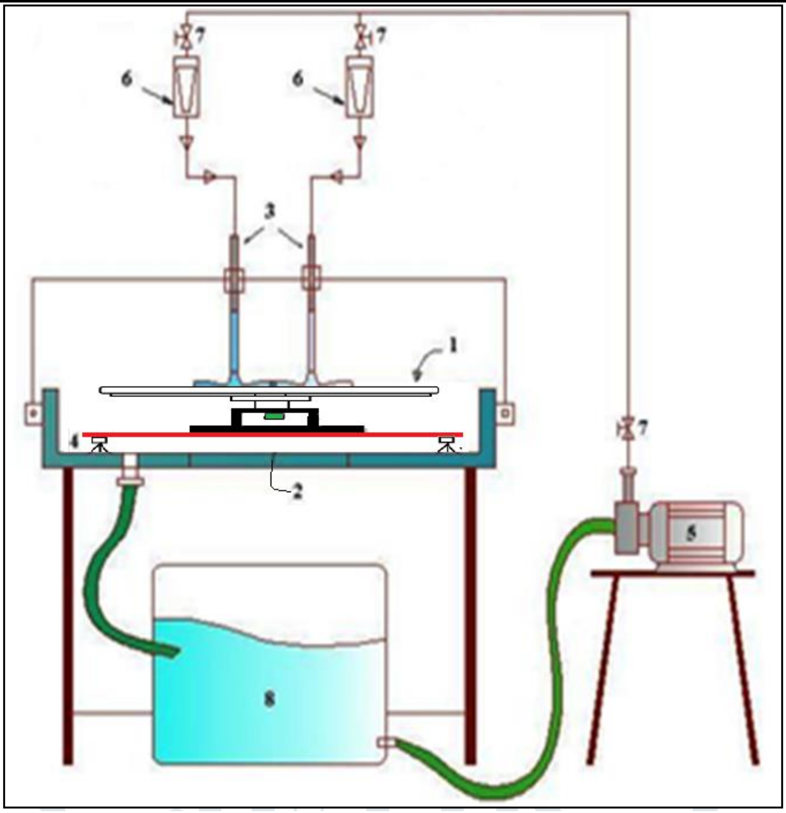


Fig. 1. The schematic diagram of Experimental setup for multiple hydraulic jumps on a rptating plate. (1 – acrylic plate, 2 - water collecting tray, 3 - nozzle, 4 - leveling screw, 5 -centrifugal pump, 6 – flow meter, 7 - flow control valve, and 8 - storage tank)

III. HYDRAULIC JUMP INTERACTION BETWEEN TWO NORMALLY ACTING CIRCULAR LIQUID JETS

In the present study, the impinging jets are termed 'jets of equal strength' or 'equal jets' when the nozzle diameters and the jet velocities of both the jets are the same, and 'jets of unequal strength' or 'unequal jets' when jet diameter and jet velocities are not same.

The system of two impinging jets can be broadly grouped into three categories: (a) Far-distant impinging jets, (b) Distant impinging jets, and (c) Adjacent impinging jets.

3.1 Far Distant Jets

Under conditions of a non rotating surface, the radial symmetry of a circular hydraulic jump does not change when the two jets are too far apart, which indicates that there is no noticeable interaction between the hydraulic jumps, as shown in fig. 2.

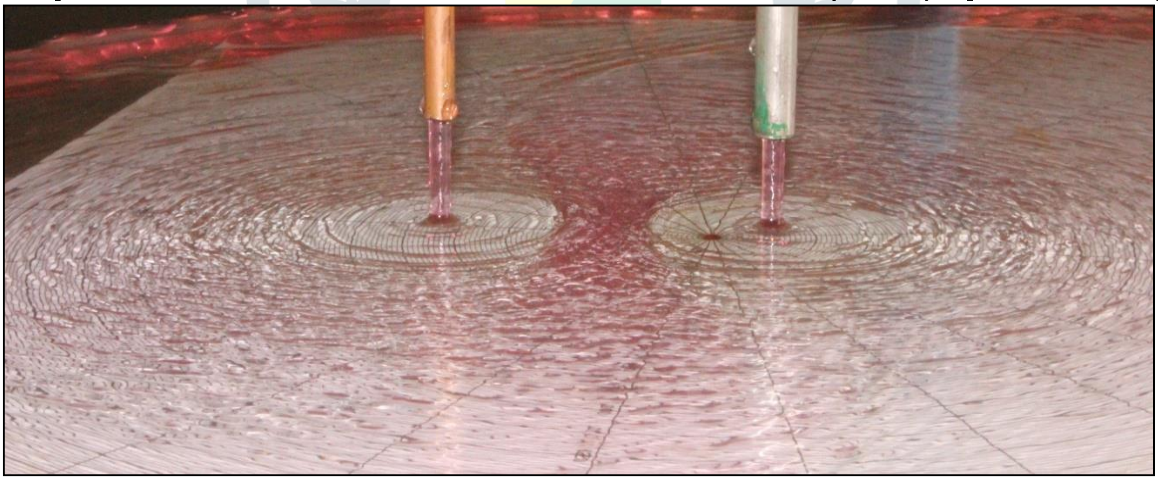


Fig.2. Far distant parallel impinging jets

3.2 Distant Jets

Below the critical distance (Sc) between the nozzles, the hydraulic jumps of the individual nozzles begin to interact, which prevents the radial symmetry of the individual jump profiles. It is noted that this critical distance (Sc) is a function of the volumetric flow rate of the fluid (Q) through each jet, as shown in Fig. 3. Hydraulic jump profiles are interacting to each other and start to form stagnation zone. This is shown in fig. 3. by a stagnation line.

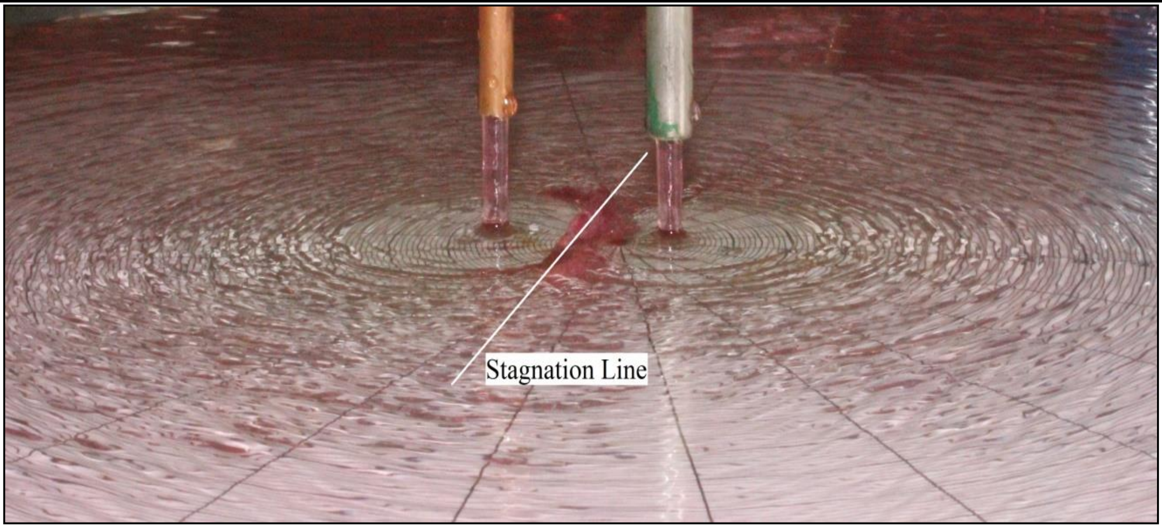
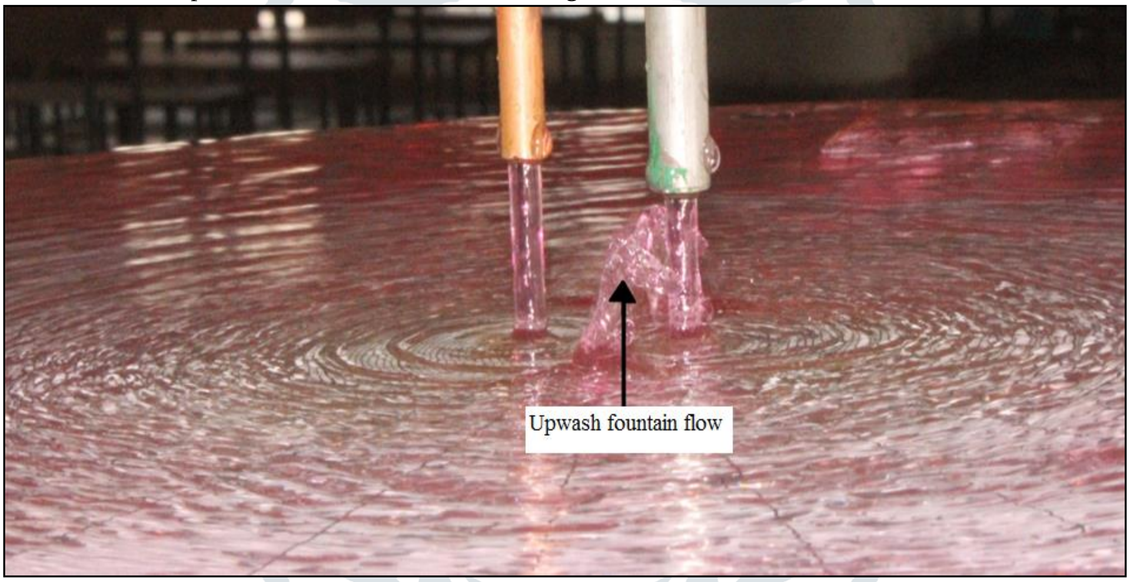


Fig. 3. Distant impinging jets

3.3 Adjacent impinging jets

Adjacent impinging jets have strong influence on the jump-jump interaction. Below the critical distant jumps the stagnation zone starts to raise and form upwash fountain flow as shown in fig. 4.



(a)

(b)

Fig. 4. Adjacent impinging jets

Different jump profiles can be obtained for different distances between the jets and their relative strength like C, S shape profiles as shown in fig. 5 and fig. 6. These profile shape is also depends on the relative distance of jets from the center of rotating surface.

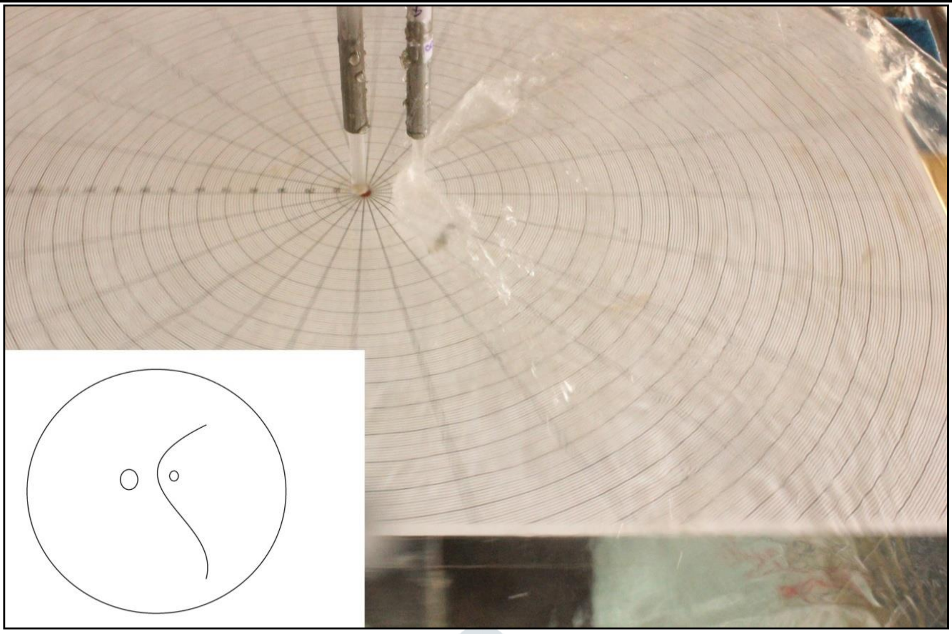


Fig.5. C-shape Profile formation due to parallel jet impingement.

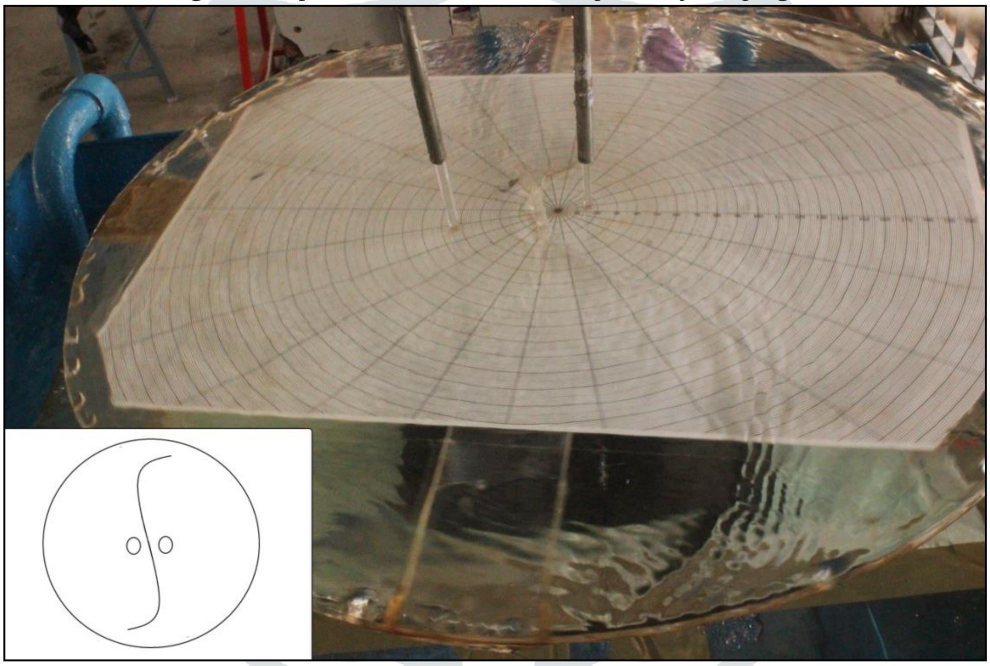


Fig. 6. S-shape Profile formation due to parallel jet impingement.

'Far-distant' when the spacing between the two jets is greater than the critical spacing for a given volume flow rate of liquid. 'Distant' is when the spacing between the two jets is less than the critical spacing, but is greater than R, where R ≈ (RJ1 + RJ2) / 2 and RJ1, RJ2 are the radius of the circular hydraulic jumps formed by two jets independently, for a given volume flow rate of liquid. 'Adjacent' impinging jets are spaced at a distance less than R.

Table 4.1: Classification of two impinging jets.

Sr. No.	System of two jets	Jet spacing	Jump interaction
1	Far-distant	S > Sc	Negligible interaction
2	Distant	Sc > S >> R	Thick film interaction
3	Adjacent	S ≤ R	Thin film interaction

The classification of two jet system i.e. 'Far distant', 'Distant', and adjacent impinging jet are summarized in table 4.1, while typical plots defining the distant and the adjacent impinging jets are depicted in figure 4.13 and figure 4.14. In case of two impinging jets, the radial symmetry in the flow field due to individual impinging jets may be considerably affected. These wall jet interactions have distinct effects on the radial symmetry of the circular hydraulic jumps. The resulting jump profiles are non circular, in general, and are dictated by the types of interaction that the opposing wall jets have. This, in turn, depends on the spacing between the jets and their relative strength.

IV. CONCLUSION

The operation of the mobile divider using the electronic system is satisfactory. It would not be an exaggeration to say that due to the use of a mobile partition of the electronic system, traffic problems during rush hours are reduced, and vehicle efficiency and travel time are reduced.

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