PRESSURE DISTRIBUTION AT INNER SURFACE OF SELECTED PELTON BUCKET FOR MICRO HYDRO

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ABSTRACT

Four different pelton bucket contours have been designed at Kathmandu University. The main aim of this work is to provide a detailed experimental analysis of the pressure distribution in the four different bucket contour, named as DB01, DB02, DB03 and DB04. The commonly used ITDG bucket contour have also been tested and compared. The head and flow rate have been maintained constant during the test period. The pressure distribution around the inner surface of the bucket has been measured in three different angle of the bucket to the jet incidence i.e 0 degree (normal to the jet), +15 degree (incline away from the jet) and -15 degree (incline towards the jet) considering extreme contact condition by the jet. The test is carried out for the stationary bucket. The pressure is measured in 20 orthogonal grid points of size 10mm$\times$10mm. The bucket is drilled normal to the surface on each pressure intake points. Fine copper pipes of 5mm diameter are fitted from the external surface of each orifice as pressure taps. Transparent PVC pipes are fitted to each pressure point for measuring pressure head in terms of water height. The bucket DB02 with elliptical section has been found with uniform pressure distribution. This profile had shown better performance in terms of torque. The pressure distribution inside the bucket DB02 has matched the flow pattern.

Key words: Pelton bucket, pressure distribution

INTRODUCTION:

Micro hydropower (MH) is one of the main sources of energy in the rural part of the Nepal where the national grid is inaccessible. Most of the micro hydropower in Nepal is running at low efficiency (Thapa et. al, 2006). One of the reasons for such low efficiency could be due to the improper bucket profile and hence hydraulic loss in traditional bucket design. The slight improvement on the bucket profile can increase the efficiency of the power plant remarkably. The fundamental of the bucket design aims that the acceleration of water particle is always normal to the surface of the bucket. So that the water particle always exerts maximum force on the bucket surface (Brekke, 1994). This is basic philosophy behind the design of bucket profile.

Project Description

This study is mainly focused on finding the pressure distribution inside the Pelton bucket.

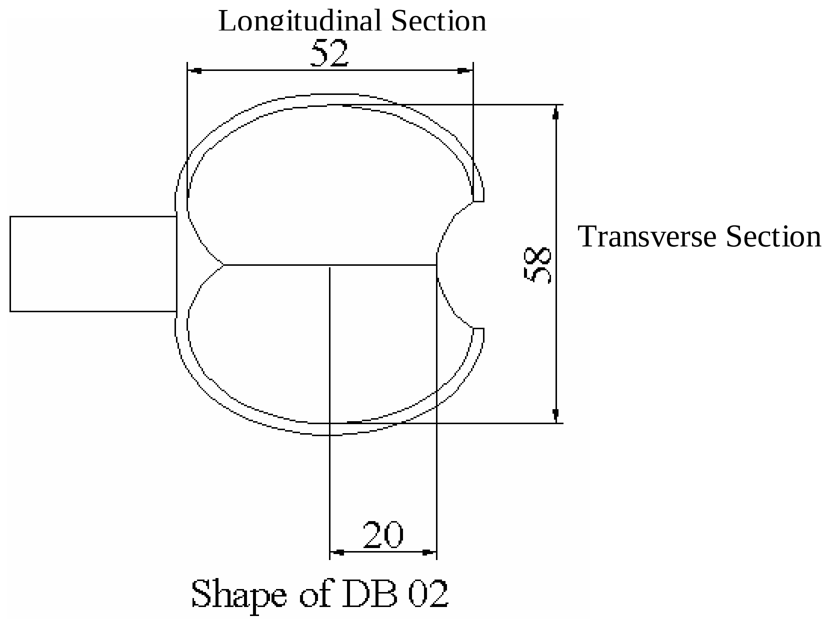


Fig1: Bucket sections

Four pelton buckets with different contours has been designed for same head and flow rate conditions. The buckets named as DB01, DB02, DB03 and DB04 are casted locally. The difference between these buckets lies in their profile.
The profile of the bucket DB01 is circular on both Longitudinal and transverse direction. In the longitudinal section at the middle of the one half of the bucket, it has a circular surface of radius of 30mm in the middle transverse section it is circle of radius 14mm.

The bucket DB02 is made elliptical sections only (fig1). The longitudinal section of the one half of the bucket DB02 is an ellipse with axes 52mm and 29mm. similarly the middle transverse section is an ellipse with axes 58mm and 29mm.

DB03 has a combination of elliptical and circular sections. The bucket is elliptical in the longitudinal section and circular in the transverse section.

The bucket DB04 also has a combination of elliptical and circular profiles. The bucket is elliptical in the transverse section and circular in the longitudinal section.
ITDG bucket profile is as discussed in Thake (2002).

The output of this study is data of pressure distribution inside the pelton bucket. The data can be used for analyzing hydraulic performance of the turbine and estimating localized stress for dimensioning bucket.

OBJECTIVES

The main objective of this study is to find out the best bucket profile in terms of the pressure distribution inside the bucket. More specifically the objectives of this study are as follows:

- To predict the pressure distribution of five different bucket design
- To find the most effective bucket profile among selected bucket.

LITERATURE REVIEW

Research and development in the field of Pelton turbines are mainly performed by experimental or analytical studies. The turbine design is carried on from long and fastidious laboratory tests, not only to determine and predict the performances of the machine, but also to estimate the service life and the rupture threshold due to fatigue or corrosion.

Zoppe and Pellone (2006) carried out experimental and numerical analysis of the flow in a fixed bucket of a Pelton turbine. The pressure was measured in 21 points with double multiplexer connected to a differential pressure transducer. Similarly, Perrig (2007) investigated the pressure distribution inside the pelton bucket in his doctoral thesis. Piezo-resistive pressure transducers were used in the inner surface of the bucket for the measurement of pressure.

MATERIALS AND METHODS

The test is carried out to find out the pressure distribution inside the bucket. The assumptions made for the test are:

a) The flow is distributed uniformly through out bucket
b) The pressure at a point nearer to the splitter is greater than that of the farthest point
c) The pressure is uniform in both the spoon section of the bucket.

Test rig

The test rig was developed at water power lab at KU for the measurement of the pressure inside the buckets. The schematic diagram of the test rig is shown in fig2. The test rig consists of 45m head and 6lps flow rate pump. The fluctuations in the flow can be absorbed by pressure tank. Pressure can be monitored outside the pressure tank and entrance of nozzle through the pressure gauge. During the test the pressure outside the pressure tank was noted 6.1m of water column and the entrance of nozzle, it was noted 6m of water column.

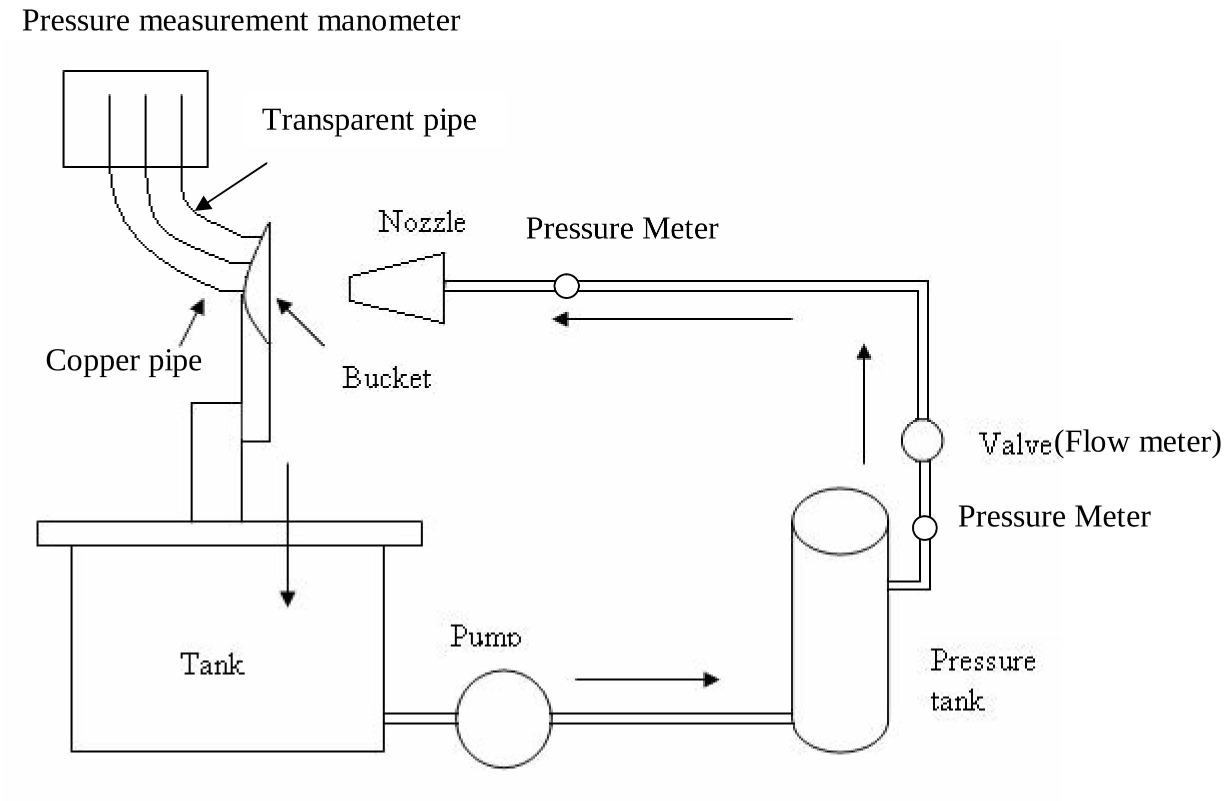


Fig2: Bucket test rig

Test bucket
For the measurement of the pressure inside the bucket, the previously casted bucket DB01, DB02, DB03, DB04 and ITDG buckets are used.

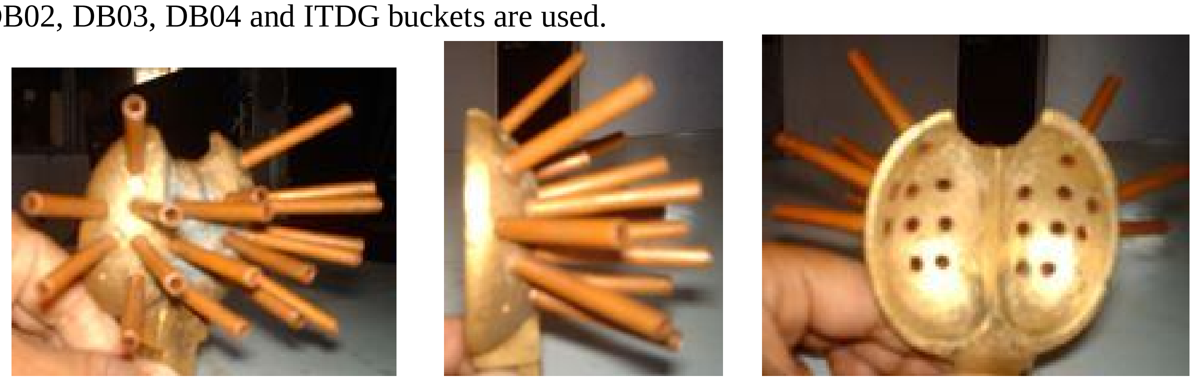


Fig3: Test Bucket

The pressure is measured in 10mm$\times$10mm grid points of the inner surface of the bucket (fig3). The pressure intakes are located as shown in the fig4. The pressure intakes are placed at the points of a regular orthogonal network: that is x-axis spacing was of 10mm and the y-axis spacing was of 10mm. Each hole has a diameter of 5mm. Copper taps are connected with flexible transparent PVC pipes for water column reading.

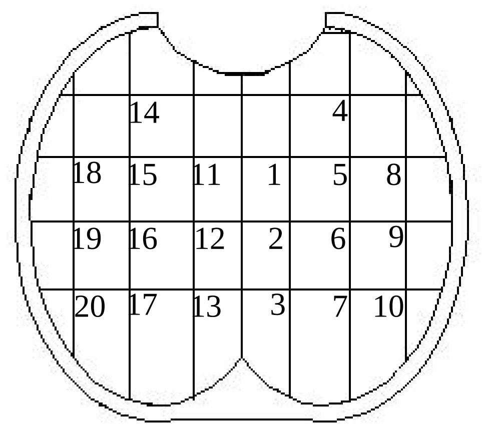


Fig4**:** Location of pressure intakes

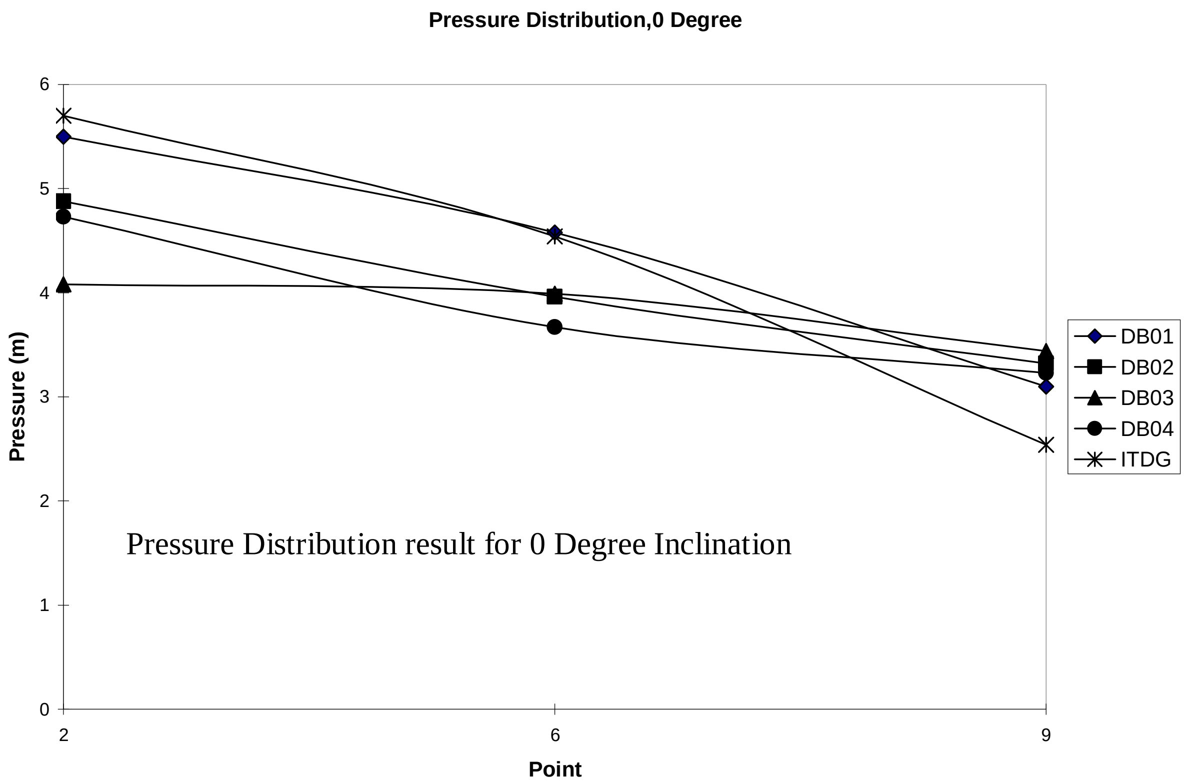
Pressure measurement

The bucket is fixed into the test rig in front of the jet in a fixed member. The pipes are fixed in the board and calibrated. The water column height in each pipes are recorded.

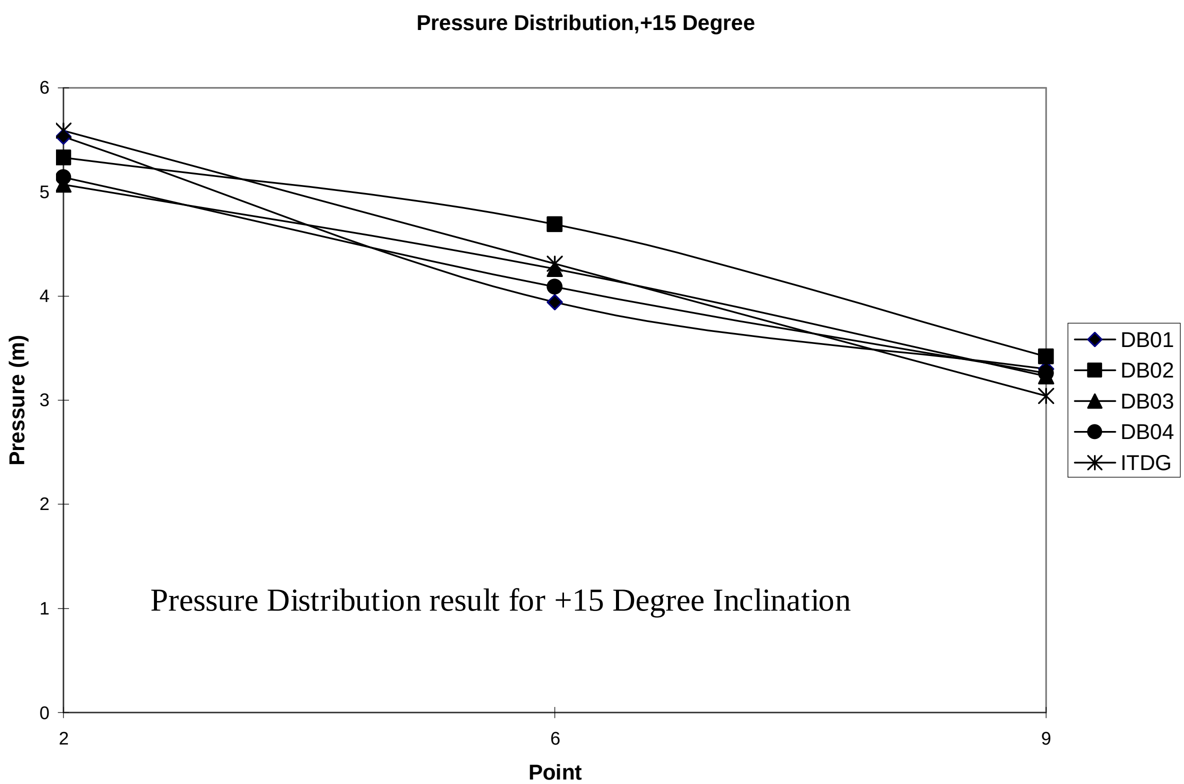
The pressure is measured for all the five different profile buckets with the three different incidence angles i.e. 0 Degree (bucket is fixed normal to the jet), +15 Degree (bucket is in incline position away from the jet) and -15 Degree (bucket is in incline position towards the jet) with respect to the nozzle. The height of water column from the reference point of nozzle axis is measured as pressure head at different points.

RESULT AND DISCUSSION

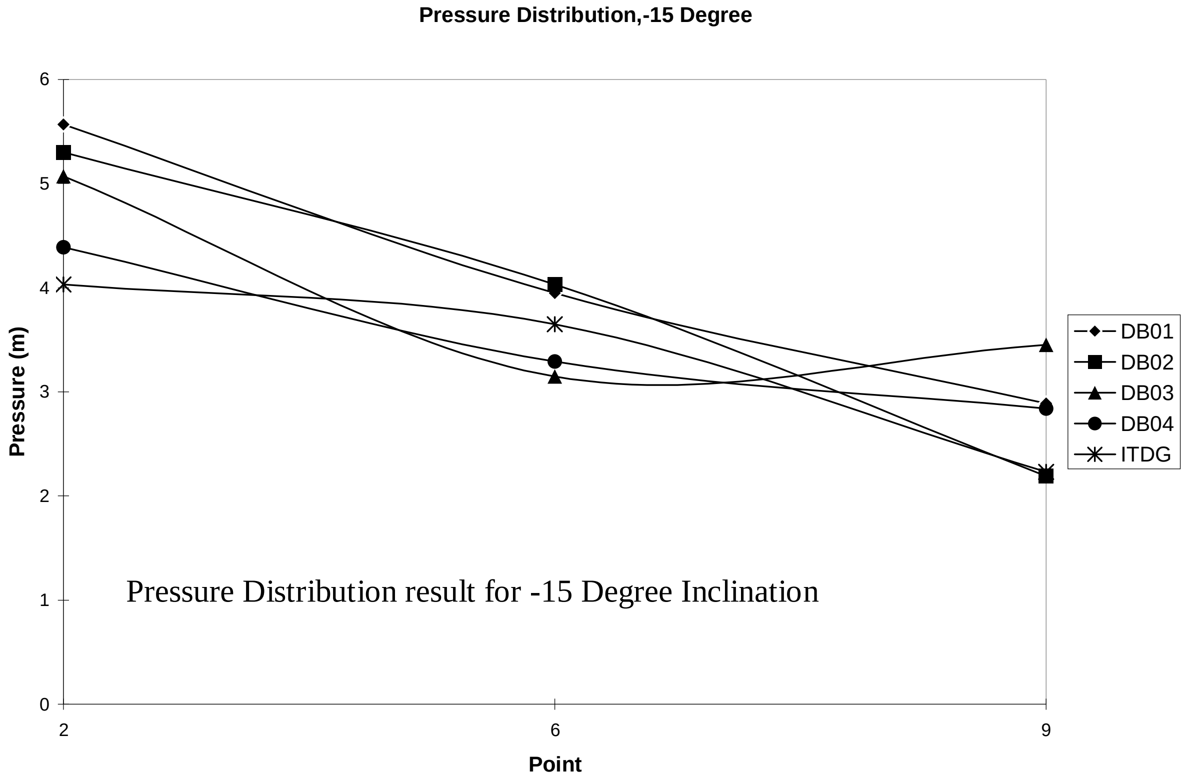
For the discussion of the pressure distribution inside the five different bucket contour, the points are selected according to the distance form the splitter at the middle section of the bucket i.e point 2, 6 and 9 (Fig4). The graph of water column height in the corresponding pressure intakes points for the different buckets are shown below:



Pressure Distribution result for 0 Degree Inclination



Pressure Distribution result for +15 Degree Inclination



Pressure Distribution result for -15 Degree Inclination

The data observed from the experiment was compared between the five different profiles of the bucket with the above graphs. It has been found that the pressure is distributed uniformly in bucket DB02 than the other bucket. Although the trend of pressure distribution in all the buckets are in decreasing fashion, the difference in pressure at different points is very low in DB02 than the other buckets. Hence from the previous result (Thapa *et al.*, 2006) and from this pressure distribution analysis, Bucket DB02 has found more effective contours than the others.

Typical distribution of pressure inside the bucket DB02 is shown in fig5 and fig6 at 0 degree and +15 degree respectively. This distribution is in agreement with the flow direction observed previously (Thapa, *et al.*, 2006).

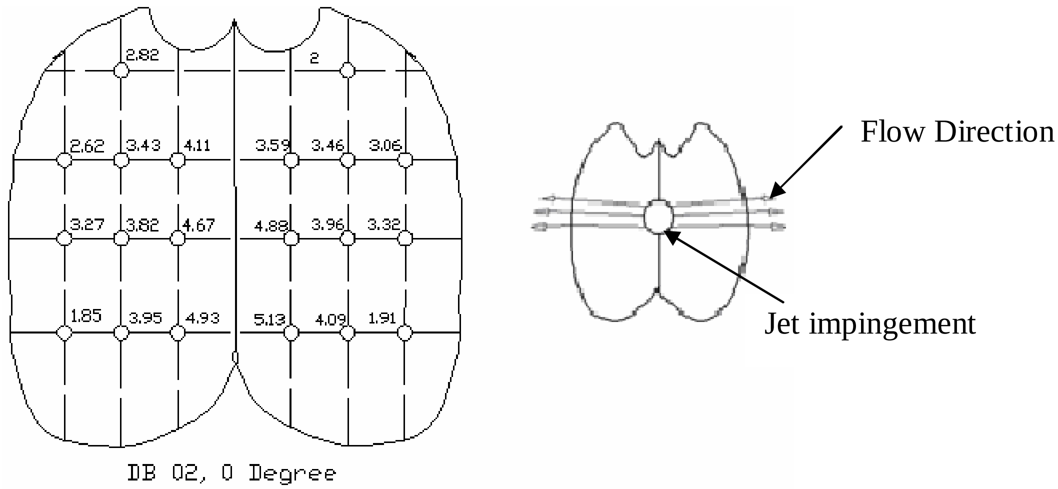


Fig5: Pressure Distribution with flow direction at 0 Degree

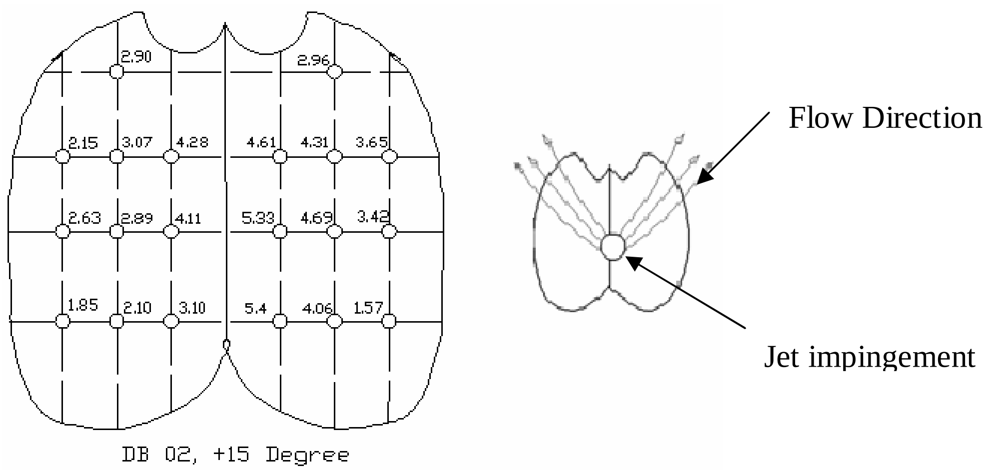


Fig6**:** Pressure Distribution with the flow direction at +15 Degree

CONCLUSION

Pressure distribution inside the pelton bucket has been analyzed for five different bucket profiles. The bucket DB02 has been found the most effective contours in terms of pressure distribution and torque produced. Also from the experiment it has been found that the pressure inside the bucket is decreasing as the distance from the splitter. It has also been observed that the pressure distribution inside the bucket DB02 is in line with the flow pattern observed in Thapa (2006).

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