

Modification, Maintenance and Investigation of Bernoulli's Apparatus

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Abstract- Present work gives idea about the investigation and modification of Bernoulli's apparatus. It includes the details study of Bernoulli's Theorem and Integration of Euler's Equation for One Dimensional Flow. This paper also prove the Bernoulli's equation by using the Bernoulli's apparatus to know the exact behavior of operating conditions of Bernoulli's apparatus at some varying condition. Some necessary test on Bernoulli's apparatus in hydraulic machine lab. Some experiments are done to know about the possible problems and errors which can appear during the numerical analysis of the Bernoulli's theorem by using the Bernoulli's apparatus. Some works are also focused on flow through the horizontal duct for which both experimental and numerical have been discussed clearly. This paper gives report on modification, Maintenance and details investigation of Bernoulli's apparatus in order to increase the efficiency of the apparatus at different operating conditions.

Index Terms- Bernoulli's theorem, Vary Cross-section, Various Fluids, Analysis and modification of flaws in Bernoulli's apparatus.

1. INTRODUCTION

Bernoulli's equation is based on the concept of conservation of energy and energy equation that is described from Euler's force equation .[1] When it is applied to a fluid passing through a pipe at first it is considered the fluid is ideal [5] i.e. viscosity of the fluid is zero. The velocity of every liquid particle across any cross section of pipe, is uniform, irrotational and incompressible.[6] Secondly the Bernoulli's apparatus demonstrate the increase in the speed of the fluid occurs simultaneously with a decrease in pressure of the fluid passing through the duct. [2] There will be no loss of energy of the liquid particle while flowing. It can also be used to examine the turbulence in the fluid stream. Necessary test has been conducted to analysis most problems in mechanics of fluid with the help of Bernoulli's equation and continuity equation as essential analytical tools. [3]

In this paper we verify Bernoulli's equation by varying the cross-section of horizontal duct tube of Bernoulli's apparatus also investigate by using various fluids like alkaline, acid, kerosene, diesel, and petrol.

2. TYPES OF FLUIDS

Fluids are classified into two types and they are ideal fluids and real fluids.

2.1. Ideal fluids

Ideal fluids are those fluids which does not exist practically, which does not have the properties like; viscosity, compressibility and surface tension. Resistance is irrespective to these fluids. [4]

2.2. Real fluids

Real fluid are those fluids which imbibes the properties like; viscosity, compressibility and surface tension. They really exist in nature and are mathematical analyzed of fluid flow problems. [4]

2.2.1. Newtonian fluid

Newtonian fluid are the types of fluid which obeys Newton's law of viscosity. They have a linear relationship between shear stress and velocity gradient. E.g.; water, air, etc. [4]

2.2.2. Non-Newtonian fluid

Non Newtonian fluids: non Newtonian fluids are the type of fluids which do not obey Newton's law of viscosity. The behavior of viscosity is given by the power law equation. e.g.: milk, blood, liquid cement. [4]

3. BERNOULLI'S PRINCIPLE

It states in a steady, ideal flow of an incompressible fluid, the total energy at any point of the fluid is constant. The total energy mainly consists of summation of pressure energy, kinetic energy and potential or datum energy.

Mathematically, the Bernoulli's theorem is written as:

$$\frac{P}{\rho g} + \frac{v^2}{2g} + z = \text{Constant} \dots(1)$$

Where,

$$\text{Pressure Head} = \frac{P}{\rho g}$$

$$\text{Kinetic head} = \frac{v^2}{2g}$$

$$\text{Datum head} = Z$$

Bernoulli's theorem is the principle of energy conservation for ideal fluids in steady and streamlines flow and it is the basis for many engineering applications.

3.1 Bernoulli's Equation For Real Fluid

Equation (1) represent the Bernoulli's equation for ideal fluid flow and it was derived on the assumption that fluid is non-viscous in nature and therefore frictionless. But all the real fluid are viscous. Thus there are always some losses in fluid flows and hence in the application of Bernoulli's equation these losses have to be taken into concern.[6] Thus the Bernoulli's equation for real fluids between point 1 and point 2 is given as below:

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2 + h_L$$

Where,

h_L = Loss of energy between 1 and 2

3.2 Practical Application of Bernoulli's Equation

This is one of the most used equations which applied in all types of problems related to incompressible fluid flow where energy considerations are involved.

It's applied over measuring devices as below:

1. Venturimeter
2. Orificemeter
3. Pitot-tube

4. BERNOULLI'S APPARATUS



Fig. 1. Bernoulli's Apparatus

This apparatus basically used in the hydraulic machine lab to verify the Bernoulli's theorem, to check whether different head remain constant or not. [3]

4.1 Apparatus

Different apparatus needed for conducting this test are:

1. Base Frame
2. Sump tank
3. Water pump set
4. Measuring tank
5. Gate valve
6. Hose pipe
7. Supply tank
8. Delivery tank
9. Test section

The equipment is designed as a self-sufficient unit it has a sump tank, measuring tank and 0.5 HP pump for water circulation. The apparatus consists of a supply tank and delivery tank which are connected to a Perspex flow channel. The channel tapes for a length of 25 cm and then are fixed at a distance of 5 cm center to center for measurement of pressure head.

4.2 Problems in the Apparatus:

1. System was not in running condition since four.
2. Piezometer tubes were broken.
3. Inlet and outlet fluid flow pipes were destroyed.
4. Water supply line was disturbed.
5. Apparatus was corroded due to ageing.

6. The horizontal duct was destroyed and leakage are there.
7. The discharge measurement bucket was not in good condition.

4.3 Analysis of Components:

Steps achieved during analysis of the components are:

1. The apparatus was cleaned and get painted.
2. Discharge bucket was repaired and painted.
3. The piezometer tubes are installed on the apparatus.
4. New water supply lines are fitted correctly.

4.4 Technical Specification

- Cross-sectional area of different piezo metric tubes:

Tube No	Cross Sectional Area (mm ²)	Tube No	Cross Sectional Area (mm ²)
1	3.6	8	2.6
2	3.2	9	2.8
3	2.8	10	3.0
4	2.4	11	3.2
5	2.0	12	3.4
6	2.2	13	3.6
7	2.4		

Table: 1

- Centrifugal pump:

Power	Frequency	Speed
1 HP, 370w	50Hz	2800 RPM

Table: 2

- Measuring tank: 60L capacity.

5. EXPERIMENTAL SETUP

Bernoulli's apparatus consists of a two dimensional rectangular section convergent divergent duct designed to fit in between constant head inlet tank and outlet tank which is variable in nature. An eleven tube static pressure manometer bank is attached to the convergent divergent duct.

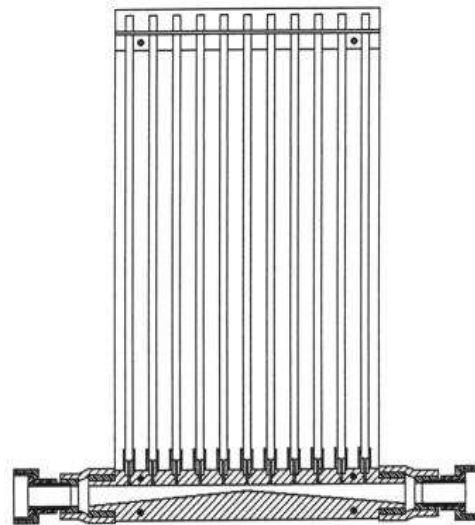


Fig: 2 General Test section of a Bernoulli's apparatus

The piezometer tubes are fitted on the duct at equal intervals for measuring the pressure heads at different gauge points.[6] The duct is connected in between two tanks, one at the upstream end (inlet tank) and the other at the downstream end. The inlet tank is fitted with a piezometer for showing the water level in the tank. The outlet tank is provided with an outlet valve for controlling the outflow. The set-up is placed on a hydraulic bench. Water is supplied to the inlet tank through the inlet valve or supply valve and connected to a constant overhead water tank.

6. PROCEDURE

1. Keep the bypass valve open and start the pump and slowly start closing the valve.
2. The water shall start flowing through the flow channel. The level in the piezometer tubes will start rising. [1]
3. Open the valve in the delivery tank side and adjust the head in the piezometer tubes to steady position.
4. Measuring the heads at all the points and also discharge with the head of diversion pan and measuring tank.
5. Charge the discharge and repeat the procedure .[1]

7. OBSERVATION AND CALCULATION

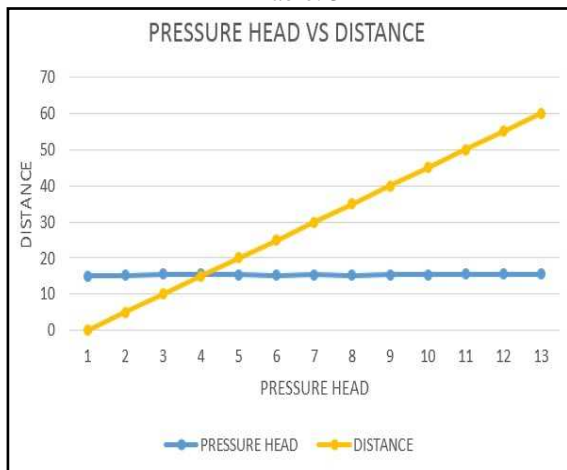
- **7.1 Observation-1**

$$W=5 \text{ lt } T=171\text{sec } Q=\frac{5 \times 1000}{171} = 29.23 \text{ cm}^3/\text{sec}$$

$$V = Q/A = 29.23/A$$

Sl.No	PRESSURE HEAD	CROSS-SECTIONAL AREA	Q	V=Q/A	V ² /2g	TOTAL HEAD
1.	15	3.6	29.23	8.11	0.033	15.033
2.	15.2	3.2	29.23	9.13	0.042	15.242
3.	15.5	2.8	29.23	10.43	0.055	15.055
4.	15.6	2.4	29.23	12.17	0.075	15.075
5.	15.4	2.0	29.23	14.61	0.108	15.108
6.	15.2	2.2	29.23	13.28	0.089	15.289
7.	15.4	2.4	29.23	12.17	0.075	15.475
8.	15.3	2.6	29.23	11.24	0.064	15.364
9.	15.4	2.8	29.23	10.43	0.055	15.455
10.	15.4	3.0	29.23	9.74	0.048	15.548
11.	15.5	3.2	29.23	9.13	0.042	15.542
12.	15.6	3.4	29.23	8.51	0.037	15.637
13.	15.5	3.6	29.23	8.11	0.033	15.533

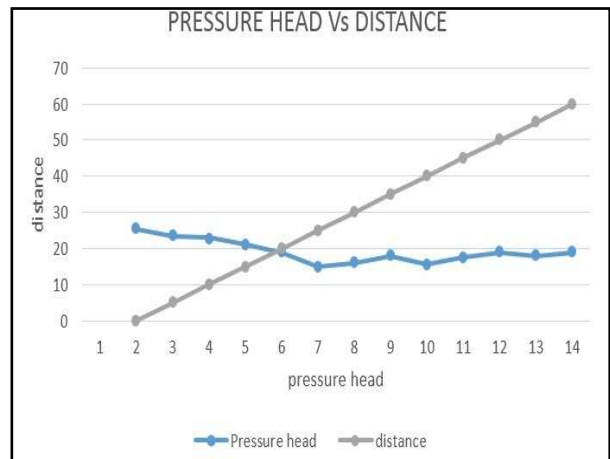
Table: 3



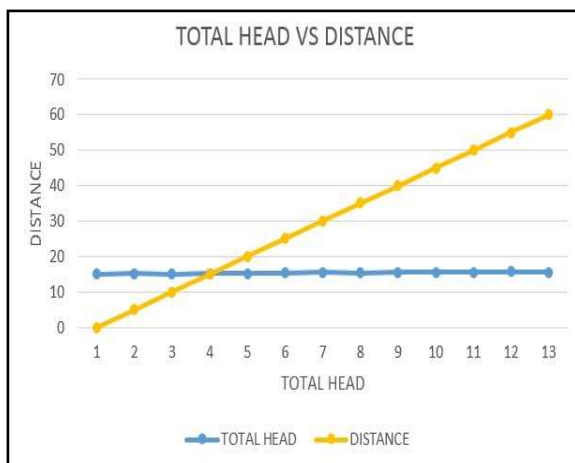
Graph: 1

Sl.No	PRESSURE HEAD	CROSS-SECTIONAL AREA	Q	V=Q/A	V ² /2g	TOTAL HEAD
1.	25.50	3.6	277.78	77.45	3.03	28.54
2.	23.50	3.2	277.78	86.86	3.84	27.34
3.	23.00	2.8	277.78	99.20	5.01	28.02
4.	21.00	2.4	277.78	118.73	6.82	27.83
5.	19.00	2.0	277.78	138.885	9.83	28.84
6.	15.00	2.2	277.78	126.55	8.12	23.13
7.	16.00	2.4	277.78	115.73	6.82	22.83
8.	18.00	2.6	277.78	106.83	5.81	22.82
9.	15.50	2.8	277.78	99.20	5.01	20.52
10.	17.50	3.0	277.78	92.39	4.36	21.87
11.	19.00	3.2	277.78	81.69	3.84	22.84
12.	18.00	3.4	277.78	77.75	3.40	21.40
13.	19.00	3.6	277.78	77.75	3.03	22.03

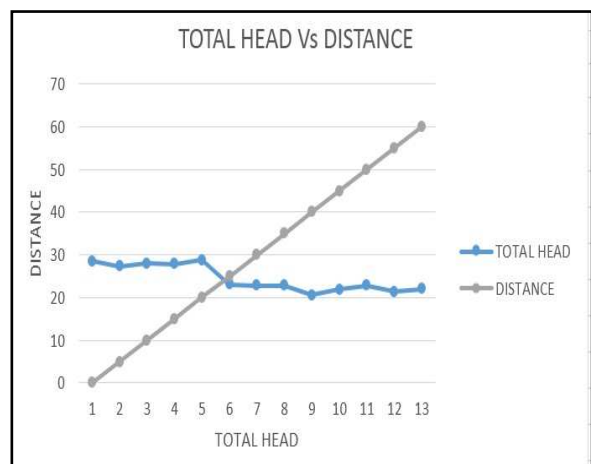
Table: 4



Graph: 3



Graph: 2



Graph: 4

7.2 Observation-2

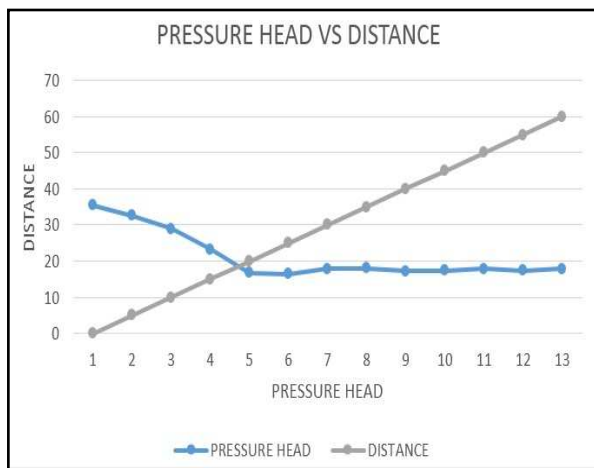
W=5 lt T=18.03sec $Q = \frac{5 \times 1000}{18.03} = 277.17 \text{ cm}^3/\text{sec}$
 $V = Q/A = 277.17/A$

7.3 Observation-3

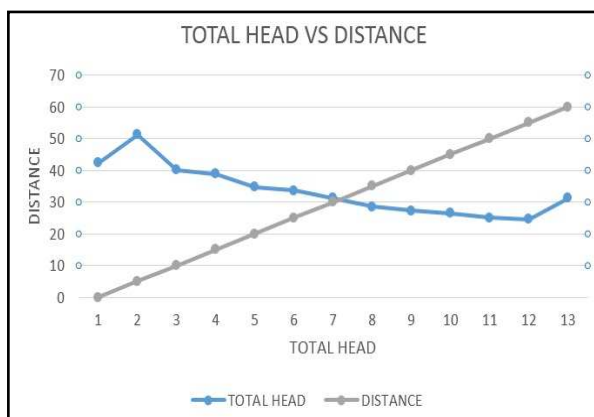
W=5 lt T=12sec $Q = \frac{5 \times 1000}{12} = 416.66 \text{ cm}^3/\text{sec}$
 $V = Q/A = 416.66/A$

Sl. No	PRESSURE HEAD	CROSS-SECTIONAL AREA	Q	V=Q/A	V ² /2g	TOTAL HEAD
1.	35.5	3.6	416.6	6.826	115.37	42.32
2.	32.6	3.2	416.6	8.64	130.2	51.24
3.	28.9	2.8	416.6	11.24	148.3	40.18
4.	23.2	2.4	416.6	15.36	173.6	38.82
5.	16.7	2.0	416.6	22.12	208.33	34.79
6.	16.5	2.2	416.6	18.28	109.39	33.56
7.	17.9	2.4	416.6	15.36	173.6	31.18
8.	18.1	2.6	416.6	13.08	160.25	28.58
9.	17.3	2.8	416.6	11.28	143.29	27.23
10.	17.4	3.0	416.6	9.83	148.8	26.44
11.	17.8	3.2	416.6	8.64	138.38	25.08
12.	17.4	3.4	416.6	7.65	130.2	24.62
13.	17.8	3.6	416.6	6.82	122.54	31.18

Table: 5



Graph: 5



Graph: 6

8. CONCLUSION

From the above we have concluded that total head of the streamline flow remains constant by varying the cross-section of the duct tube. Hence, the Bernoulli's equation is verified and the apparatus is justified to be working properly. Further the extension work can be done for the different categories of fluids.

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