

## **Experimental Analysis on Minor Head Loss for Flow through Locally Manufactured Ball Valve for Supplying Fluid in Bangladesh**

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### **Abstract**

An experimental set up is developed to test the locally manufactured two way ball valve usually used to supply water in different residential, industrial, medical and many other purposes in Bangladesh. Minor loss due to flow through the valve is our prime interest. The well-known Darcy-Weisbach equation is used to calculate the minor loss coefficients. Minor loss coefficients are obtained for three different size valves (3/4,1/2,1 inch diameter) under various opening conditions(20%,40%,60%,80%&100%) and flow rates. From the experiment it is found that the minor loss coefficient decreases with the increase of percentage opening of valve & also with the increase of Reynolds number.

Keywords: Ball valve, Minor loss coefficient, Darcy-Weisbach equation.

### **1. Introduction**

This paper is basically concentrated on the ball valve which is very popular and useful in industrial & medical applications. Various types of fluids can be flowed through ball valve such as compressed air, gases, liquid chemicals, oil, hot and cold water, steam, flammable liquid etc. In Bangladesh these ball valves are available in local market, which are manufactured locally, but relevant data of head loss associated with these locally manufactured ball valves are not available.

The purpose of a valve is to provide a means to regulate the flow rate. This is accomplished by changing the geometry of the system i.e., closing or opening the valve alters the flow pattern through the valve, which in turn alters the losses associated with the flow through the valve. The flow resistance or head loss through the valve may be a significant portion of the resistance in the system. In fact, with the valve closed, the resistance to the flow is infinite - the fluid cannot flow. Such minor losses may be very important indeed. The minor loss coefficient,  $k$  varies with a number of factors. These are: type of valve used, flow velocity of fluid through the valve, the percentage valve opening, other fittings associated with the valve, Valve size, geometry. Here the Reynolds number and the percentage opening are considered as most suitable depending parameters.

### **2. Methodology**

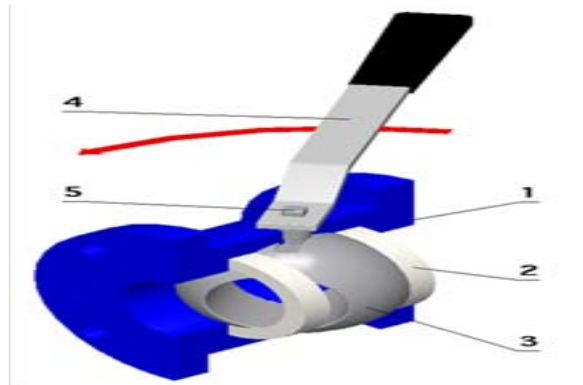
For directing the experimental investigation three size(1/2, 3/4,1 inch diameter) locally manufactured manually operated two way ball valves are taken. For the calculation the main equation used is:

$$H_L = K \frac{V^2}{2g} \quad (1)$$

Where,  $k$  = Loss coefficient

$V$  = velocity of flow (m/sec)

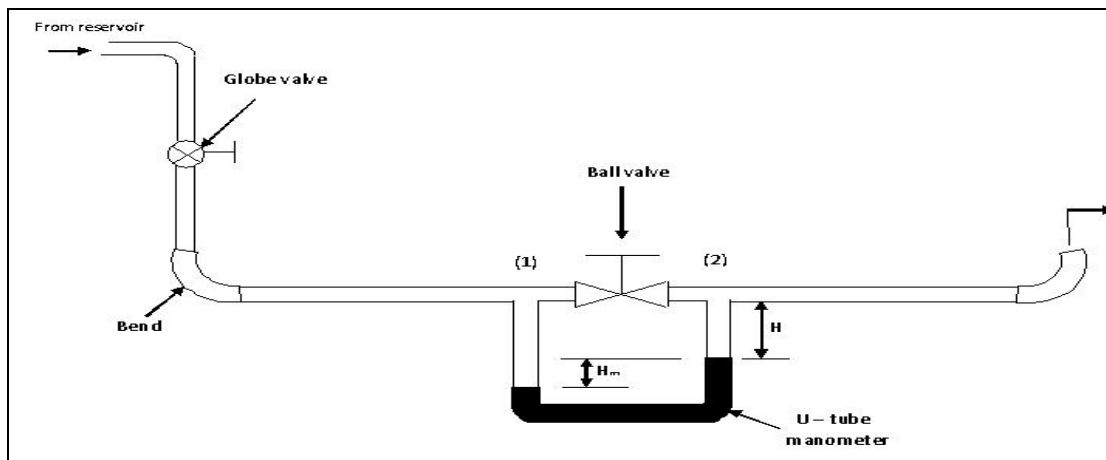
$g = \text{gravity (m/sec}^2\text{)}$



1.Body, 2. Seat, 3.Disc (ball), 4.Handle (lever), 5.Stem

**Fig. 1:** Cut-way view of a simple manual ball valve.

The components used in preparing the experimental setup are reducer, bends (90 degree), U-tube manometer, Mercury & carbon tetra chloride as working fluid in the manometer, weight measuring instruments, nipple joints, thread tape etc. At first the inside diameter of the ball valve and the pipe are measured. Then cross sectional area of the ball valve and pipe are calculated. The valve position for 20, 40, 60, 80 and 100 percent openings were marked on the ball valve. During the experiment, the handle would be placed upon those marks to keep the valve open up to desired percentages. The ball valve is connected between two pipes. Two pipe openings are created on either side of the valve and nipple joints threaded to them. The distances of the openings from the valve are approximately 6 times of the pipe diameter. Flexible tubes are connected to the inlets of the manometer. The other ends of the tubes are connected to the nipple joints threaded to the pipes either side of the valve. Water is allowed to flow inside the pipe which would fill up the manometer with water. The in-flow end of the pipe-valve setup is threaded to the reducer connected to the water supply line. Bends are connected to the out-flow end of the pipe-valve setup so that the full flow of water occurs inside the pipe when water flows out of the setup. Then valve is opened up to 20 percent opening. The valve connected to the supply line is opened very carefully to start water flow. When an observable deflection is found in the manometer the flow rate is kept constant and the deflection is measured. The discharge rate of water also measured. Deflections are measured several times by increasing flow rate. Similarly for each required percentage opening of valve flow rates are changed and the corresponding deflections are measured. Same procedure is performed for each valve.



**Fig.2:** Schematic Diagram of the Experimental Set-up

### 3. Result and Discussion

For every valve the same trends observed. For a particular pipe-valve system, at a particular percentage opening, the geometrical properties ( $d$ ), and the fluid properties ( $\rho$  and  $\mu$ ) remain constant. So Reynolds number varies with velocity ( $v$ ) directly. In this experiment it is observed that for a particular percentage opening, when the Reynolds number is increased, the Minor loss coefficient,  $k$  decreased. The value of  $k$  is observed large at low Reynolds number for smaller openings. Also  $k$  decreased sharply for small openings as Reynolds number is increased. For the larger openings (80 and 100 percent), the values of  $k$  are lower,  $k$  decreased at a lower rate and the pattern is almost linear. The same observations are made for the all three valves. The minor loss coefficient,  $k$  decreases as the percentage opening is increased. As the area of the fluid flow increases, the flow becomes more uniform and less turbulent. Minor loss mainly occurs due to change in flow pattern and direction created by the valve. So at large openings the flow is less turbulent and as such the losses are reduced. It is also observed that the minor loss coefficient decreases with the increase of valve size.

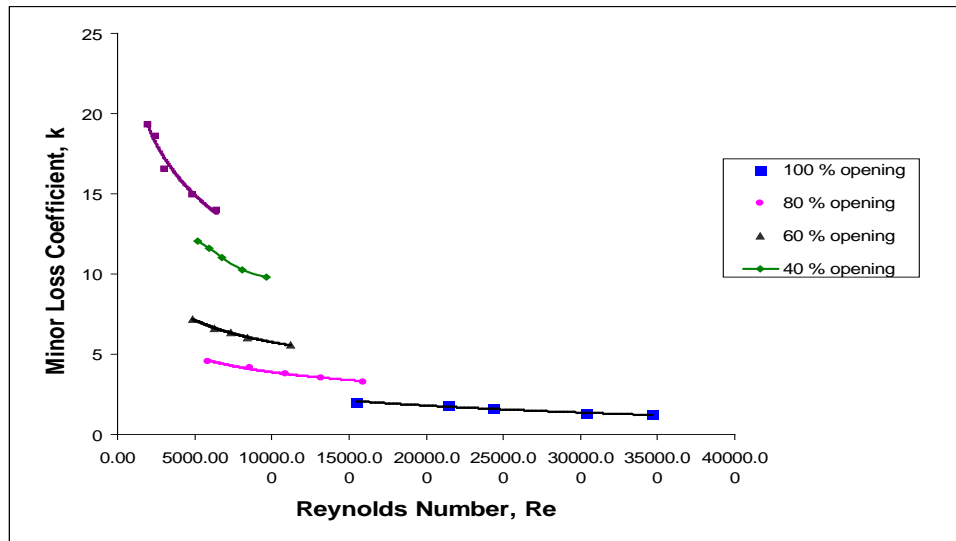


Fig. 3: Minor Loss Coefficient vs. Reynolds Number for 1/2 inch valve

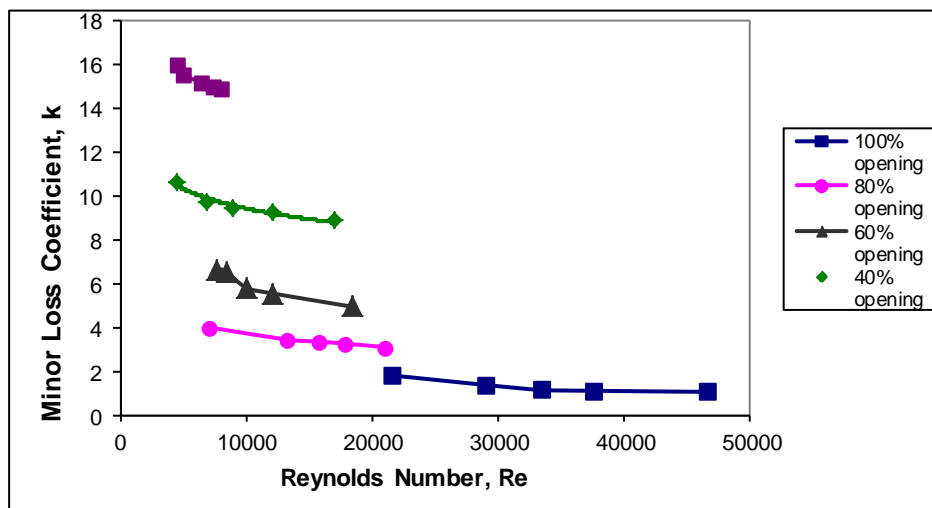


Fig. 4: Minor Loss Coefficient vs. Reynolds Number for 3/4 inch valve

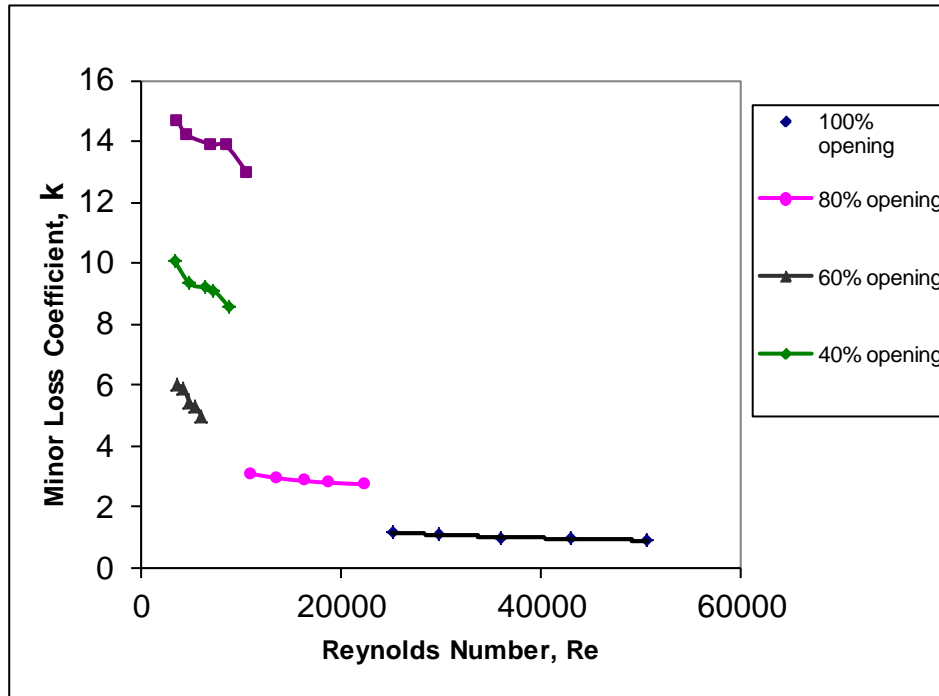


Fig 5: Minor Loss Coefficient (k) vs. Reynolds Number (Re) for 1 inch valve

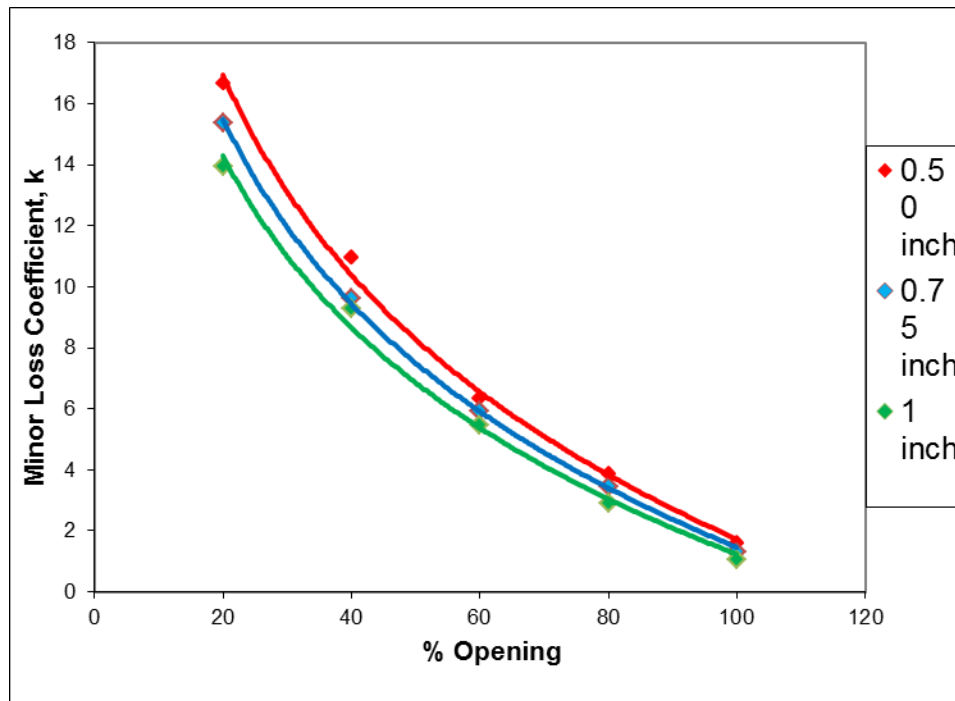


Fig. 6: Minor Loss Coefficient vs. % Opening for 1/2, 3/4 & 1 inch valve

**Table 1.** Minor Loss Coefficient and Reynolds number for various openings for ½, ¾ and 1 inch valves

Percent Opening	Observation No.	½ inch valve		¾ inch valve		1 inch valve	
		Minor Loss Coefficient k	Reynolds Number, Re <sub>D</sub>	Minor Loss Coefficient	Reynolds Number Re <sub>D</sub>	Minor Loss Coefficient	Reynolds Number, Re <sub>D</sub>
100	1	2.01	15475.83	1.83	21596.90	1.28	25158.49
	2	1.82	21451.65	1.39	29098.98	1.1	29705.21
	3	1.62	24362.94	1.17	33418.36	0.98	36070.61
	4	1.31	30338.76	1.13	37510.40	0.96	43042.24
	5	1.19	34629.09	1.08	46603.83	0.93	50620.1
80	1	4.56	5822.59	4.03	7047.41	3.1	13640.15
	2	4.18	8580.66	3.47	13185.47	2.95	16974.4
	3	3.8	10879.05	3.83	15686.17	2.86	20308.66
	4	3.52	13177.44	3.29	17732.19	2.8	23946.03
60	5	3.29	15935.51	3.13	20914.89	2.75	27889.52
	1	7.21	4903.23	6.68	7789.42	6.55	3334.26
	2	6.6	6282.27	6.59	8411.42	5.78	4243.6
	3	6.32	7354.85	5.83	10002.77	5.46	4546.72
	4	6.05	8427.43	5.58	12048.80	5.02	5456.03
40	5	5.57	11185.5	4.97	18414.2	4.49	6365.4
	1	12.08	5209.68	10.68	4546.72	10.08	3335.26
	2	11.58	5975.82	9.78	6820.07	9.54	4546.72
	3	11.01	6741.95	9.45	8866.10	9.15	6366.4
	4	10.25	8120.98	9.30	12048.8	8.86	7577.86
20	5	9.78	9653.24	8.89	17050.18	8.67	8790.32
	1	19.28	1991.94	16.03	4546.72	15.33	3637.37
	2	18.61	2451.62	15.57	5001.39	14.64	4546.72
	3	16.54	3064.52	15.23	6365.40	13.66	6971.63
	4	14.95	4903.24	15.01	7274.74	13.24	8487.2
	5	13.97	6435.49	14.96	7956.75	12.78	10609

**Table 2.** Average Minor Loss Coefficient for various openings for ½, ¾ and 1 inch valves

% Opening	Average Minor Loss Coefficient, k		
	½ inch valve	¾ inch valve	1 inch valve
20	16.67	15.36	13.93
40	10.94	9.62	9.26
60	6.35	5.93	5.46
80	3.87	3.46	2.89
100	1.59	1.32	1.05

#### **4. Conclusion**

- Minor loss coefficient depends on percentage opening of valve, Reynolds number and size of valves significantly.
- In this study only metallic valves were used. Locally manufactured valves constructed of other materials, namely plastic, should also be included in the study.
- Minor loss phenomena are also prevalent in other valves used in piping system. Further studies should be undertaken including different valves.
- Due to constrain in resources minor loss coefficients are obtained for a small number of Reynolds number flows. Studies should be carried out for other Reynolds number flows also.

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