PERFORMANCE EVALUATION OF A LOCALLY FABRICATED FRICTION LOSS IN PIPE APPARATUS

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Abstract: The development and accurate experimental results of friction loss in pipe apparatus allows the detailed study of the fluid friction head losses which occur when an incompressible fluid flows through pipes. But high cost of this imported model of this equipment makes it unaffordable for most Nigerians; hence there is a need for locally fabricated friction loss in pipe apparatus, aiming at economic viability and readily availability of the equipment to Nigerians for quality control. All the materials used in this work were sourced locally and they are readily available. In this work only laminar flow was considered and the t–test analysis at 95% confidence level of experimental results and graphical comparison of both imported and locally fabricated friction loss in pipe apparatus were carried out. It is seen from the results that there is no significant difference between the imported and fabricated apparatus.
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KEY WORDS; Apparatus, Incompressible fluids, Indigenous materials, Fabrication, Laminar flow, Turbulent flow

1. Introduction

The economic development of any nation depends on the level of its industrial development. Industrial development can only be achieved when there is a strong volume of output of locally manufactured goods (Agbetoye et al, 2006). This will ensure conservation of foreign exchange earnings, maintainability and affordability to average Nigerians. Hence the need for locally fabricated equipment for the benefit of students especially in our laboratories is highly essential, considering the high cost of imported equipment. Considering the friction loss in pipe apparatus, the flow of fluid in the pipe is always goes with loss of energy in which the major causes is friction loss (Gardiner and Harrington, 2005).This energy loss is not reversible and hence is not recoverable as useful energy .The water flow in to the apparatus from a supply thank is lead through a flexible hose to the bell mouthed entrance to a straight tube along which the friction loss is measured. The piezometer tapping are connected to an inverted U-tube manometer, which reads the differential pressure directly in millimeter of water. The rate of flow along the pipe is controlled by a needle valve at the pipe exit and is measured by timing the collection of water in a measuring cylinder.

According to Gardiner and Harrington (2005), it was stated that in 1883, Osborne Reynolds recorded a number of experiments to determine the law of resistance in pipes, and concluded that the parameter which determines whether the flow shall be laminar or turbulent in any particular case is

$$Re = \frac{\rho u D}{\mu}$$

There are widely accepted approaches used by industries, each having a validity which irrespective of procedure- provides identical final answer. As a comparison the friction factor developed in 1893 by an American Engineer John Thomas Fanning (1837-1911) is known as Fanning Friction Factor $f = \frac{16}{Re}$ is related to other commonly encountered forms and symbol for the friction factor, where Re is the Reynolds number (Churchill, 1977; Massey. 1987 and White, 1999).

Whither the flow is laminar or turbulent it will depend on the size of Reynolds no. It is laminar when Re ≤ 2100 and turbulent is ≥ 2100. The friction head is related to pressure loss due to friction with the formula

$$h_1 - h_2 = \frac{2fV^2L}{gD}$$

While the hydraulic gradient (i) is related to friction factor as shown in the formula below (White, 1999 and Rajput 1998):

$$i = \frac{2fv^2}{gD}$$

Where $h_1 - h_2 = h_f$ = *friction loss of the pipe*

f =fanning friction factor of the pipe
V=.velocity of fluid in pipe
L =Length of the pipe
D=pipe diameter
g=.Acceleration due to gravity
ρ. =Density of fluid
μ =.Coefficient of Viscosity of fluid
i=hydraulic gradient

Considering the importance of this apparatus both in school laboratories and industry using indigenous material for its fabrication, it will provide better knowledge, good understanding and advantage for student and Engineers in the field.

This paper presents performance evaluation of a locally fabricated friction loss in pipe apparatus (Fig. A) for teaching aids and industrial application.

2. Material and Methods

2.1 Material Selection

Considering the economic factor, environmental factor and availability of this apparatus to the Nigerian for quality control, all the material used were sourced locally and they were selected based on the following factors; availability, strength ,cost and comfort. The frame work of the apparatus placed on hydraulic bench (as shown in Fig. B). Some parts of the apparatus were purchased (e.g. rubber hose (pipe) of mm, clips, steel meter rule and the bleed screws (Fig. C)) while the others were fabricated (piezometer tappings, base and stand). The body of the apparatus was fabricated by welding the piezometer tappings and the iron pipe to the base and then with the stand. The base is rectangular in shape with dimension 165mm×1153mm and the height is 25mm.The piezometer is cuboid in shape and of dimension 25mm×25mm×170mm, welded to it is a pipe of length 30mm and internal diameter 20mm in which a tap was incorporated in other to control the flow of the fluid flowing into the system. The test pipe has an internal diameter of 0.05mm.The air valve channel is also cuboid in shape and of dimensions 135mm×55mm×20mm and made up of sheet metal incorporated in it is the air valve. The needle valve where the rubber hose is attached is of pipe of external diameter 5mm was welded to the piezometer. The steel meter rule and rubber hose were arranged on the vertical flat iron bar to give the manometer. The air valve, the manometer and the base including the piezometer tappings and test pipe were then arranged as shown in the Figures A and B (in the appendices).

2.2 Experimental Methods

The apparatus was set on the bench and leveled so that the manometers stand vertically. The water manometer is then introduced into the circuit by directing the lever on the tap towards the relevant connecting pipe. The bench supply valve was opened and adjusted until there was a steady flow down the supply tank overflow pipe. With the needle valve partly opened to allow water to flow through the system, any trapped air was removed by manipulation of the flexible pipes. Necessary care was ensured so as to clear the piezometer connection of air. The needle valve was then closed whereupon the levels in the two limbs of the inverted U-tube should settle to the same value. The needle valve was opened fully to obtain a differential head of at least 400mm, and the collection of a suitable quantity of water in the measuring cylinder timed. The values of h_1 (head in downstream manometer) and h_2 (head in upstream manometer) were taken. Further readings were taken at decreasing flows, the needle valve serving to reduce the discharge from each reading to the next.

3. Results and Discussion

Tables 1and 2 show the results obtained from both imported and locally fabricated friction loss in pipe apparatus respectively. Also, Fig 1 shows the graphical comparison of experimental result of log of velocity for both imported and fabricated frictional loss in pipe apparatus and Fig 2 shows the graphical comparison of experimental results of log of hydraulic gradient for both imported and fabricated friction loss in pipe apparatus. The deviation of imported and fabricated apparatus result was so negligible, thereby confirming the reliability of the fabricated apparatus as a veritable substitute for the imported one.

The results were further investigated using t-test analysis at 95% confidence level as shown in both Tables 3 and Table 4. It is however seen from Table3 that, there is no significance difference in imported and locally fabricated friction loss in pipe apparatus since T-tabulated (2.073875294) is greater than the T-calculated (0.013489485) and that there is no significance difference in imported and locally fabricated friction loss in pipe apparatus since T-tabulated (2.073875294) is greater than the T-calculated (- 0.090361508).

The cost estimate which is the bill of Engineering Measurement and Evaluation (BEME) of locally fabricated friction loss in pipe apparatus is given in Table 4 as shown.

Table 1; Results obtained from imported friction loss in pipe apparatus

Qty(ml)	t(s)	u(m/s)	h_1(mm)	h_2(mm)	h_f(m)	i	Temp °C	Logi	Log u
400	50.8	1.11	521	56	0.465	0.887	25	-0.0521	0.0453
400	54	1.049	500	85	0.415	0.794	25	-0.1002	0.208
400	58.8	0.961	476	114	0.362	0.692	25	-0.1599	-0.0173
400	61.8	0.915	452	145	0.307	0.586	25	-0.2321	-0.0586
400	67.2	0.843	427.5	174	0.2535	0.483	25	-0.3161	-0.0742
300	57.8	0.734	390	223	0.167	0.319	25	-0.4962	-0.1343
300	71.9	0.592	375	245	0.13	0.248	25	-0.6055	-0.2277
300	92.9	0.457	362	263	0.099	0.189	25	-0.7235	-0.3401
200	92.4	0.306	349	282	0.067	0.128	25	-0.8928	-0.5143
150	100.8	0.22	340	295.5	0.455	0.085	25	-1.0771	-0.6576
85	113.6	0.106	332.5	306	0.0265	0.05	25	-1.2958	-0.9747
50	129.4	0.055	325	316	0.009	0.017	25	-1.7645	-1.2596

Table 2; Results obtained from locally fabricated friction loss in pipe apparatus

Qty(ml)	t(s)	u(m/s)	h_1(mm)	h_2(mm)	h_f(mm)	i	Temp °C	Logi	Log u
400	51.1	1.11	521	58	0.463	0.884	25	-0.054	0.045
400	54.3	1.04	500	86	0.414	0.79	25	-0.102	0.017
400	59.1	0.96	475.5	115.5	0.36	0.687	25	-0.163	-0.017
400	62.1	0.91	452	147	0.305	0.582	25	-0.235	-0.041
400	67.6	0.84	427	174	0.253	0.483	25	-0.316	-0.076
300	58.1	0.73	389.5	224.5	0.165	0.315	25	-0.502	-0.137
300	72.7	0.58	375	244	0.131	0.25	25	-0.602	-0.237
300	95	0.45	361.5	264.5	0.097	0.185	25	-0.733	-0.347
200	93.3	0.3	348	283	0.065	0.124	25	-0.907	-0.523
150	101.2	0.2	339.5	294.5	0.045	0.086	25	-1.066	-0.699
85	113.9	0.11	332	306	0.026	0.05	25	-1.301	-0.959
50	129.7	0.06	325	316	0.009	0.017	25	-1.77	-1.221

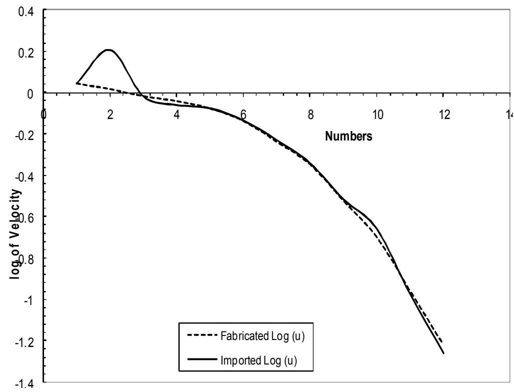

Figure 3; the graphical comparison of experimental result of log of velocity for both imported and fabricated frictional loss in pipe apparatus

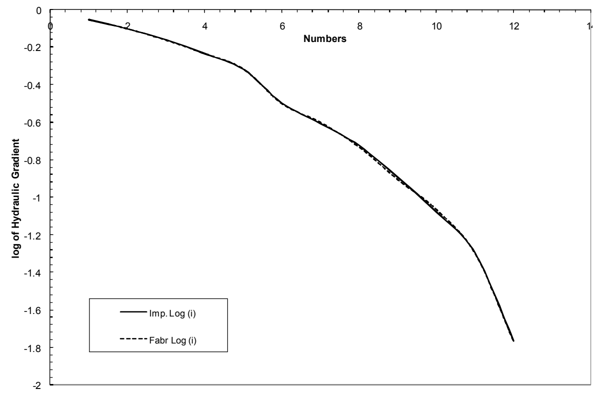

Figure 4; the graphical comparison of experimental result of log of hydraulic gradient (i) for both imported and fabricated frictional loss in pipe apparatus

Table 3; T-test comparison results of logarithm of hydraulic gradient (i) and logarithm of velocity (u) between imported and fabricated apparatus

	Log i		*Log u*	
	Imported	*Fabricated*	*Fabricated*	*Imported*
Mean	-0.642983333	-0.645916667	-0.349583333	-0.333758333
Variance	0.283370214	0.284061174	0.173777902	0.194267797
Observations	12	12	12	12
Hypothesized Mean Difference	0		0	
Df	22		22	
t Stat	0.013489485		-0.090361508	
P(T<=t) one-tail	0.49467943		0.464408802	
t Critical one-tail	1.717144187		1.717144187	
P(T<=t) two-tail	0.989358859		0.928817604	
t Critical two-tail	2.073875294		2.073875294	

Table 4; Bill of Enginnering Measurement and Evaluation for the apparatus

S/N	Items	QUANTITY	UNIT COST (₦)	COST (₦)
1	Iron flat bar 1020mm×185mm×0.05mm	1	1200	1200
2	Iron flat 1153mm×165mm×0.05mm	1	1400	1400
3	Squared pipe 25mm×170mm	2	450	900
4	Rubber hose	2438.4mm	400	400
5	Steel meter rule	2	200	400
6	Paint		1000	1000
7	Bolts and nuts	9	120	120
8	Washers	8		100
9	Aluminum clips	5	30	150
10	Miscellaneous			2000
11	Overhead			1500
12	Contingence			2200
	Total			11370

4. Conclusions

The reliability of the locally fabricated friction loss in pipe apparatus was confirmed based on T-test analysis carried out on the experimental laminar flow test results. It has also been established in this paper that the experimental result carried out using imported friction loss in pipe apparatus and locally fabricated fiction loss in pipe apparatus has no significant difference at 95% confidence level. Considering the cost implication, the locally fabricated apparatus is preferably reliable because many Nigerian institutions and industrial laboratories may not be able to afford the high price of imported friction loss in pipe apparatus. The production cost of the locally fabricated friction loss in pipe apparatus is ₦11370 as stated in Table 4. The cost is likely to reduce when standard approach is adopted in manufacturing different component on a large scale. It is expected that another group of people or individual will commenced further work from here.

5. Recommendations

Having completed this paper work, it is therefore recommended:

1. That government should facilitate the manufacturing of this apparatus in large scale so as to reduce the cost of production.
2. That government or institutional management should ensure the availability of adequate facilities in the workshop to increase engineering students' skills in handing engineering equipment.

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APPENDICES (Figure A, Figure B, Figure C)

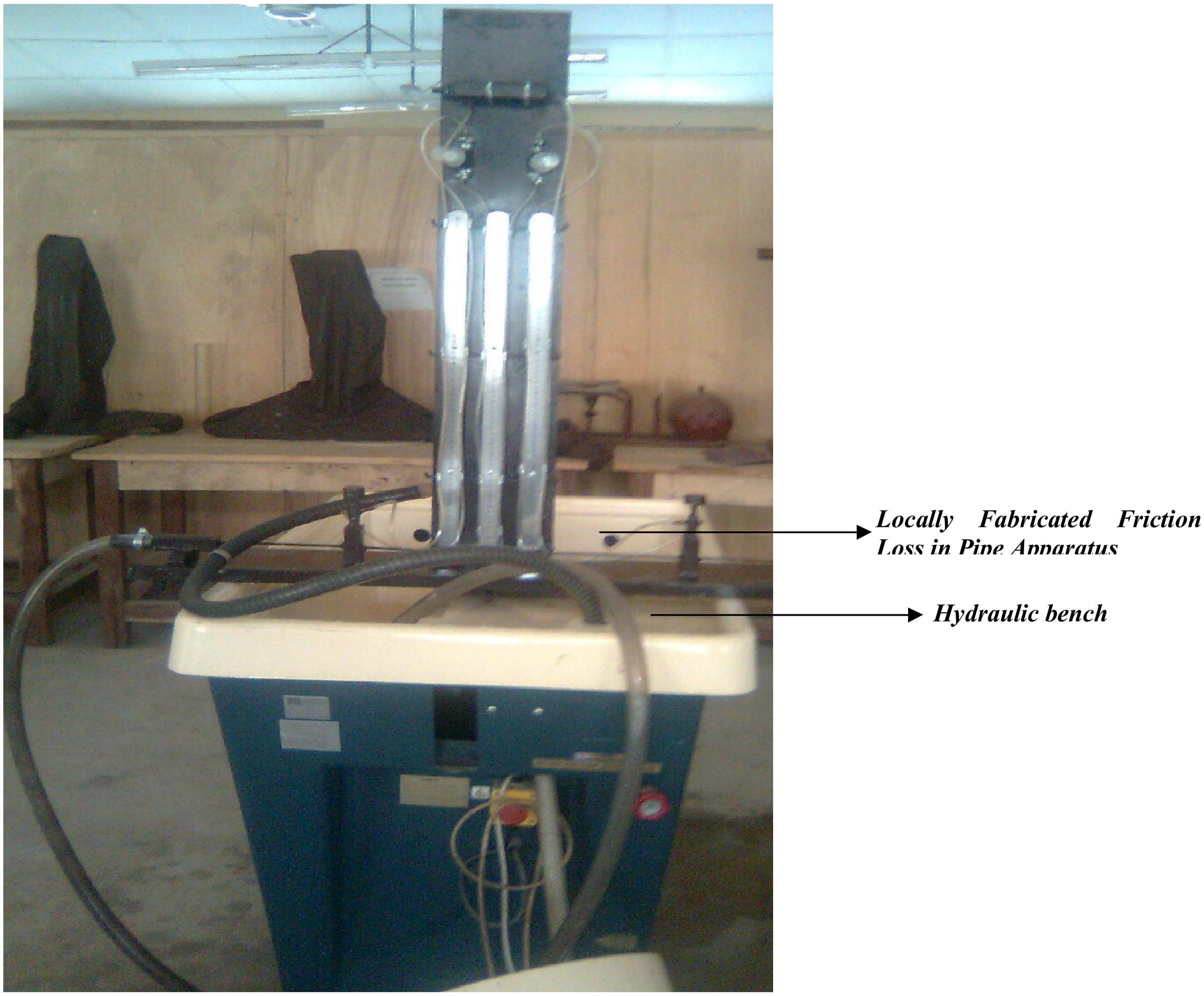

Figure A: Locally fabricated fiction loss in pipe apparatus on hydraulic bench during testing.

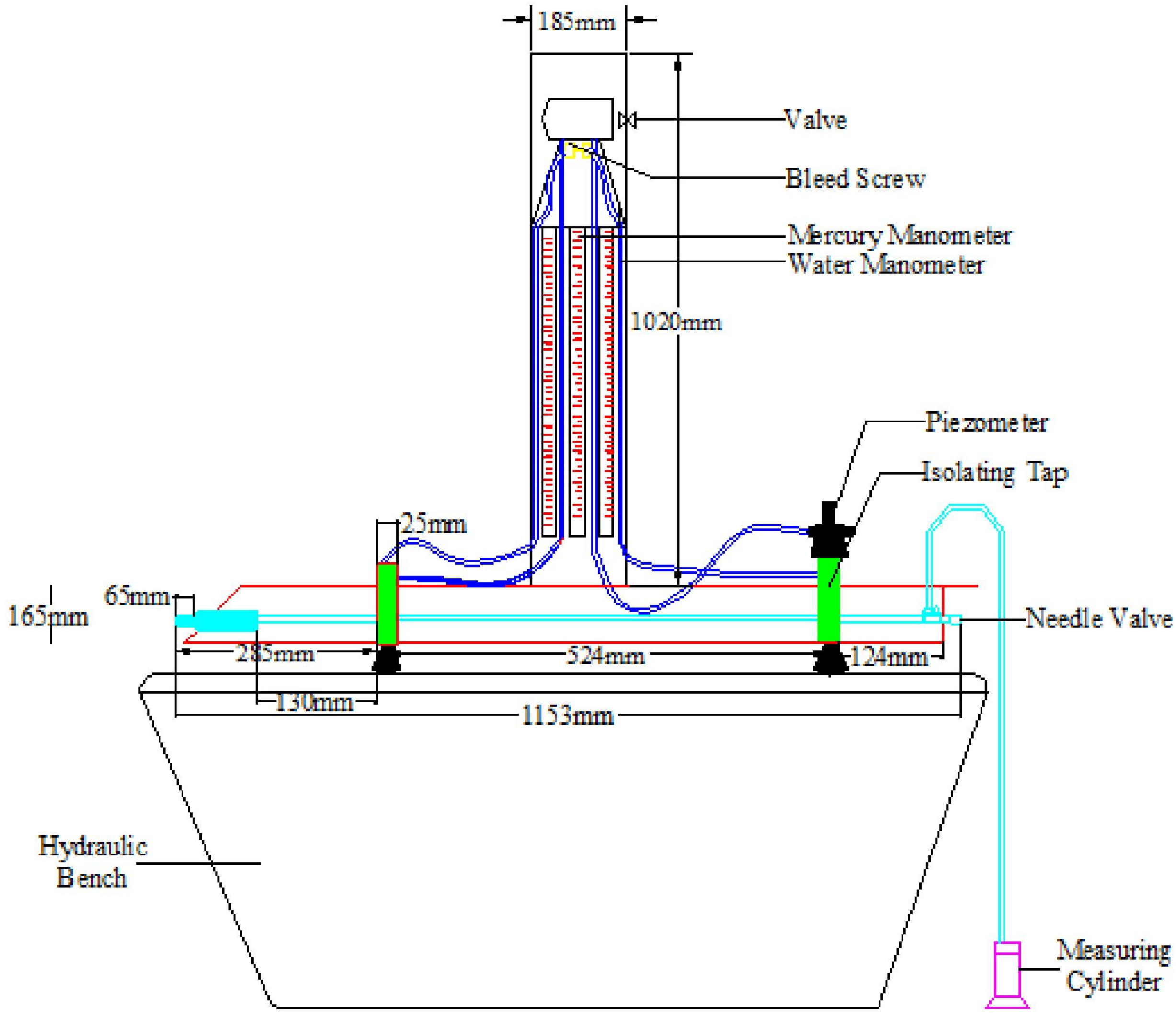

Figure B; *Sketch of Friction loss in apparatus placed on hydraulic bench*

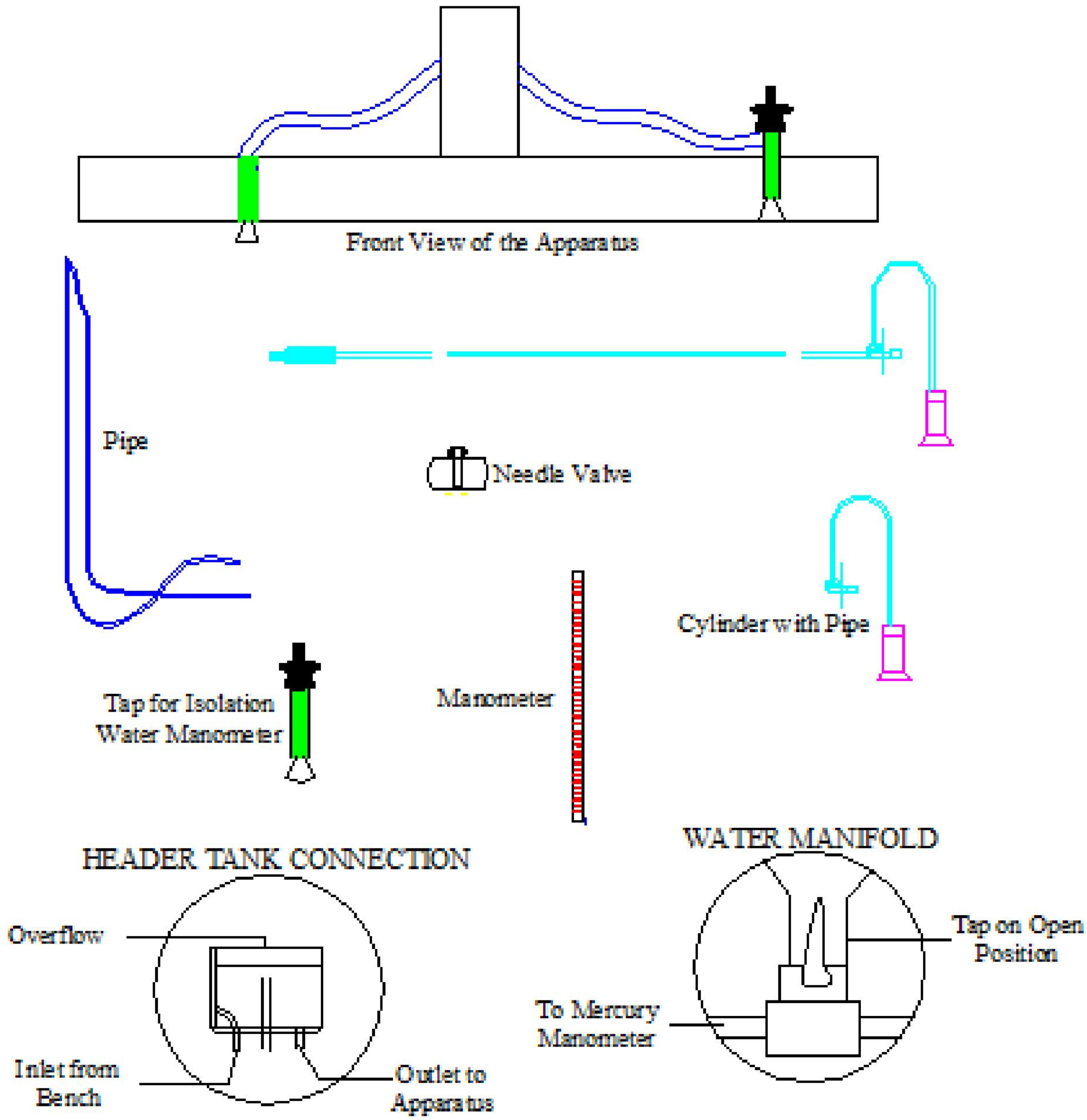

Figure C: *Some part of friction loss in pipe apparatus*