A PROJECT REPORT

ON

"UNIVERSAL FLUID MECHANICS APPARATUS"

Submitted by

KHARBE MUJEEB
MAJGAONKAR Mhod. HUZAIFA
SANGE UBAID
KHAN SAIF ALI
MANSURI FAIZAN
MOOSA SAIM
ANSARI NAVEED
SHAIKH SOHAIL

In partial fulfilment for the award of the Degree

Of

BACHELOROFENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. ALTAMASH GHAZI

DEPARTMENT OFMECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKARTECHNICALCAMPUS,

NEW PANVEL

NAVIMUMBAI– 410206

UNIVERSITYOFMUMBAI

ACADEMIC YEAR 2017-2018

ANJUMAN-I-ISLAM

KALSEKARTECHNICALCAMPUS, NEW PANVEL **(Approved by AICTE, recognized by Maharashtra Govt. DTE) Affiliated to Mumbai University**

PLOT#2&3,SECTOR16, NEARTHANANAKA,KHANDAGAON,NEWPANVEL,NAVIMUMBAI-410206, Tel.: +912227481247/48 *Website:www.aiktc.org

CERTIFICATE

This is to certify that the project entitled,

"**UNIVERSAL FLUID MECHANICS APPARATUS**" Submitted by,

KHARBE MUJEEB	**MANSURI FAIZAN**
MAJGAONKAR Mohd. HUZAIFA	**MOOSA SAIM**
SANGE UBAID	**ANSARI NAVEED**
KHAN SAIF ALI	**SHAIKH SOHAIL**

To the Kalsekar Technical Campus, New Panvel is a record of bonafied work carried out by them under our supervision and guidance, for partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examiner
(Prof. Altamash Ghazi)

External Examiner

Head of Department
(Prof. Zakir Ansari)

Director
(Dr. Abdul Razzak Honnutagi)

ANJUMAN-I-ISLAM
KALSEKARTECHNICALCAMPUSNEW PANVEL
(Approved by AICTE, recognized byMaharashtraGovt.DTE)
Affiliated to Mumbai University
PLOT#2&3,SECTOR16, NEARTHANANAKA,KHANDAGAON,NEWPANVEL,NAVIMUMBAI-410206,Tel.: +912227481247/48 *Website:www.aiktc.org

---

APPROVAL OF DISSERTATION

This is to certify that the thesis entitled,

"**UNIVERSAL FLUID MECHANICS APPARATUS**" Submitted by.

KHARBE MUJEEB	**MANSURI FAIZAN**
MAJGAONKAR Mohd. HUZAIFA	**MOOSA SAIM**
SANGE UBAID	**ANSARI NAVEED**
KHAN SAIF ALI	**SHAIKH SOHAIL**

In partial fulfilment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

Date: ___________

ACKNOWLEDGEMENT

After the completion of this work we would like to give our sincere thanks to all those who helped us to reach our goal .It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. Altamash Ghazi** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof.ZakirAnsari**, Head Of Department, and **Prof.RizwanShaikh**, Project coordinator from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

We takethis opportunity to give sincere thanks to **Mr.Randhive sir**, fluid mechanics lab incharge, **Mr.Khalil sir** and **Mr.Faiyaz sir ,**machine shop of mechanical department for all the help rendered during the course of this work and their support, motivation, guidance and appreciation.

We are thankful to **Dr.AbdulRazzak Honnutagi**, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least we would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

ABSTRACT

The objective of this project is to develop a compact fluid mechanics lab to optimize the floor space along with performing almost all the requisite experiments which are part of Mumbai university syllabus. This project is proposed to overcome the difficulty faced by the students and staffs of mechanical & civil Engineering departments of Anjuman Islam's Kalsekar Technical Campus (AIKTC). As due to time constrain of exist fluid mechanics lab which should ideally run for 34 hours (5 days ×7 hours) weekly have weekly load of around 48 hours (6 class × 4 batches ×2 hours/batch).Managing of this is a nightmare to time table co-ordinator of institute as well as students & staffs of both the departments.

To overcome this there was an idea to make two fluid mechanics labs for both departments. But due to financial and space constrains of building it is impossible. So here we got the idea to design and develop a compact apparatus on which all requisite experiments can be performed, which can be accommodated in a tiny space in any available laboratory.

CONTENT

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND NOTATIONS

C_d- Coefficient Of Discharge

Q_{th}- Theoretical Discharge

Q_{act}- Theoretical Discharge

F_t- Feet

HP - Horse Power

SST – Shear stress transport

CFX - computation fluid dynamics program

CHAPTER 1 INTRODUCTION

1.1 PROBLEM IDENTIFICATION:

As per the Mumbai University syllabus department has to complete fluid mechanics experiment /practical on orifice meter, venturi meter, pitot tube , major losses and minor losses, for completion of these experiments they require the fluid mechanics lab by which they can perform their experiments.

In this circumstance the college has the fluid mechanics lab which is placed for civil Engineering. For the completion of fluid mechanics practical syllabus of Mechanical Engineering department is using this lab as mentioned. The two departments simultaneously using same lab. The working hours for completion of the experiment are not sufficient about 570 students per week. The size of the lab is around 1744 sq.ft. In which the apparatus used by mechanical department consuming the space around 120 sq.ft in which the setups like Orifice meter, venturi meter, pitot tube, major and minor losses are placed. Overall cost of these setups are around 1,80,000 Rs.

1.2 AIM OR OBJECTIVE:

To overcome the mentioned problems we have to design and develop a setup which carries required setups i.e. orifice meter, venturi meter, pitot tube, major and minor losses. After the completion of this setup we can perform all the mentioned experiments on single working unit hence.

Universal fluid mechanics apparatus is defined as the integration of fluid mechanics experiment setups like orifice meter, venturi meter, pitot tube, major and minor losses and placed them in a single assemble working unit.

By making of this setup the following advantages are obtained;

1) Initial cost will decrease compared to previous setup.

2) Space required less compared to previous setup.

3) Human effort for the operation of the experiment will decrease.

4) Since using the single pump for the operation whole setup input power source will also decrease compared to previous setup.

CHAPTER 2 - LITERATURE REVIEW

2.1.1 REVIEW ON VENTURI METER:

Professors Nikhil Tamhankar, Amar Pandhare, Ashwinkumar Joglekar and Vaibhav Bansode (Department of Mechanical engineering) have calibrated the coefficient of discharge (C_d) of Venturimeter by comparing the results with the analysis. This analysis was analyzed on Ansys Fluent 13.0. The research covers the following aspects: to study the theory of the venturimeter and calculate the data theoretically by using Bernoulli's equation, to analyse the experimental data and to plot graphs for it. The focus here is to analyse the pressure variations across the venturi section by means of Ansys Fluent 13.0, a commercial CFD code, which explores the use of computational methods to compute the flow parameters in the tube. The study aims at comparing the results calculated by both, the computational and experimental methods. Their effort is made to check the validity of Bernoulli's equation when applied to the steady flow of water in a tapered duct and to calibrate the venturi as a flow meter by calculating the coefficient of discharge (C_d). In this research, researchers concluded that The coefficient of discharge obtained from both, the experimental tests and the CFD analysis are approximately same within 5% accuracy.[1]

2.1.2 REVIEW ON ORIFICE METER:

In the paper, orifice plates with different geometry were designed and compared on the basis of their coefficient of discharge. This was done with the help of simulations done with k-ε and SST model on CFX as a solver. Simulations were carried out on a single hole, perforated (5 holes, 7 holes and 9 holes) and triangular shape orifice plates. β ratio taken was 0.6 for single hole, perforated, triangular orifice plates. perforated orifices have been experimentally studied in terms of discharge coefficient and compared with a single hole orifice plate which is generally used in orifice meters to measure flow. Through simulation and experimentation, the 7 holes orifice plate is found to be having the highest value of coefficient of discharge i.e. 0.76 with an actual discharge of 3.82*10-4 m 3 /s. Compared with single hole orifice plate, the coefficient of discharge of 7 holes orifice plate is 10-12% greater. The Cd found out from CFD is greater than that found from experimentation because of the losses occurring in the physical model due to friction inside the pipe, leakage, impurities present in the fluid, etc. which are not considered in CFD.[2]

2.1.3 REVIEW ON PITOT TUBE:

Starting in 1856 Henry Darcy, with the assistance of Henry Bazin, published four works that show various forms of an improved Pitot tube design. Although Henri Pitot had invented the device in 1732, theoretical and design weaknesses had kept it little more than a scientific toy. Darcy's improved instruments provided accurate and easy measurements of point velocity for the first time, which allowed advances in open channel and pipe flow hydraulics. His final design for the instrument tip is reflected today in all of our modern instruments. A reproduction of Darcy's published 1858 design was completed and shown to work as reported. Darcy's contribution to the development of the device equaled or exceeded Pitot's initial work, thus making it appropriate to refer to the modern instrument as the "Pitot- Darcy tube". This paper, which is a revised and expanded version of Brown (2001), will discuss the first instrument created by Henri Pitot, and the improvements made by Henry Darcy. It will be shown that Darcy, with the support of Henry Bazin, perfected the design into the useful instrument we use today. Clearly, Darcy’s contribution to the development of the device equaled or exceeded Pitot's initial work. Thus it is only right, as some authors do now, to refer to the modern instrument as the "Pitot-Darcy tube". With this nomenclature, the dynamic pressure is measured with the "Pitot" tube, while the hydrostatic pressure is obtained with the "Darcy" tube.[3]

2.1.4 REVIEW ON NOZZLE METER:

The analysis is carried out by using academic version of ANSYS 16 software. Computational fluid dynamics (CFD) approach has been used for the calibration of nozzle meter. Also very less work is done on the performance of nozzle meter with the change of beta ratio. The simulation was conducted with five different nozzle meters having different beta ratios. Differential pressure head was assessed by creating two planes one at a distance equal to pipe diameter and other at a distance half the diameter of pipe on either sides of nozzle. Five curves were plotted between Reynolds number vs. coefficient of discharge) & a single curve showing actual discharge vs. pressure head drop for different beta ratios in order to compare the results obtained through the simulation with experimental results. It was observed that the coefficient of discharge is varying rapidly at lower Reynolds number and going in a constant way for the higher value of the same. However in the simulation coefficient of discharge remains well above and constant as compared to the experimental value. Also change in beta ratio affects the relation between variables as per exponent n. This concluded that The coefficient of discharge (Cd) increases with the increase in Reynolds number for all β ratios. However, Cd becomes constant and independent of β ratio in case of simulation, where as Cd varies in unpredictable way in case of experimental analysis.[4]

2.1.5 REVIEW ON MAJOR LOSSES:

The purpose of carrying out current experimental & analysis is to co-relate the head loss with various affecting parameters. For mathematical analysis and graphical analysis purpose use of MATLAB is considered to find the more accurate equation for head loss. This new formula and study will provide the base for chemical and irrigation department for calculating the accurate head loss by using various materials in various working conditions. Experimental work also helps to calculate the accurate lost power to overcome the friction. In the past review it is shown that head loss is directly proportional to the square of velocity, but in experimental study it observed that the relation is non-linear. Also the linearity varies with discharge rate. It is found minimum for some particular value of discharge. The accuracy of formula validated and verified on head loss measuring apparatus by using known values of discharge rate which are calculated from interpolation of graph & gives expected result regarding head loss.

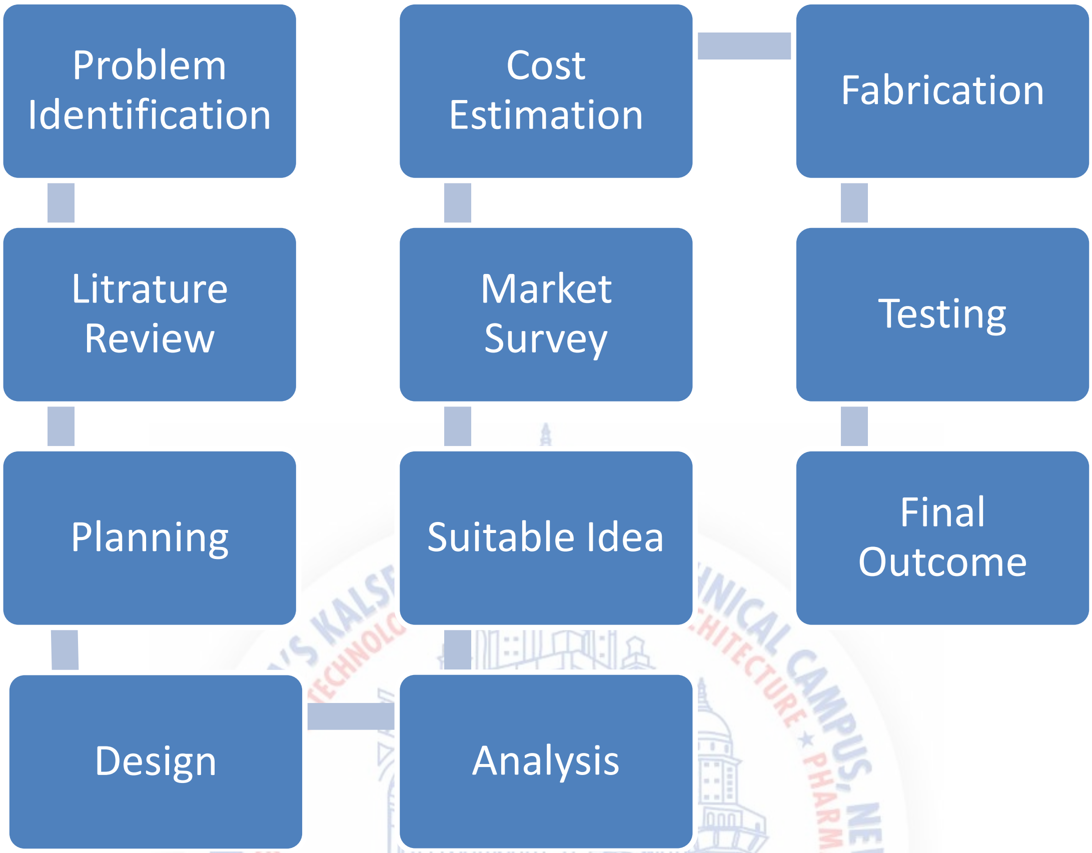
Following conclusions was drawn from the present experimentation;

1) For 12.5mm diameter friction factor for MS is highest of all while least for PVC pipe.
2) For 12.5mm diameter discharge is more for PVC and least for MS.
3) For 22mm diameter, stainless steel has more friction factor and less for Al.
4) For 22mm diameter Al have high discharge value and MS have lesser.[5]

2.2 MATERIAL SURVEY:

For all setups the material used for pipes is Mild Steel (MS). For all setup the ball valves of size 1 inch, 0.5 inch, 0.25 inch are used of Mild Steel. The storage tank is of plastic tank and delivery tank is of sheet metal. The structure is made of 1 inch M.S square pipe which is supporting the whole setup. The standard fiber glass mercury manometer operates in the range of 0-250mm.

CHAPTER 3 – METHODOLOGY



As discussed, the objectives of this project is to design and development of the fluid mechanics apparatus to overcome the difficulty in handling the mechanical and civil department practical's of fluid mechanics subject under the Mumbai university syllabus. So we decided to solve this problem by designing and developing the apparatus. This apparatus will be the integration of all setups like flow meters and head losses. That's why this developed setup is called as UNIVERSAL FLUID MECHANICS APPARATUS. After this, we decided to design a new apparatus of having all setups. So we decided to design three levels/floors. On each level, there are three equipments are placed for performing practical's. On first floor, we decided to place the venturimeter, orifice meter, and Pitot tube .and on the second floor there would be major losses and on third or top floor minor losses and nozzle meter. We designed structure on the basis of this levelling as shown in fig.4.1. The structure is fabricated by MS square pipe of 1 inch of dimension. On this structure, storage and measuring tank is kept. We also analyze the structure. We analysed individual components on solid works and then we had simulated that also.

After design and analysis, we came to about the requirement of material and specification. We surveyed market for material to Nagdevi Street, Mumbai. We purchased the material as per the design and next step was fabrication of entire apparatus. Firstly, we fabricated the structure on which the all experiment will be mounting and then we painted that structure. After that we assembled all the equipments as per design which includes assembling of pipes, different pipe and tubing's. Before the utilization of this setup for practical purpose, we tested that setup and calculated the results of each equipments.

CHAPTER 4 - DESIGN

4.1 STRUCTURE:

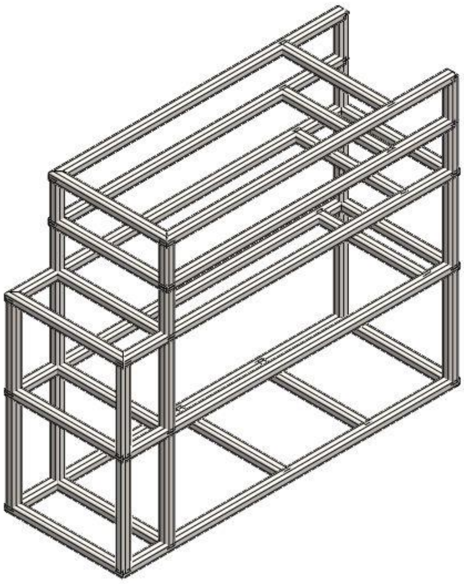


Fig 4.1: STRUCTURE

4.2 VENTURIMETER:

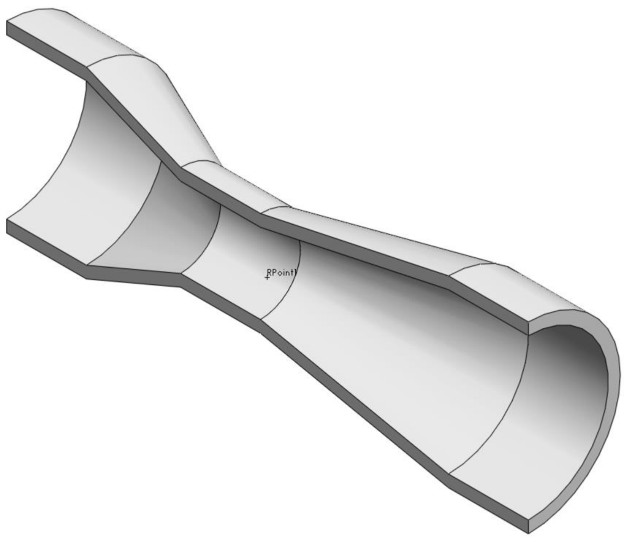


Fig4.2.1: VENTURIMETER SECTIONVIEW

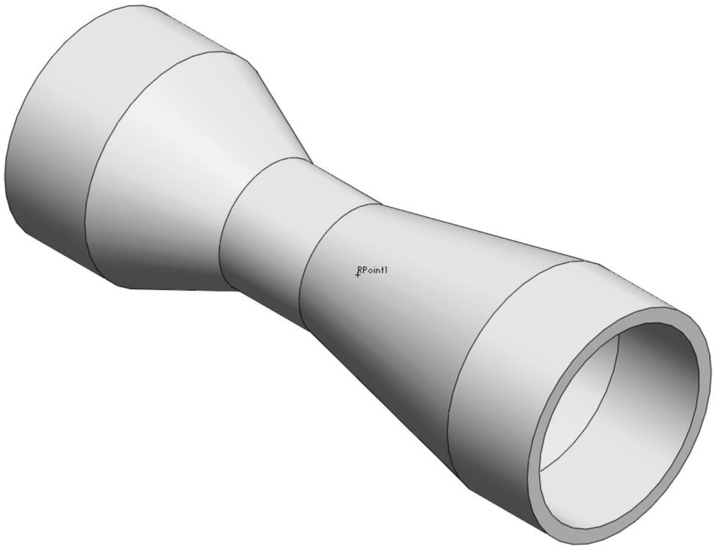


Fig.4.2.2: **VENTURIMETER**

4.3 ORIFICE METER:

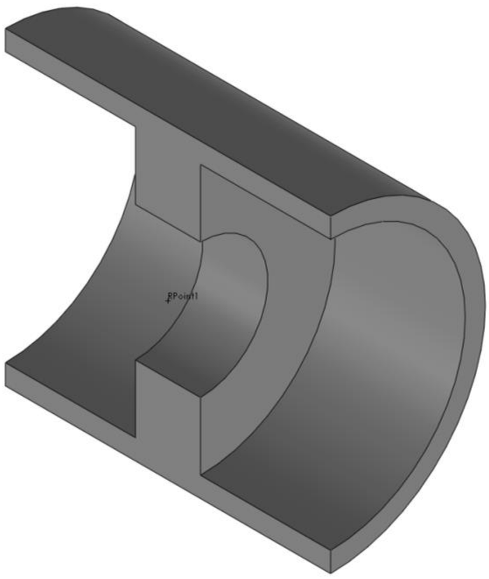


Fig.4.3.1: **ORIFICEMETER SECTION VIEW**

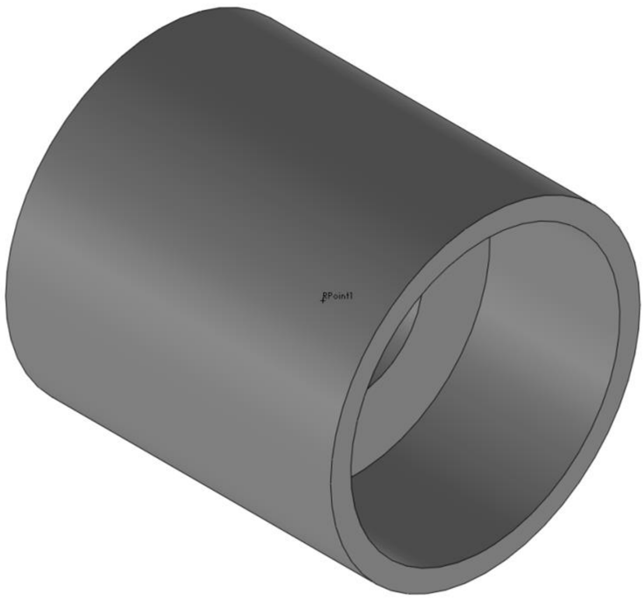


Fig.4.3.2: **ORIFICEMETER**

4.4 PITOTTUBE:

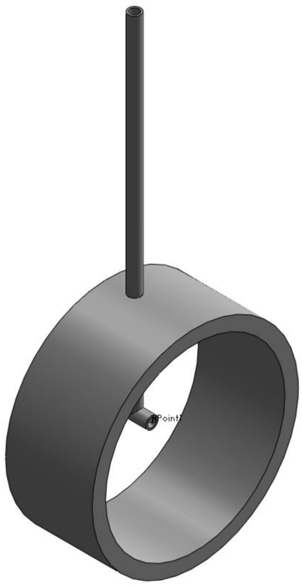


Fig.4.4: **PITOT TUBE**

4.5 NOZZLEMETER:

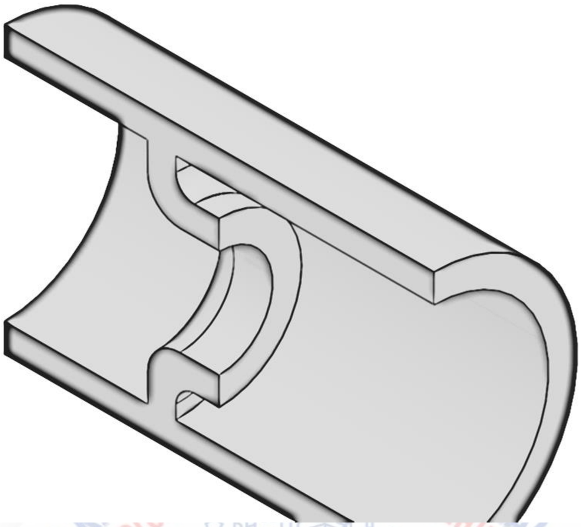


Fig.4.5: NOZZLE METER

CHAPTER 5– ANALYSIS

5.1 STRUCTURE:

As we know about the structure is subjected to number of loads like load of pipes, other components, storage tank and measuring tank. So we applied a load on different cross section on pipes. Following are some result of it. we analyzed it with following material specifications:

Name:	**Mild Steel**
Model type:	**Linear Elastic Isotropic**
Default failure criterion:	**Max von Mises Stress**
Yield strength:	**6.20422e+008 N/m^2**
Tensile strength:	**7.23826e+008 N/m^2**
Elastic modulus:	**2.1e+011 N/m^2**
Poisson's ratio:	**0.28**
Mass density:	**7700 kg/m^3**
Shear modulus:	**7.9e+010 N/m^2**
Thermal expansion coefficient:	**1.3e-005 /Kelvin**

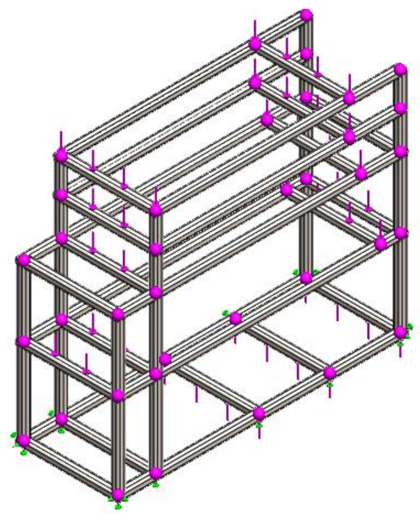
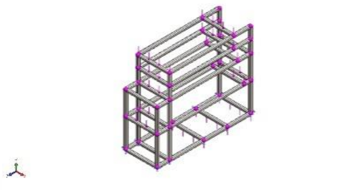
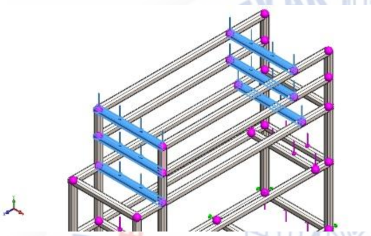
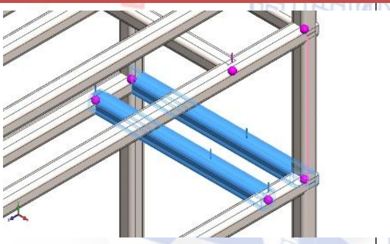
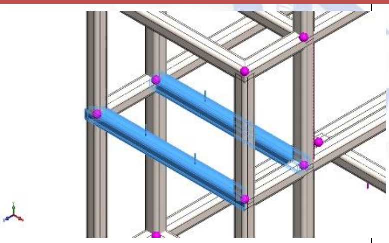
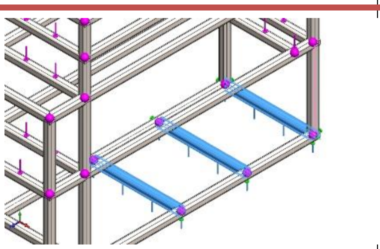


Fig. 5.1.1: Applied forces on structure

5.1.1 Loads and Fixtures:

Fixture name	Fixture Image	Fixture Details
Fixed-2		**Entities:** 10 Joint(s) **Type:** Fixed Geometry

Load name	Load Image	Load Details
Force-2		**Entities:** 6 Beam (s) **Reference:** Edge< 1 > **Type:** Apply force **Values:** ---, ---, -300 N **Moments:** ---, ---, --- N.m
Force-3		**Entities:** 2 Beam (s) **Reference:** Edge< 1 > **Type:** Apply force **Values:** ---, ---, -25 N **Moments:** ---, ---, --- N.m
Force-4		**Entities:** 2 Beam (s) **Reference:** Edge< 1 > **Type:** Apply force **Values:** ---, ---, -440 N **Moments:** ---, ---, --- N.m
Force-6		**Entities:** 3 Beam (s) **Reference:** Edge< 1 > **Type:** Apply force **Values:** ---, ---, 800 N **Moments:** ---, ---, --- N.m

5.1.2 Results:

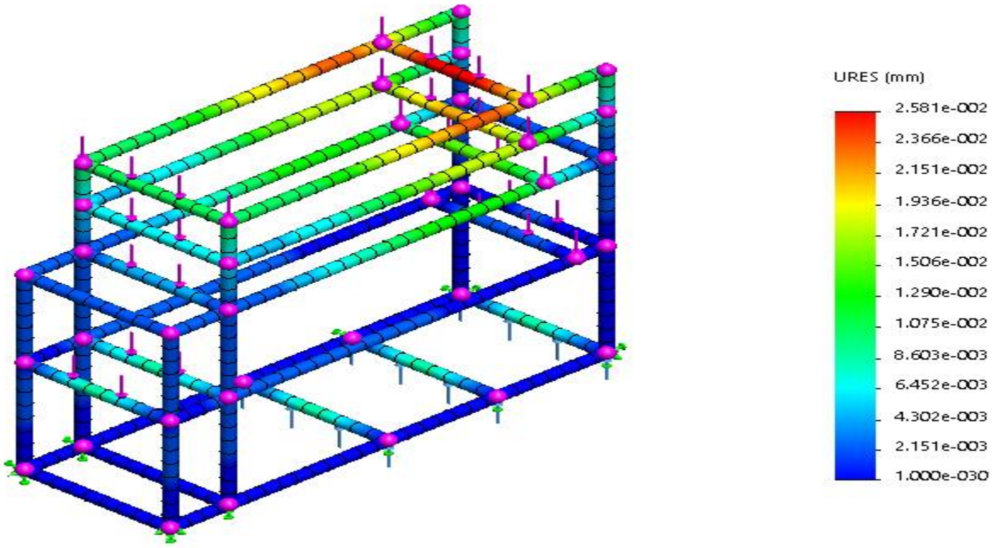


Fig. 5.1.2: static displacement

5.2: venturi meter:

Venturi meter measures the flow rate of water or fluid flowing through the pipes. It produces the pressure differential at its inlet and throat which is used to calculate flow rate through pipes. Following is the total pressure indication which we can understand by colour coding,

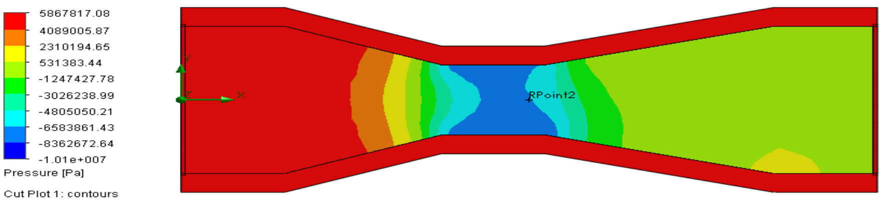


Fig. 5.2.1: Total pressure on venturi meter

5.2.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	-1.01e+007
GG Av Static Pressure 1	Pa	1569459.64
GG Max Static Pressure 1	Pa	5867817.08
GG Min Total Pressure 1	Pa	-1.01e+007
GG Av Total Pressure 1	Pa	4346667.30
GG Max Total Pressure 1	Pa	1.04e+007
GG Av Dynamic Pressure 1	Pa	2777207.66
GG Max Dynamic Pressure 1	Pa	1.56e+007
GG Av Velocity 1	m/s	61.567
GG Max Velocity 1	m/s	176.923
GG Normal Force 1	N	1806.330
GG Force 1	N	1868.557

5.2.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	997.53	998.41
Pressure [Pa]	-1.01e+007	5867817.08
Temperature (Fluid) [K]	289.61	293.32
Velocity [m/s]	0	173.097
Velocity (X) [m/s]	-24.805	173.027
Velocity (Y) [m/s]	-46.656	46.698
Velocity (Z) [m/s]	-46.698	46.655

5.3: Orifice meter:

Orifice meter measures the flow rate of water or fluid flowing through the pipes. It produces the pressure differential at its inlet and vena contracta which is used to calculate flow rate through pipes. Following is the total pressure indication which we can understand by colour coding,

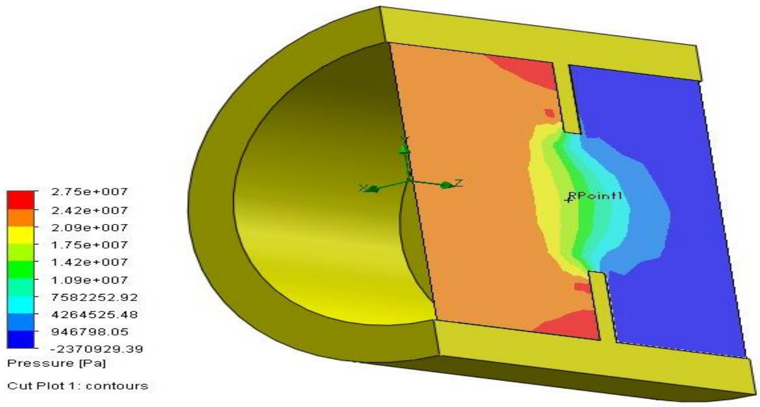


Fig. 5.3.1: Total pressure on orifice meter

5.3.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	-2370929.39
GG Av Static Pressure 1	Pa	1.31e+007
GG Max Static Pressure 1	Pa	2.75e+007
GG Min Total Pressure 1	Pa	-2370929.39
GG Av Total Pressure 1	Pa	1.53e+007
GG Max Total Pressure 1	Pa	4.76e+007
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	2208528.85
GG Max Dynamic Pressure 1	Pa	2.48e+007
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	45.354

GG Max Velocity 1	m/s	222.964

5.3.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.69	997.30
Pressure [Pa]	-2370929.39	2.75e+007
Temperature (Fluid) [K]	294.21	300.16
Velocity [m/s]	0	223.081
Velocity (X) [m/s]	-139.447	139.909
Velocity (Y) [m/s]	-140.796	139.315
Velocity (Z) [m/s]	-16.083	223.079

5.4: Nozzle meter:

Nozzle meter measures the flow rate of water or fluid flowing through the pipes. It produces the pressure differential at its inlet of pipe and outlet of nozzle meter which is used to calculate flow rate through pipes. Following is the total pressure indication which we can understand by colour coding,

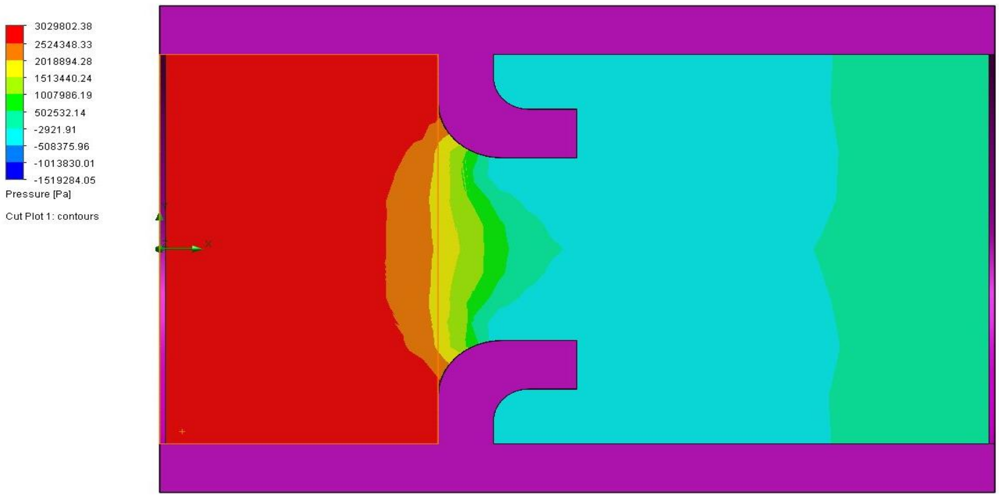


Fig. 5.4.1: Total pressure on nozzle meter

5.4.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	-1519284.05
GG Av Static Pressure 1	Pa	1031840.97
GG Max Static Pressure 1	Pa	3029802.38
GG Min Total Pressure 1	Pa	-1519284.05
GG Av Total Pressure 1	Pa	1444210.31
GG Max Total Pressure 1	Pa	3499090.00
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	412369.34
GG Max Dynamic Pressure 1	Pa	3498397.32
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	20.306
GG Max Velocity 1	m/s	83.816
GG Normal Force 1	N	2765.038

5.4.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.73	995.97
Pressure [Pa]	-1519284.05	3029802.38
Temperature (Fluid) [K]	299.19	300.03
Velocity [m/s]	0	83.609
Velocity (X) [m/s]	-11.543	83.579
Velocity (Y) [m/s]	-31.098	31.238
Velocity (Z) [m/s]	-31.112	31.259

5.5 Pitot tube:

Pitot tube measures the flow rate of water or fluid flowing through the pipes. It produces the pressure differential at its inlet of pitot tube and static pressure which is used to calculate flow rate through pipes. Following is the total pressure indication which we can understand by colour coding,

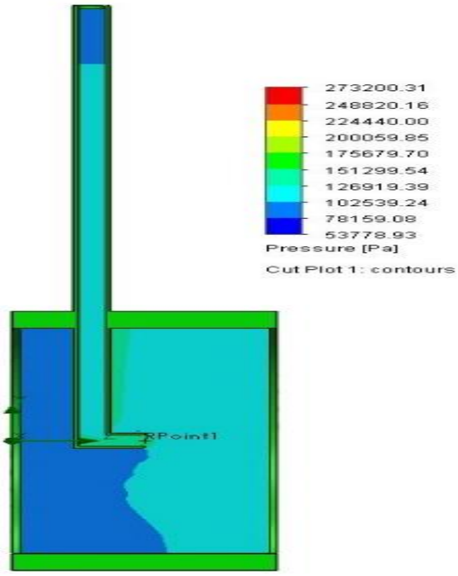


Fig. 5.5.1: Total pressure on Pitot tube

5.5.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	53778.93
GG Av Static Pressure 1	Pa	103817.07
GG Max Static Pressure 1	Pa	273200.31
GG Min Total Pressure 1	Pa	53778.93
GG Av Total Pressure 1	Pa	147227.94
GG Max Total Pressure 1	Pa	301692.78
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	43410.87

GG Max Dynamic Pressure 1	Pa	74954.54
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	9.294
GG Max Velocity 1	m/s	12.270
GG Normal Force 1	N	4.565
GG Force 1	N	5.016
GG Friction Force 1	N	0.594

5.5.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.73	995.74
Pressure [Pa]	53778.93	273200.31
Temperature (Fluid) [K]	299.99	300.01
Velocity [m/s]	0	11.442
Velocity (X) [m/s]	-6.017	6.028
Velocity (Y) [m/s]	-3.511	7.909
Velocity (Z) [m/s]	-11.095	1.655

5.6 Minor losses:

When the water is flowing in a channel it experiences some conflict to its motion, whose effect is to reduce the velocity & eventually the head of water existing. While there are many kinds of losses, yet the minor loss is due to the different fitting of the pipe. Loss due to entry, loss due to changes in cross - section of the pipe such as sudden contraction, sudden expansion including loss due to change of direction elbows, bends, loss due to obstruction (valve, diaphragm) loss due to exit.

5.6.1 Sudden contraction:

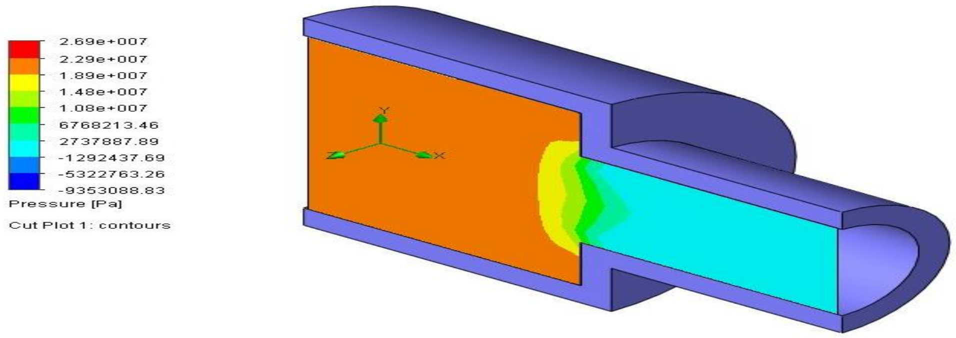


Fig. 5.6.1: Total pressure on sudden contraction

5.6.1.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	-9353088.83
GG Av Static Pressure 1	Pa	1.78e+007
GG Max Static Pressure 1	Pa	2.69e+007
GG Min Total Pressure 1	Pa	-9353087.66
GG Av Total Pressure 1	Pa	2.14e+007
GG Max Total Pressure 1	Pa	3.92e+007
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	3543013.52

GG Max Dynamic Pressure 1	Pa	2.30e+007
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	65.844
GG Max Velocity 1	m/s	214.888
GG Normal Force 1	N	8247.578
GG Force 1	N	8304.163
GG Friction Force 1	N	56.585

5.6.1.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.69	997.19
Pressure [Pa]	-9353088.83	2.69e+007
Temperature (Fluid) [K]	294.67	300.19
Velocity [m/s]	0	216.965
Velocity (X) [m/s]	0	216.963
Velocity (Y) [m/s]	-72.404	71.883
Velocity (Z) [m/s]	-72.431	71.859

5.6.2 Sudden expansion:

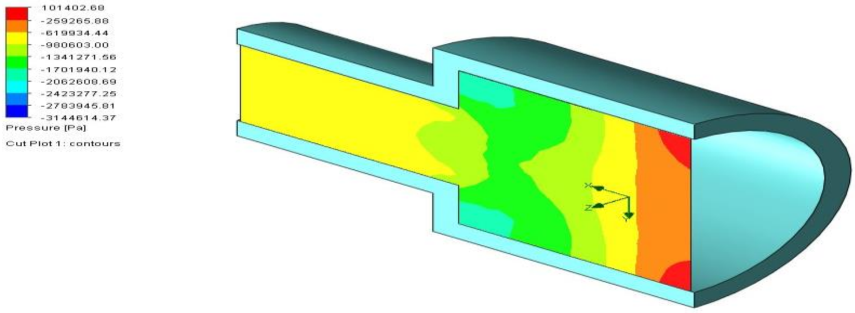


Fig. 5.6.2: Total pressure on sudden expansion

5.6.2.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	-3144614.37
GG Av Static Pressure 1	Pa	-1057129.64
GG Max Static Pressure 1	Pa	101402.68
GG Min Total Pressure 1	Pa	-3144614.37
GG Av Total Pressure 1	Pa	3610787.65
GG Max Total Pressure 1	Pa	1.23e+007
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	4667917.29
GG Max Dynamic Pressure 1	Pa	1.35e+007
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	72.489
GG Max Velocity 1	m/s	164.745

5.6.2.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	994.98	995.79
Pressure [Pa]	-3144614.37	101402.68
Temperature (Fluid) [K]	299.82	302.57
Velocity [m/s]	0	164.916
Velocity (X) [m/s]	-164.915	24.652
Velocity (Y) [m/s]	-32.446	31.643
Velocity (Z) [m/s]	-32.434	31.652

5.7: Major losses:

When a real (viscous) fluid flows during a pipe, some of energy is depleted through maintaining the flow. Owing to internal friction and disorder, this energy is transformed into thermal energy. Such a change leads to the appearance of the energy loss in terms of the fluid depth termed as the head loss. Effectively due to friction is known as linear or major head loss. It is there all through the length of the channel.

5.7.1 Major losses in 0.75 inch pipe:

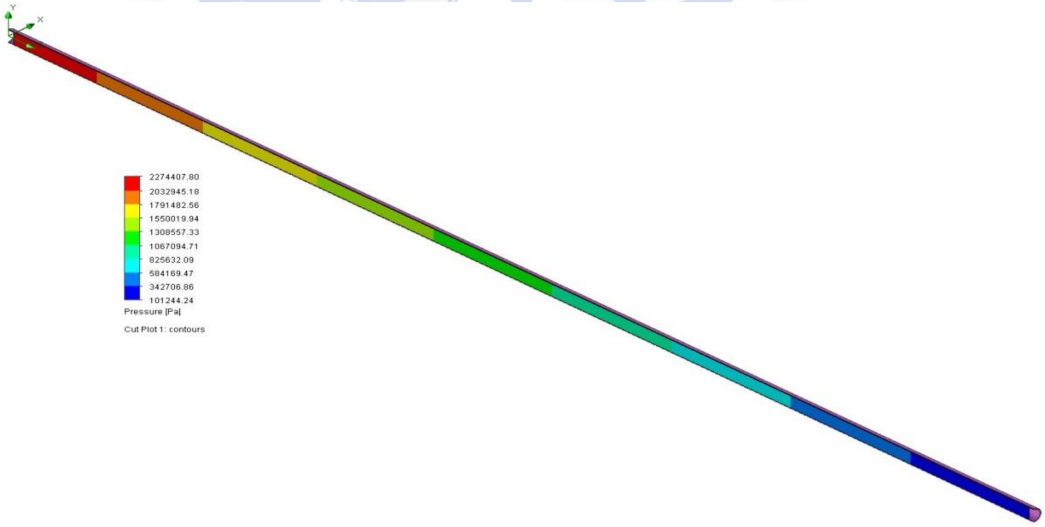


Fig. 5.7.1: Total pressure in 0.75 inch pipe

5.7.1.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	101244.24
GG Av Static Pressure 1	Pa	1139989.97
GG Max Static Pressure 1	Pa	2274407.80
GG Min Total Pressure 1	Pa	102204.53
GG Av Total Pressure 1	Pa	3676769.47
GG Max Total Pressure 1	Pa	4794421.79
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	2536779.50
GG Max Dynamic Pressure 1	Pa	3095248.43
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	71.143
GG Max Velocity 1	m/s	78.846
GG Friction Force 1	N	597.334

5.7.1.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.67	995.78
Pressure [Pa]	101244.24	2274407.80
Temperature (Fluid) [K]	299.86	300.24
Velocity [m/s]	0	78.846

Velocity (X) [m/s]	-0.102	0.102
Velocity (Y) [m/s]	-0.102	0.102
Velocity (Z) [m/s]	0	78.846

5.7.2 Major losses in 0.5 inch pipe:

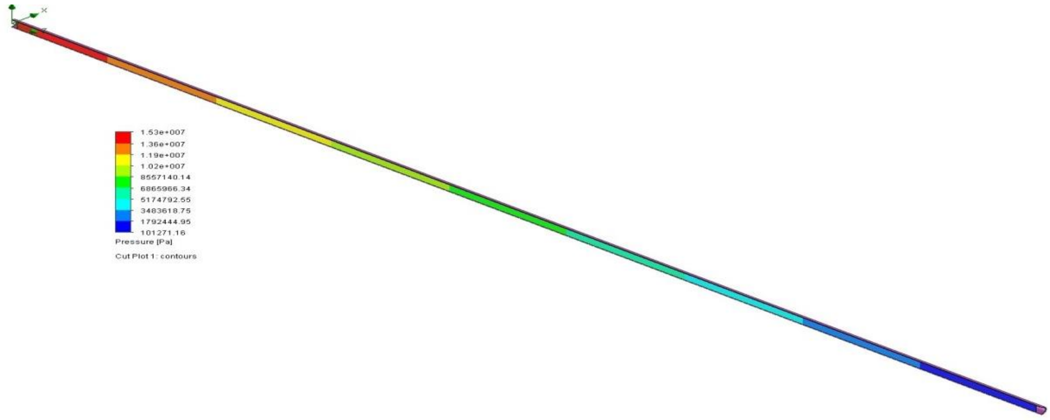


Fig. 5.7.2: Total pressure in 0.5 inch pipe

5.7.2.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	101271.16
GG Av Static Pressure 1	Pa	7480211.36
GG Max Static Pressure 1	Pa	1.53e+007
GG Min Total Pressure 1	Pa	119953.76
GG Av Total Pressure 1	Pa	2.03e+007
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	1.28e+007
GG Max Dynamic Pressure 1	Pa	1.62e+007
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	160.073
GG Max Velocity 1	m/s	180.339

5.7.2.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.41	995.96
Pressure [Pa]	101271.16	1.53e+007
Temperature (Fluid) [K]	299.20	301.13
Velocity [m/s]	0	180.339
Velocity (X) [m/s]	-0.189	0.188
Velocity (Y) [m/s]	-0.189	0.188
Velocity (Z) [m/s]	0	180.339

5.7.3 Major losses in 1 inch pipe:

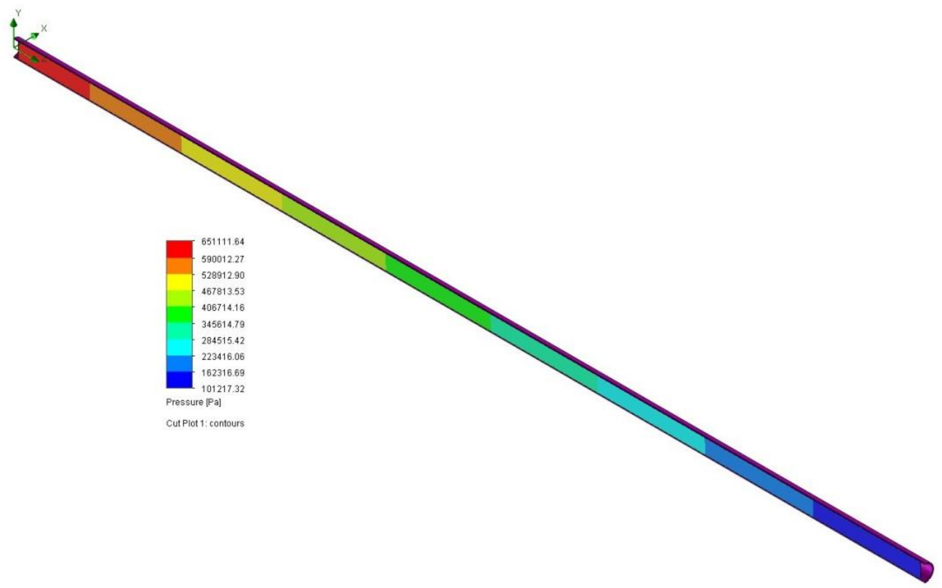


Fig. 5.7.3: Total pressure in 1 inch pipe

5.7.3.1 Results:

Name	Unit	Value
GG Min Static Pressure 1	Pa	101217.32
GG Av Static Pressure 1	Pa	361497.45
GG Max Static Pressure 1	Pa	651111.64
GG Min Total Pressure 1	Pa	101683.17
GG Av Total Pressure 1	Pa	1164365.19
GG Max Total Pressure 1	Pa	1448456.21
GG Min Dynamic Pressure 1	Pa	0
GG Av Dynamic Pressure 1	Pa	802867.74
GG Max Dynamic Pressure 1	Pa	985862.02
GG Min Velocity 1	m/s	0
GG Av Velocity 1	m/s	40.018
GG Max Velocity 1	m/s	44.499

5.7.3.2 Minimum / Maximum Table:

Name	Minimum	Maximum
Density (Fluid) [kg/m^3]	995.72	995.75
Pressure [Pa]	101217.32	651111.64
Temperature [K]	299.96	300.08
Temperature (Fluid) [K]	299.96	300.08
Velocity [m/s]	0	44.499
Velocity (X) [m/s]	-0.061	0.061
Velocity (Y) [m/s]	-0.061	0.061
Velocity (Z) [m/s]	0	44.499

CHAPTER 6– STRUCTURE WITH STORAGE TANK

Structure is a rigid body on which all the arrangements of setup is mounted. It is made of 1 inch square pipe and welded it for rigidity. All the setups with their accessories like manometer, clamping, pump, delivery tank and storage tank are kept on this structure. Size of structure is about $6ft \times 2ft \times 5.2ft$ of length, width and height respectively. One common storage tank is used in this setup for space constrain. The storage tank is used for storing water used as a medium of work in calculating different parameters. This tank is of plastic polymer. The capacity of this tank is about 240 litres.

Fig. 6.1 STRUCTURE WITH TANK

CHAPTER 7 – VENTURI METER

Venturimeter is a device used for measuring the rate of flow of a fluid through a pipe. The basic principle on which a venturimeter works is by reducing the cross sectional area of the flow of passage, a pressure difference is created and the measurement of the pressure difference enables the determination of the discharge through a pipe. It contains a converging section which gives an increase in the flow velocity and a corresponding pressure drop. The venturimeter consists of three main parts viz.

- Converging part
- Throat
- Diverging part

The inlet section of the venturimeter is of the same diameter as that of the pipe, which is followed by a convergent cone. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the throat of the venturimeter. The throat of the venturimeter is a short parallel-sided tube having uniform cross sectional area smaller than that of the pipe. The minimum cross section diameter is called throat. The divergent cone of venturimeter is a gradually diverging pipe with its cross sectional area increasing from that of the throat to the original size of the pipe.

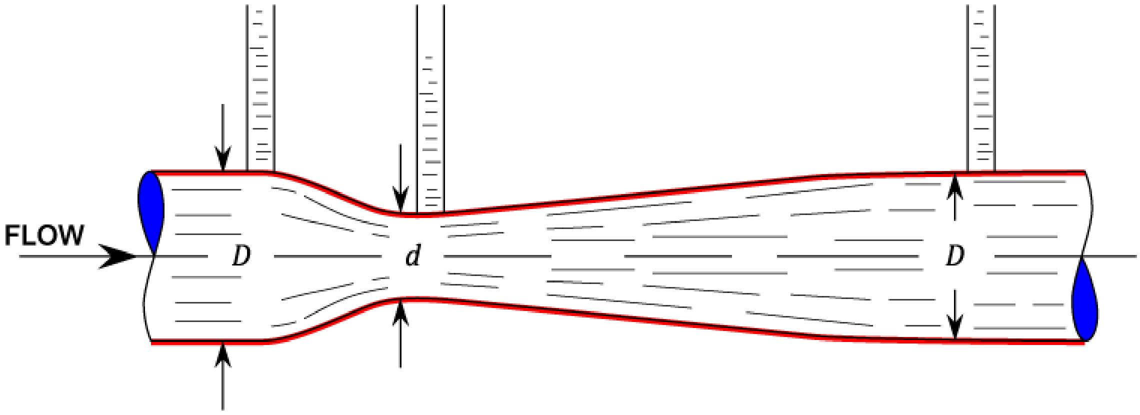


Fig.7.1 VENTURI METER

7.1 WORKING PRINCIPLE:

When a venturimeter is placed in a pipe carrying the fluid whose flow rate is to be measured, a pressure drop occurs between the entrance and throat of the venture meter. This pressure drop is measured using differential pressure sensor i.e manometer and when calibrated this pressure drop becomes a measure of flow rate.

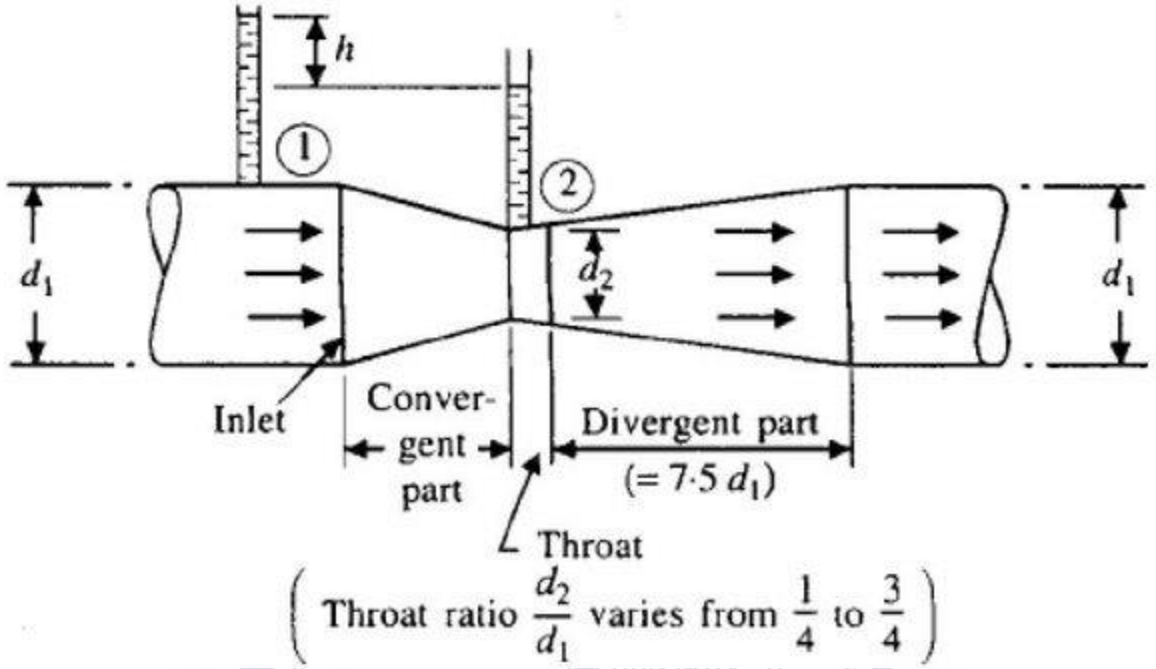


Fig.7.2 SCHEMATIC DIAGRAM

7.2: APPLICATION:

1) It is used where high pressure recovery is required.
2) It can be used for measuring flow rate of water, gases, suspended solids, slurries and dirty liquids.
3) It can be used to measure high flow rates in pipes having diameters in few meters.

7.3: PROCEDURE TO CALCULATE COEFFICIENT OF DISCHARGE:

1) Measure the diameter of inlet pipe(d_1) and throat diameter (d_2)of venturimeter.
2) Measure the dimensions of the collecting tank.
3) Allow the water to pass through a venturimeter and adjust the flow rate to the maximum value by fully opening the gate valve.

4) Wait for steady flow.
5) Record the manometer differential head (h) when steady condition is established, and compute the theoretical discharge (Q_{th}).
6) Collect the water in measuring tank for knowing height and calculate the actual discharge (Q_{act}).
7) Compute the coefficient of discharge(C_d)
8) Repeat the above procedure by varying discharge.

7.4 OBSERVATIONS:

1) Diameter of an inlet pipe (d_1)=..................m

2) Area of inlet pipe (a_1) = $\frac{\pi}{4} \times d_1^2$=...............m²

3) Diameter of throat (d_2) =...............m

4) Area of throat (a_2) = $\frac{\pi}{4} \times d_2^2$=................m²

5) Area of measuring tank (A) =...............m²

6) Venturimeter constant (K) = $\frac{a_1 \times a_2 \times \sqrt{2gh}}{\sqrt{{a_1}^2 - {a_2}^2}}$=.....................

7.5 OBSERVATION TABLE:

Sr. No	Manometer readings			Differential pressure head	Time required for 50 mm rise of water level in measuring tank 't' sec	Actual discharge	Theoretical discharge	Coefficient of discharge	Mean
	X_1 Mm	X_2 Mm	Manometer head h = ($x_2 - x_1$) m	(H)=12.6 h M		(Q_{act})=$\frac{volume}{time}$ m³/sec	(Q_{th}) $= k\sqrt{H}$ m³/sec	$C_d = \frac{Q_{act}}{Q_{th}}$	C_d

7.6 CALCULATION:

CHAPTER 8 – ORIFICE METER

An orifice plate is a plate with a hole in it which is used to determine the flow rate of flowing fluid. As fluid passes through the orifice the pressure increases at the upstream of the orifice and the fluid is forced to pass through the hole. Due to obstruction, the velocity increases and the pressure decreases. At downstream, flow reaches at point where velocity is maximum and pressure is minimum and this section is known as vena contracta. This pressure difference is used to calculate the actual discharge of flow (Q_{act}). Then coefficient of discharge (c_d) is calculated.

8.1 WORKING PRINCIPLE:

When a liquid/gas whose flow rate is to be measured, is passed through a orifice meter, there is a drop in pressure between the inlet section and outlet section of orifice meter. This drop in pressure can be measured using a differential pressure measuring instrument. Since this pressure is directly proportion to the flow rate as per bernoulli's equation hence the differential pressure instrument can be configured to display flow rate instead of showing pressure.

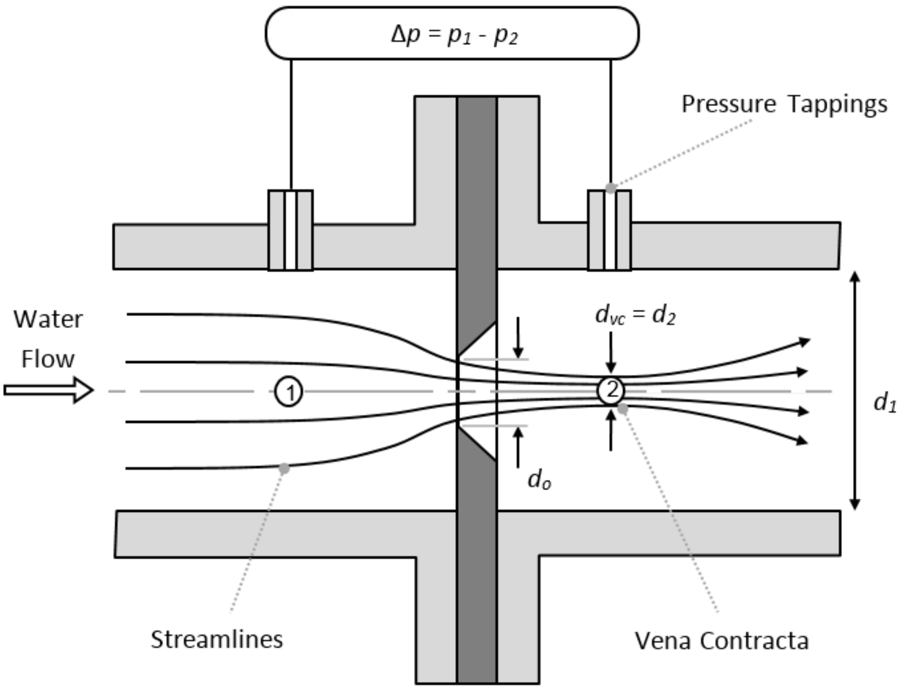


Fig 8.1 ORIFICE METER

8.2 APPLICATION:

1) Natural gas
2) Water treatment plants
3) Oil filtration plants
4) Petrochemical and refineries

8.3 PROCEDURE TO CALCULATE COEFFICIENT OF DISCHARGE:

1) Measure the diameter of inlet pipe(d_1) and throat diameter (d_2)of venturimeter.
2) Measure the dimensions of the collecting tank.
3) Allow the water to pass through a venturimeter and adjust the flow rate to the maximum value by fully opening the gate valve.
4) Wait for steady flow.
5) Record the manometer differential head (h) when steady condition is established, and compute the theoretical discharge (Q_{th}).
6) Collect the water in measuring tank for knowing height and calculate the actual discharge (Q_{act}).
7) Compute the coefficient of discharge(C_d)
8) Repeat the above procedure by varying discharge.

8.4 OBSERVATIONS:

1) Diameter of an inlet pipe (d_1)=..................m

2) Area of inlet pipe (a_1) = $\frac{\pi}{4} \times d_1^2$=...............m²

3 Diameter of vena contracta (d_2) =...............m

4) Area of vena contracta (a_2) = $\frac{\pi}{4} \times d_2^2$=................m²

5) Area of measuring tank (A) =...............m²

6) Orifice meter constant (K) = $\frac{a_1 \times a_2 \times \sqrt{2gh}}{\sqrt{{a_1}^2 - {a_2}^2}}$=....................

8.5 OBSERVATION TABLE:

Sr. No	Manometer readings			Differential pressure head (H)=12.6 h m	Time required for 50 mm rise of water level in measuring tank 't' sec	Actual discharge $(Q_{act})=\frac{volume}{time}$ m³/sec	Theoretical discharge $(Q_{th}) = k\sqrt{H}$ m³/sec	Coefficient of discharge $C_d = \frac{Q_{act}}{Q_{th}}$	Mean C_d
	X_1 Mm	X_2 Mm	Manometer head $h = (x_2 - x_1)$ m						

8.6 CALCULATIONS:

CHAPTER 9 – PITOT TUBE

The Pitot tube is a simple and inexpensive instrument for the measurement of fluid velocity. While largely replaced by rotating vane meters and various electronic instruments in hydraulic applications, it is still commonly used in pneumatic measurements and particularly for aviation airspeed determination. Its strength is of course its simple, robust design that allows an accurate velocity determination by measuring the pressure differential across two ports. This pressure difference is used to calculate actual flow or discharge through the pipe or tunnel.

9.1 WORKING PRINCIPLE:

It consists of tube pointing directly into the fluid flow. As this tube contains fluid, the pressure can be measured 'the moving fluid is brought to rest stagnates as there is no outlet to allow flow to continue. This pressure is stagnation pressure of the fluid also known as total pressure (particularly aviation) the pitot pressure. This pressure is used to calculate flow of the fluid through the pipe.

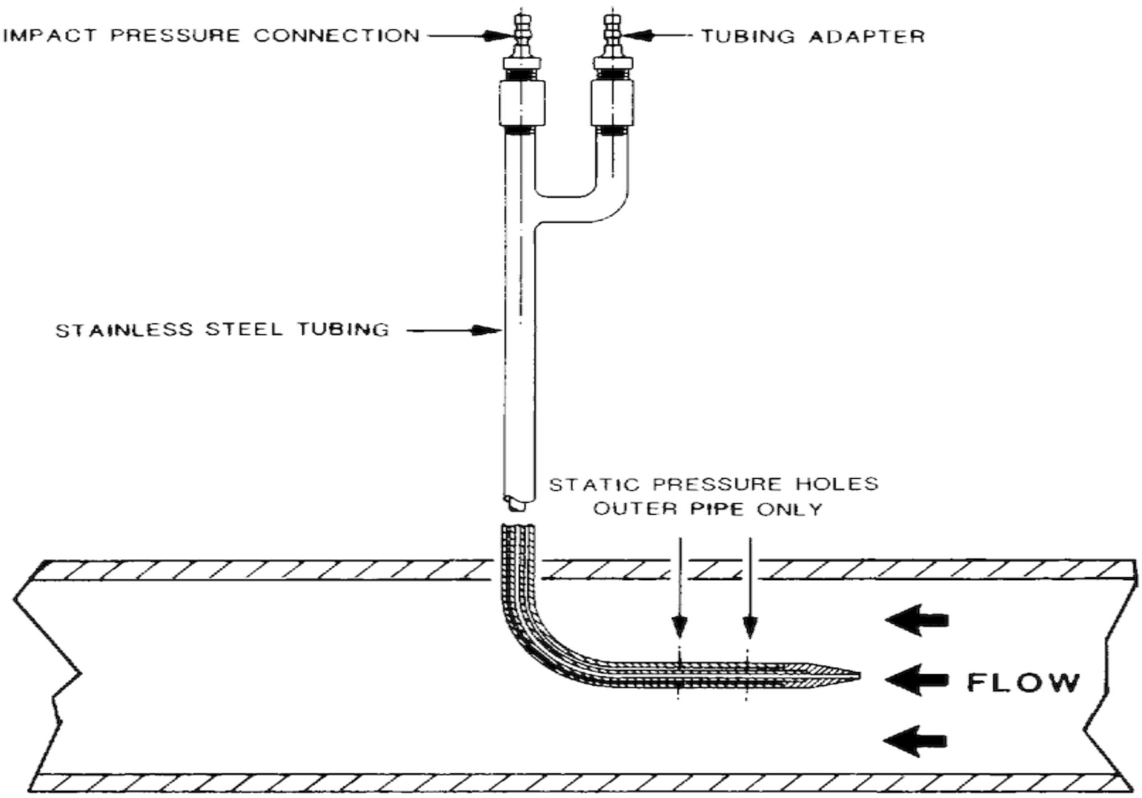


Fig. 9.1 PITOT TUBE

9.2 APPLICATION:

1) Water speed of the boat
2) Wind tunnel experiments
3) Airspeed of an aero planes
4) To measure liquid, air and gas velocities in industrial applications.

9.3 PROCEDURE TO CALCULATE COEFFICIENT OF DISCHARGE:

1) Measure the diameter of inlet pipe(d_1) and diameter of pitot tube(d_2).
2) Measure the dimensions of the collecting tank.
3) Allow the water to pass through a pitot tube and adjust the flow rate to the maximum value by fully opening the gate valve.
4) Wait for steady flow.
5) Record the manometer differential head (h) when steady condition is established, and compute the theoretical discharge (Q_{th}).
6) Collect the water in measuring tank for knowing height and calculate the actual discharge (Q_{act}).
7) Compute the coefficient of discharge(C_d)
8) Repeat the above procedure by varying discharge.

9.4 OBSERVATIONS:

1) Diameter of an inlet pipe (d_1)=..................m

2) Area of inlet pipe (a_1) = $\frac{\pi}{4} \times d_1^2$=...............m²

3) Area of measuring tank (A) =...............m²

9.5 OBSERVATION TABLE:

Sr. No	Manometer readings h = ($x_2 - x_1$)			Differential pressure head (h)=12.6X m	Velocity head (v) $= \sqrt{2gh}$ m/sec	Time required for 50 mm rise of water level in measuring tank 't' sec	Actual discharge $Q_{act} = \frac{volume}{time}$ m³/sec	Theoretical discharge $Q_{th} = V \times a_1$ m³/sec	Coefficient of discharge $C_d = \frac{Q_{act}}{Q_{th}}$	Mean C_d
	X_1 mm	X_2 mm	X m							

9.6 CALCULATION:

CHAPTER 10 – NOZZLE METER

A flow nozzle meter consists of a short nozzle, usually held in place between two pipe flanges. It is simpler and less expensive than a venturi meter. Flow nozzles or Nozzle meters, are often used as measuring elements for air and gas flow in industrial applications. The turndown ratio and accuracy are similar to the orifice plate. The main parts of flow nozzle arrangement used to measure flow rate are as follows:

A flow nozzle which is held between flanges of pipe carrying the fluid whose flow rate is being measured. The flow nozzle's area is minimum at its throat. Openings are provided at two places 1 and 2 for attaching a differential pressure sensor (u-tube manometer, differential pressure gauge etc.,) .

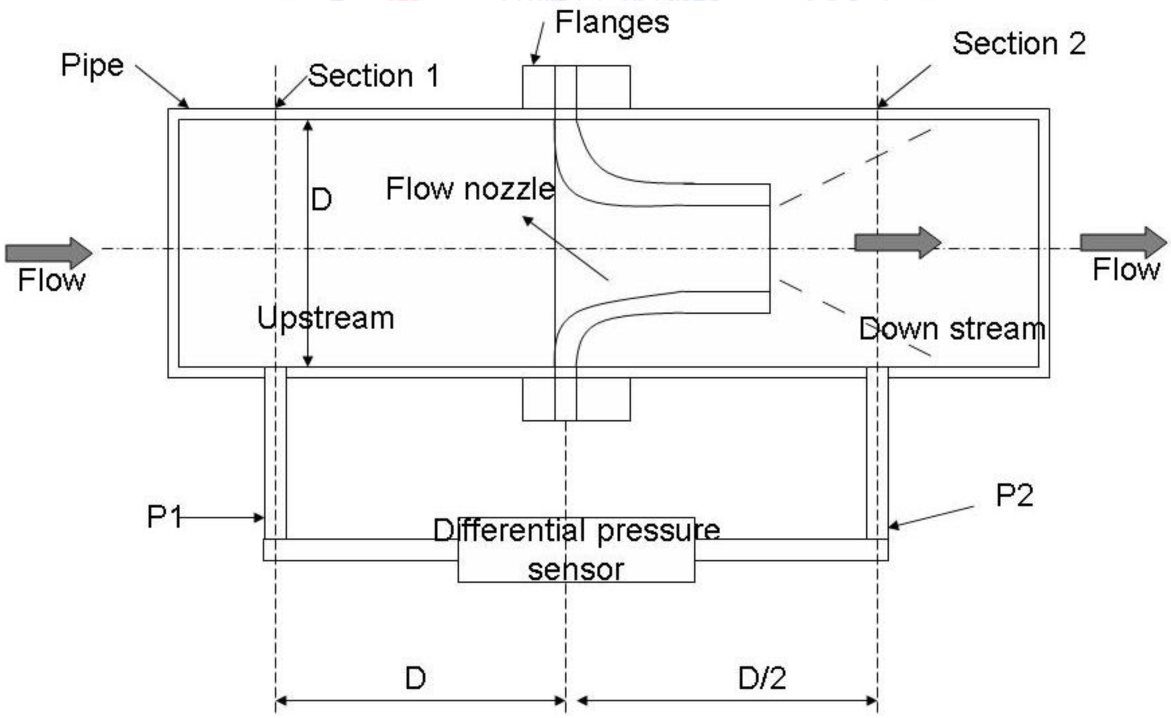


Fig. 10.1 NOZZLE METER

10.1 Principle of Nozzle meter:

When a flow nozzle is placed in a pipe carrying whose rate of flow is to be measured, the flow nozzle causes a pressure drop which varies with the flow rate. This pressure drop is measured using a differential pressure sensor and when calibrated this pressure becomes a measure of flow rate.

10.2 Applications of Nozzle meter:

1) It is used to measure flow rates of the liquid discharged into the atmosphere.
2) It is usually used in situation where suspended solids have the property of settling.
3) Is widely used for high pressure and temperature steam flows.

10.3 PROCEDURE TO CALCULATE COEFFICIENT OF DISCHARGE:

1) Measure the diameter of inlet pipe(d_1) and diameter of nozzle meter(d_2).
2) Measure the dimensions of the collecting tank.
3) Allow the water to pass through a nozzle meter and adjust the flow rate to the maximum value by fully opening the gate valve.
4) Wait for steady flow.
5) Record the manometer differential head (h) when steady condition is established, and compute the theoretical discharge (Q_{th}).
6) Collect the water in measuring tank for knowing height and calculate the actual discharge (Q_{act}).
7) Compute the coefficient of discharge(C_d)
8) Repeat the above procedure by varying discharge.

10.4 OBSERVATIONS:

1) Diameter of an inlet pipe (d_1)=..................m

2) Area of inlet pipe (a_1) = $\frac{\pi}{4} \times d_1^2$=..............m²

3) Area of measuring tank (A) =..............m²

10.5 OBSERVATION TABLE:

Sr. No	Manometer readings h = $(x_2 - x_1)$			Differential pressure head (h)=12.6X M	Velocity head $(v) = \sqrt{2gh}$ m/sec	Time required for 50 mm rise of water level in measuring tank 't' sec	Actual discharge $Q_{act} = \frac{volume}{time}$ m³/sec	Theoretical discharge $Q_{th} = V \times a_1$ m³/sec	Coefficient of discharge $C_d = \frac{Q_{act}}{Q_{th}}$	Mean C_d
	X_1 mm	X_2 mm	X m							

10.6 CALCULATION:

CHAPTER 11 – MAJOR LOSSES IN PIPES

Fluid flow in pipes is continuously impacted by the resistance to flow offered by the roughness of pipe at the walls based on the law of friction. Smooth pipes offer little or negligible resistance to flow while rougher surfaces offer increasing resistance depending on the degree of roughness.. Such resistance affects flow rate (q) and velocity distribution of process fluid in the pipe.

11.1 Working principle:

When a real (viscous) fluid flows during a pipe, some of energy is depleted through maintaining the flow. Owing to internal friction and disorder, this energy is transformed into thermal energy. Such a change leads to the appearance of the energy loss in terms of the fluid depth termed as the head loss. Effectively due to friction is known as linear or major head loss. It is there all through the length of the channel. These losses are due to friction.this cam be calculated by darcy's equation which is as follows:

Loss of head due to friction (H_f) = $\frac{4flv^2}{2gd}$

11.2 PROCEDURE:

1) Note down the diameter of the pipe (d).
2) Note the density of manometric liquid (ρ_m) and that of fluid flowing through pipe.
3) Connect the U-tube manometer to pipe in between two pressure tapings.
4) Start the flow and adjust the control valve in pipe line to discharge.
5) Measure the pressure at two points A & B of pipe by U-tube manometer.
6) By collecting the water in tank for same time.
7) Determine the velocity of flow (V) and frictional head loss (h_f) in pipe by using darcy-weisbach formula.
8) Change the flow rake and the above procedure.
9) Find out mean friction factor (f) mean of pipe.

11.3 OBSERVATIONS:

1) Diameter of small pipe (d_1) = 0.015 m.
2) Area of small pipe (a_1) = $\frac{\pi}{4}d_1^2$=
3) Diameter of medium pipe (d_2) =0.020 m.
4) Area of medium pipe (a_2) =$\frac{\pi}{4}d_2^2$=
5) Diameter of large pipe (d_3) =0.025m.
6) Area large pipe (a_3)= $\frac{\pi}{4}d_3^2$=
7) Length of pipe between two tapings (l) = 1.5m.
8) Area of measuring tank (A) = 0.5 x 0.35 = 0.175m^2.

11.4 OBSERVATION TABLE:

Sr. No.	Manometer Readings			Diff. pressure head(H_f) =12.6H m	Time required for 250 mm rise of water level in measuring tank 't' sec	Actual discharge (Q_{act})=$\frac{vol}{time}$ m^3/sec	Velocity (v)= $\frac{Qact}{Area\ of\ pipe}$ m/sec	Head loss due to sudden enlargement H_f=$\frac{2gdH_f}{4flv^2}$	Mean (F)
	h1 mm	h2 mm	h m						
1	For small pipe								
2	For medium pipe								
3	For large pipe								

11.5 CALCULATION:

CHAPTER 12 – MINOR LOSSES IN PIPES

When the water is flowing in a channel it experiences some conflict to its motion, whose effect is to reduce the velocity & eventually the head of water existing. While there are many kinds of losses, yet the minor loss is due to the different fitting of the pipe. Loss due to entry, loss due to changes in cross - section of the pipe such as sudden contraction, sudden expansion including loss due to change of direction elbows, bends, loss due to obstruction (valve, diaphragm) loss due to exit. In a long pipe the major loss of head is due to friction in the pipe only. The minor losses are so small, as compared to friction loss, that they may be neglected. But in the case of a short pipe, the minor losses, as compared to the friction loss, are of appreciable amount & thus cannot be neglected.

12.1 PROCEDURE:

1) Measure the diameter of small pipe and large pipe.
2) Measure the area of small pipe and large pipe.
3) Measure the cross-sectional area of measuring tank.
4) Connect the differential U-tube manometer to the pressure tapping point of a pipe.
5) Open the inlet valve and regulate the flow to obtain the steady state condition.
6) Measure the differential manometer readings (h_f).
7) Measure the discharge of flow through pipe using collecting tank and stop watch.
8) Calculate the energy loss due to sudden enlargement, sudden contraction, bend and elbow and calculate constant (K).
9) Repeat the above procedure different discharge and calculate the average energy of loss.

12.2 SUDDEN ENLARGEMENT:

12.2.1 OBSERVATION FOR SUDDEN ENLARGEMENT:

1) Diameter of small pipe (d_1) =0.015m.
2) Area of small pipe (a_1) =$1.767 \times 10^{-4} m^2$.
3) Diameter of large pipe (d_2) =0.025m.
4) Area of large pipe (a_2) =$4.908 \times 10^{-4} m^2$.
5) Area of measuring tank (A) =0.5x0.35=$0.175 m^2$.

12.2.2 OBSERVATION TABLE:

Sr. No.	Manometer Readings			Diff. pressure head(H_f) =12.6H m	Time required for rise of water level in measuring tank 't' sec	Actual discharge (Q_{act})= $\frac{vol}{time}$ m^3/sec	Velocity (v_1)= $\frac{Qact}{A1}$ m/sec	Velocity (v_2)= $\frac{Qact}{A2}$ m/sec	Head loss due to sudden enlargement H_f= $\frac{K(v1-v2)^2}{2g}$	Avg. head loss due to sudden enlargement
	X1 mm	X2 mm	H m							

12.3 SUDDEN CONTRACTION:

12.3.1 OBSERVATIONS FOR SUDDEN CONTRACTION:-

1) Diameter of large pipe (d_2) = 0.025 m.
2) Area of large pipe (A_2) = 4.908x$10^{-4}$$m^2$.
3) Area measuring tank (A) = 0.5 x0.35 = 0.175m^2.

12.3.2 OBSERVATION TABLE:

Sr. No.	Manometer Readings			Diff. pressure head(H_f) =12.6H m	Time required for rise of water level in measuring tank 't' sec	Actual discharge (Q_{act})= $\frac{vol}{time}$ m^3/sec	Velocity (v_2)=$\frac{Qact}{A2}$ m/sec	Head loss due to sudden enlargement H_f=$\frac{KV_2{}^2}{2g}$	Avg. head loss due to sudden enlarge ment (K)
	X1 mm	X2 mm	H m						

12.4 CALCULATION:

CHAPTER 13 – RESULTS

CHAPTER 14 – CONCLUSION

By using this setup, the number of following advantages is obtained,

1) Overall size of the setup is reduced up to 80 sq.ft.

2) The overall cost is around 80,000 Rs which is 1,80,000 Rs lesser than the current experiment cost .

3) The supply pump required to run the setup is one.

4) Only single storage and delivery tank is used as compared to current setup which is having separate storage and delivery tank for each setup.

5) The number of manometers required is3 which is lesser than the current setup.

6) The human effort required for operate the setup to obtain the satisfactory output is lesser because the whole working line of pipe , position of valve , position of manometer are comfortable for the user.

CHAPTER 15 – REFRENCES

[1] Nikhil Tamhankar, Amar Pandhare, Ashwinkumar Joglekar, Vaibhav Bansode (2014) Experimental and CFD analysis of flow through venturimeter to determine the coefficient of discharge, International Journal of Latest Trends in Engineering and Technology (IJLTET), Vol. 3 Issue 4, 194-200.

[2] Akshay Dandwate, Sagar Mittal, Oshin Umale, Pallavi Shelar, Rahul Bajaj (2016) Effect of Orifice Plate Shape on Performance Characteristics, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) Volume 13, Issue 4 Ver. VII, 50-55

[3] Glenn O. Brown,(2001), Henry Darcy and the Pitot Tube, ResearchGate, DOI:10.1061/40594(265)43 Conference: Third National Congress on Civil Engineering History and Heritage,14-23

[4]Suyog Sharma, Dr. Ruchi Khare (2016), CFD Approach for Calibration of Nozzle Meter, International Journal of Engineering Science and Computing, Volume 6 Issue 8, 2858-2861

[5] Naresh Dhamane, Sachin B. Labade† and Dharam S. Maradiya (2016) Modification and Testing on Major Loss Apparatus by considering various Effecting Parameters International Journal of Current Engineering and Technology, Special Issue-6, 100-103.