STUDY OF PRESSURE EFFECTS THROUGH SCREENS IN A RECTANGULAR FLOW FIELD

A project report submitted in partial fulfillment of the
requirements for the Award of the Degree of

BACHELOR OF ENGINEERING
in
MECHANICAL ENGINEERING

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PRAGNANAM BRAHMA
ANITS
(2017-2018)

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CERTIFICATE

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ACKNOWLDGEMENTS

We express immensely our deep sense of gratitude to **Sri. M. Chandra shekar** ,Assistant Professor, Department of Mechanical Engineering, Anil Neerukonda Institute of Technology & Sciences, Sangivalasa, Bheemunipatnam Mandal, Visakhapatnam district for his valuable guidance and encouragement at every stage of the work made it a successful fulfillment.

We were very thankful to **Prof.T.V.Hanumantha rao**, Principal and **Prof.B.Naga Raju**, Head of the Department, Mechanical Engineering Department, Anil Neerukonda Institute of Technology & Sciences for their valuable suggestions.

We express our sincere thanks to the members of non-teaching staff of Mechanical Engineering for their kind co-operation and support to carry on work.

Last but not the least, we like to convey our thanks to all who have contributed either directly or indirectly for the completion of our work.

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ABSTRACT

From the past few decades, there has been growing importance for various tools being used to study the effects of air moving past the solid bodies. Generally a closed passage is preferred for the testing of objects. There is a proper criteria to state that it is the effect of flow that generates the variable results. So it is much more important to make sure that the flow over the test object must be laminar and streamlined.

The test object is instrumented with a sensitive balance to measure the forces generated by airflow; or, the airflow may have smoke or other substances injected to make the flow lines around the object visible. So it is the primary design of the research tool we are using on which the test results depend. So it is more important to make a proper design of the tool according to the test requirements and testing conditions. The Screens come into play in order to meet our flow requirements for testing i.e., to convert a turbulent flow into laminar or streamlined.

This project discusses those main aspects associated with various types of screens, it shows the results obtained for different flow regimes and conditions, requirements and problems associated in practical point of view. All the ideas presented in this paper are the result of practical approach to study of screens in a self designed tunnel.

CHAPTER-1

INTRODUCTION

1.1 MOTIVATION

Turbulence suppression by use of screens was studied in a small wind tunnel especially designed and built for the purpose. Wide ranges of mesh sizes and wire diameter Reynolds numbers were covered in the present investigation, enabling the study of sub- and super-critical screens under the same, well-controlled, flow conditions. For the latter type small-scale fluctuations, produced by the screen itself, interact with the incoming turbulence. In the immediate vicinity of the screen the turbulence was found to be highly anisotropic and the intensities were higher than on the upstream side. Downstream of a short initial decay region, where the intensities decrease rapidly, the return to isotropy was found to be much slower than for the unmanipulated turbulence. The latter was generated by a rectangular rod grid, and was shown to become practically isotropic beyond a certain distance behind the screen. The role of the turbulence scales for the overall reduction effectiveness, and for the optimization of screen combinations for application in low turbulence wind tunnels was studied.

1.2 OBJECTIVES OF THE PROJECT

- Understanding the basic principle of operation of the tunnel
- Study of existing tunnels and their results
- Analyzing the existing design requirements
- Explanation of some design and construction features
- Studying the effects so obtained by varying different flow parameters
- Plotting the results accordingly

1.3 LIMITATIONS OF THE PROJECT

When coming to production phase of the project, this phase takes a finite amount of time for perfect experimental setup. The setup is produced in such a way that it meets all the design requirements associated with the previous studies. In order to fulfil this proper and perfect machining equipments are used which reduces human effort and at the same time contributes for producing the required setup in a much shorter span.

1.4 ORGANISATION OF DOCUMENTATION

In this project documentation we have initially kept the objectives, research methodology and production techniques along with various literature papers followed by the results so obtained by varying different parameters. The project has been concluded successfully at the last.

CHAPTER-2

LITERATURE REVIEW

2.1 INTRODUCTION

A literature review is done on what is the effect of using various types and sizes of meshes on the airflow associated with the smoke. All those who have carried out the experiments made use of different kinds of metals having different structural properties. They have explained the results obtained according to the position of mesh with respect to testing bodies and the airflow inlet. Some of those have been discussed here.

2.2 STUDIES ON MESHES

According to some Anonymous person he studied the airflow by placing a screen in between and carried out the experiment aiming to bring a relationship between the pressure, velocity and free hole area of the screen. He says that there will be pressure and velocity variations around the mesh screen placed ahead of the test body to incur proper laminar flow instead of the turbulent flow.

He says that insertion of mesh screens ahead of the test section will certainly induce good results. He found that screens with less free hole area maintain laminar flow for a greater distance. He found the relationship between airflow velocity, the pressure behind the screen and the free hole area of the screen.

The relation was given as:

$$P = \frac{V^{1.50}}{42.8 \times 10^{2.59A}}$$

Where P is the screen pressure, V is the velocity and A is the free hole area

He concluded by saying that the developed pressure is proportional to the velocity for a given free hole area, and inversely proportional to free hole area for a given velocity. Screens with less free hole area also maintain laminar flow on exit for a greater distance.

Johan Groth and Arne V.Johansson studied the turbulence suppression by use of screens in a small wind tunnel especially designed and built for the purpose. Wide ranges of mesh sizes and wire-diameter Reynolds numbers were covered in the investigation, enabling the study of sub- and super-critical screens under the same, well-controlled, flow conditions. For the latter type small-scale fluctuations, produced by the screen itself, interact with the incoming turbulence. In the immediate vicinity of the screen the turbulence was found to be highly anisotropic and the intensities were higher than on the upstream side. Downstream of a short initial decay region, where the intensities decrease rapidly, the return to isotropy was found to be much slower than for the unmanipulated turbulence. The latter was generated by a square rod grid, and was shown to become practically isotropic beyond a distance of roughly **20** mesh widths from the grid.

Cesar Farell and Sadek Youssef presented the results of some experiments on turbulence management using combinations of honeycombs of different lengths and coarse and fine screens, carried out in highly non-uniform and turbulent flows generated in a 127-mm plexiglass pipe by an upstream blower and diffuser. The performance of the devices as single manipulators and in combination was evaluated through hot-wire measurements of the mean and rms values of the longitudinal velocities over the pipe cross section. The results show that relatively short honeycombs, preceded by a coarse screen and followed by one or more fine screens, can be used for effective management of highly nonuniform and turbulent flows.

T. J. O'Hern and J. R. Torczynski studied the laminar flow downstream of fine-mesh screens experimentally and numerically. Two different screen types are examined experimentally, both with open areas greater than 50% and wire dimensions less than 100 micrometers. Such screens produce flow disturbances of much smaller scale than those examined in most previous studies of flow-conditioning screens and grid-generated turbulence. Instead of using standard woven-wire screens, high uniformity screens are used which are fabricated by photoetching holes into 50.8 micrometers thick Inconel sheets. The holes thus produced are square with rounded corners, arranged to form a square array, with a minimum wire thickness (located halfway between wire crossings) of $D = 50.8$ micrometers. A flow facility has been constructed for experiments with these screens. Air at 85 kPa and 295 K is passed through each screen at upstream velocities of 1 to 12 m/s, yielding Reynolds numbers $Re_D = \rho U D/\mu$ in the range $2 \leq Re_D \leq 35$ Pressure drops across the screens are measured at the conditions using pressure transducers and manometers. From these data, the Reynolds number dependence of the drag coefficient C_D is determined. Concluded by saying that the experimental and computational of drag coefficient are in reasonably good agreement over Reynolds numbers in the range $2.5 \leq Re_D \leq 15$.

R.D.Mehta says that the screens make the flow velocity profiles more uniform by imposing a static pressure drop proportional to square of the speed and thus reduce the boundary layer thickness so that the ability to withstand a given pressure gradient is increased. A screen with a pressure drop coefficient of about 2 removes nearly all variation in the longitudinal mean velocity. A screen also refracts the incident flow towards the local normal and reduces the turbulence intensity in the whole flow-field. For a given open-area ratio, it is better to have a smaller mesh for reduction of pre-existing turbulence. Plastic screens tend to yield a more uniform flow beyond the boundary layer edge, mainly due to the weaving properties, and produce an ‘overshoot’ in the velocity profile near the edge, mainly caused by screen deflection angle which is a maximum at the wall. In terms of tackling a given pressure gradient or avoiding separation, this overshoot could be beneficial.

James Scheiman says that a half-scale model of a portion of the NASA Langley 8-Foot Transonic Pressure Tunnel was used to conduct some turbulence reduction research using screens, honeycomb, and combinations. The experimental results are compared with various theories. The axial turbulence reduction for screens agrees with the Prandtl theory, where as the lateral turbulence reduction agrees with the Dryden and Schubauer theory.

Screens alone reduce axial turbulence more than lateral turbulence. Honeycomb alone reduces lateral turbulence more than axial turbulence.

The turbulence reduction of a screen when placed downstream of the honeycomb is far better than that forth screen along with the result that the honeycomb with a downstream screen is an excellent combination for reducing turbulence.

Chun-Guang Li,John C. K. Cheung and Z.Q. Chen studied the effects of square cells with different length and width sizes in improving flow quality. The focus of this study was put on the effects of the square cells in attenuating the total turbulence intensity including the free-turbulence carried by the incoming flow and the turbulence generated by the square cells itself. The change tendency of the mean wind velocity and the total turbulence characteristics in the decay area have been studied by varying the length to cell size ratio L/D, and ratio of distance between the square cells and the measuring position to cell size X/D. He concluded by saying that for the flow straightening function, square cells with L/D ratio around 7 will have satisfying performance, like honeycombs. In the downstream area where self-turbulence also begins to decay, the power law decay tendency of the total turbulence intensity in the downstream flow is influenced by the length of the square cells. When judged by the X/D ratio, the longer square cells are more effective in attenuating the turbulence at the same X/D ratio, and the longitudinal turbulence length scales also becomes smaller.

Ali Ansari conducted a numerical and experimental study of turbulent flow through and around expanded metal screens partially covering the cross-section of a low turbulence wind tunnel. Three screen types at three screen heights were studied. He concluded by saying that higher cross-sectional coverage resulted in higher pressure drops, flow deflection, and velocities downstream of the screens. Higher screen solidity ratios resulted in higher pressure drops, velocity reduction by screens, velocity acceleration above the screens, and turbulence generation. Plane turbulent mixing layers were produced by the shearing action of the screens upper edge, resultïng in increased turbulence generation and pressure loss.

Ramakumar Bommisetty, Dhanvantri Joshi and Vighneswara Rao Kollati together carried out the numerical study on how to find the flow losses in screens. Simulations are performed for both incompressible and compressible fluids. Laminar model is used for screen Re$\leq$10 and Standard kε turbulence model for higher screen Reynolds Numbers. Based on the present study the following conclusions can be derived.

1. Predicted discharge coefficient values of incompressible fluid matched with the available experimental results upto screen Reynolds number of 10. But for the turbulent region, predicted discharge coefficients are lesser compared to the experimental values.
2. Discharge coefficient has increased with increase in Reynolds number up to screen Reynolds number of 1000 and then constant discharge coefficient is obtained with further increase in Reynolds number. The constant discharge coefficient obtained from the simulation is 0.91 against the value of 1.4 in experiments.
3. For compressible fluids, predicted discharge coefficients are in line with incompressible fluids till the density variation across the screen is about 20%.

4. Considerable reduction (maximum of 50% reduction) is noticed in discharge coefficient with higher density change for compressible fluids.

5. Density change of fluid in the screen is found to be stronger influencing parameter for flow loss in screens compared to the screen Reynolds number.

CHAPTER-3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The production phase is the most important phase of the project. According to the previously made studies and specifications the test rig or tunnel is decided on which the experiment is to be performed. Inspection is carried out is selected test rig whether it satisfies the specifications required. The completed setup is calibrated and can be used as a test rig.

3.2 TEST RIG CALCULATIONS

A rectangular cross-section tunnel is built inorder to calculate and determine the varying flow properties and its effects at specific flow conditions.

3.2.1 SPECIFICATIONS OF TUNNEL

- Total length of the tunnel = 970 mm
- Distance from inlet to screen = 250 mm
- Distance from screen to exit = 720 mm
- Cross-sectional area of flowfield = (45x50) = 2250 mm^2
- Diameter of inlet = 20 mm
- Distance of 1st total and static pressure taps from inlet = 200 mm
- Distance of 2nd total and static pressure taps from inlet = 350 mm
- Distance of total and static pressure taps infront of screen = 50 mm
- Distance of total and static pressure taps behind the screen = 100 mm
- Distance between successive static pressure taps behind the screen (6 taps) = 100 mm
- Diameter of total and static pressure taps = 10 mm

3.3 FABRICATION

The test rig is prepared by making use of Acrylic (PMMA) glass sheets. PMMA (Poly(methyl methacrylate)) is a transparent thermoplastic, often used as a lightweight or shatter-resistant alternative to glass. Although it is not technically a type of glass, the substance has sometimes historically been called acrylic glass. Chemically, it is the synthetic polymer of methyl methacrylate.

The chemical formula for one unit of methyl methacrylate is $C_5H_8O_2$. Many individual units of methyl methacrylate join together in a polymer to make acrylic plastic. A polymer is a very large molecule of indefinite size in which many individual identical units of elements called monomers are joined together.

Sometimes all of the monomers are the same kind, while at other times two or three different kinds combine in the overall polymer. All plastics are polymers, including acrylic plastic.

Other notable trade names include:

- Lucite
- Plexiglas
- Optix (Plaskolite)
- Perspex
- Oroglas
- Altuglas

3.3.1 UNIQUE FEAUTURES OF ACRYLIC GLASS

Acrylic sheet is a material with unique physical properties and performance characteristics. It weighs half as much as the finest optical glass,yet is equal to it in clarity and is up to 17 times more impact resistant. Cast acrylic sheet is made in over 250 colours, in thicknesses from .030" to 4.25' and can transmit ultraviolet light or filter it out, as required.

Some of the properties of acrylic are:

Expansion and Contraction:

Cast acrylic sheet responds to temperature changes by expanding or contracting at a far greater rate than glass

Flexibility:

Cast acrylic sheet is much more flexible than glass or many other building materials. When using large sheets for windows, it is important that rabbets or channels be deep enough to provide support against high winds.

Chemical Resistance:

Cast acrylic sheet has excellent resistance to attack by many chemicals. It is affected, in varying degrees, by benzene, toluene, carbon tetrachloride, ethyl and methyl alcohol, lacquer thinners, ethers, ketones and esters.

Electrical Properties:

Cast acrylic sheet is an excellent insulator. Its surface resistivity is higher than that of most plastics.

Light Transmission:

Colourless Cast acrylic sheet has a light transmittance of 92%. It is clearer than window glass and will not turn yellow. Cast acrylic sheet is also available in a large variety of transparent and translucent colours.

UV Light Resistance:

Clear acrylic sheet resists ultraviolet light degradation. Each acrylic sheet has a ten-year-limited warranty against yellowing and loss of light transmission.

Optical Clarity:

Acrylic sheets have excellent light transmission. Clearer than glass will not become yellow after prolonged sun exposure.

Weather Resistance:

Despite heat, cold, sunlight, and humidity acrylic sheet maintains its original appearance and colour.

Safety:

Shatter-resistant, earthquake safe, and burglar-resistant. Increase safety with windows glazed of acrylic.

Light Weight:

Even with its strength and durability, acrylic sheet is only half the weight of glass.

3.3.2 APPLICATIONS

Acrylic plastic works well as a substitute for glass when you need something strong, lightweight and transparent but also shatter-resistant. Large public aquariums often use acrylic instead of glass to make their exhibit tanks and underwater tunnels.

- Poly(methyl methacrylate) (PMMA) is a transparent thermoplastic, often used as a lightweight or shatter-resistant alternative to glass. Although it is not technically a type of glass, the substance has sometimes historically been called acrylic glass. Chemically, it is the synthetic polymer of methyl methacrylate.
- PMMA is an economical alternative to polycarbonate (PC) when extreme strength is not necessary. Additionally, PMMA does not contain the potentially harmful bisphenol-A subunits found in polycarbonate. It is often preferred because of its moderate properties, easy handling and processing, and low cost. The non-modified PMMA behaves in a brittle manner when loaded, especially under an impact force, and is more prone to scratching than conventional inorganic glass. However, the modified PMMA achieves very high scratch and impact resistance.
- Aircraft manufacturers use Cast Acrylic sheet in jets and helicopters. Because of its light and energy transmission properties architects find Cast acrylic sheet ideal for skylights, sun screens, fascia panels and dome structures.
- There are many other uses of acrylic sheet including poster framing, model making and machine guards. There is even a UV grade acrylic sheet that transmits UV rays and can

be used for sun rooms and sun beds. Acrylic sheets can also be fabricated into different shapes and ideal for DIY applications around the home.

3.3.3 ASSEMBLY

The acrylic glass sheet is made to cut into a number of pieces according to the required dimensions of the tunnel. The so cutted sheets are attached or glued to form a rectangular tunnel using cynoacrylate (chemical composition of fewikwik). The leftout gaps of the tunnel are closed by making use of Anabond. The tunnel is settled for about 2-3 hours after which it is cleaned properly by caustic soda and made available for testing.

3.4 EXPERIMENTAL APPARATUS AND PROCEDURE

The present flow facility is designed specifically for the study of turbulence damping and pressure effects by screens and permits different screens to be readily interchanged. It is built as an open-circuit blowing type wind tunnel with a 1 metre long (45x50 mm^2) test section. The air is sent through the tunnel using an air compressor having a range of 0-10 kg/cm^2. By regulating the pressure of the flow slowly by compressor the readings are taken from the pressure taps by connecting them to a U-tube manometer setup. The readings so obtained are tabulated and the same process is repeated by changing the screens. The necessary conclusions are drawn from the readings so obtained.

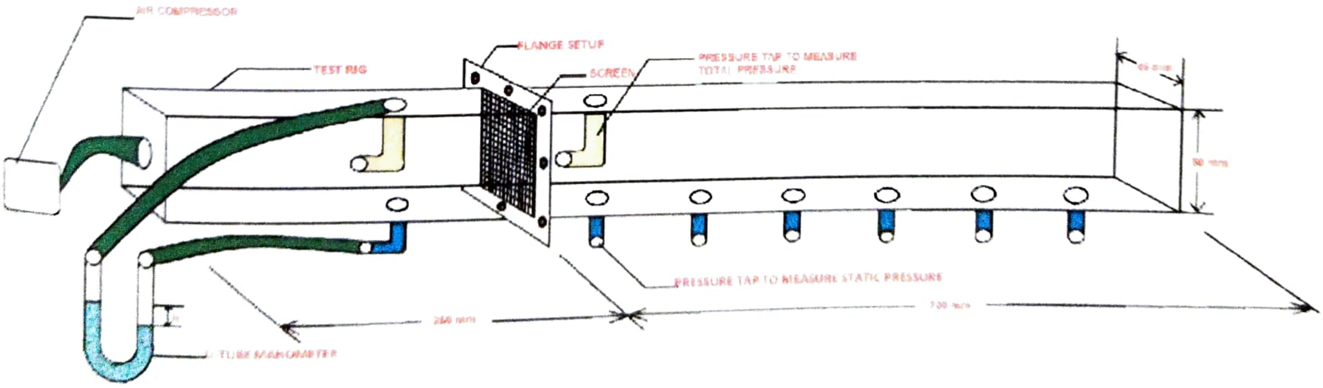


Fig 3.1Experimental Setup

The Screens used are shown below:

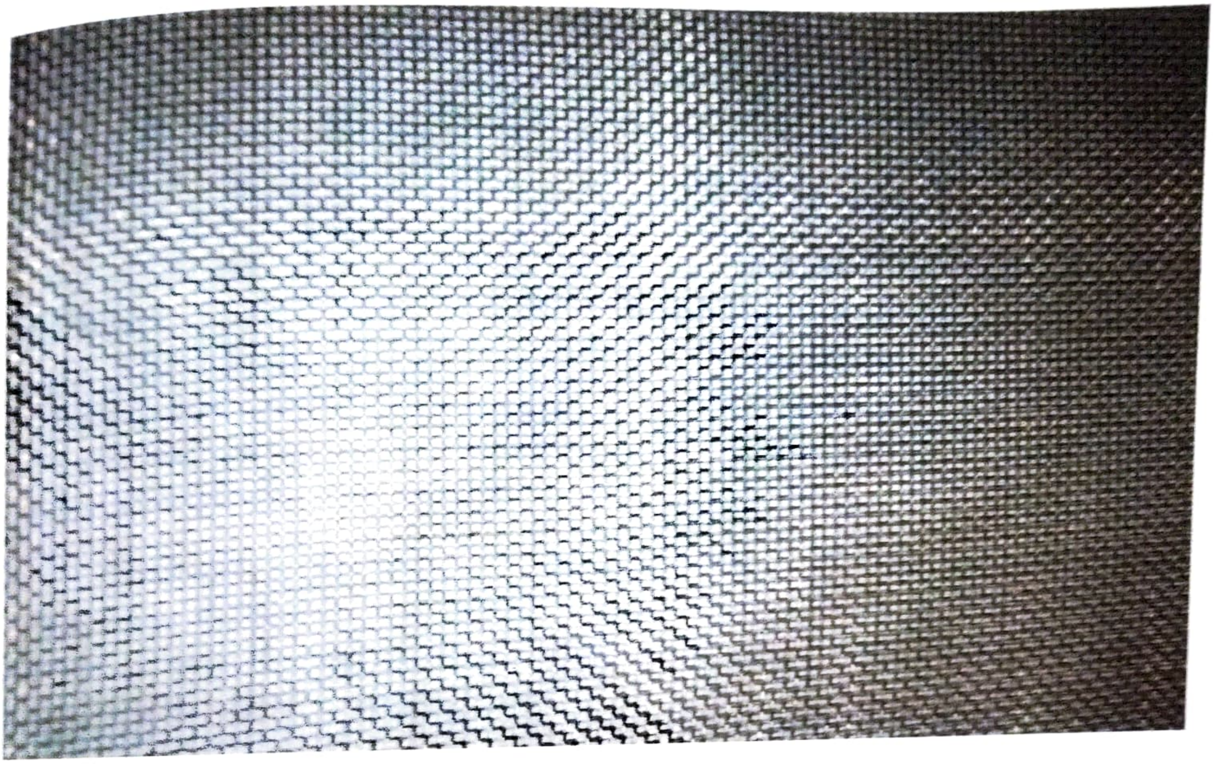


Fig 3.2 0.62mm screen (67.89% F.H.A)

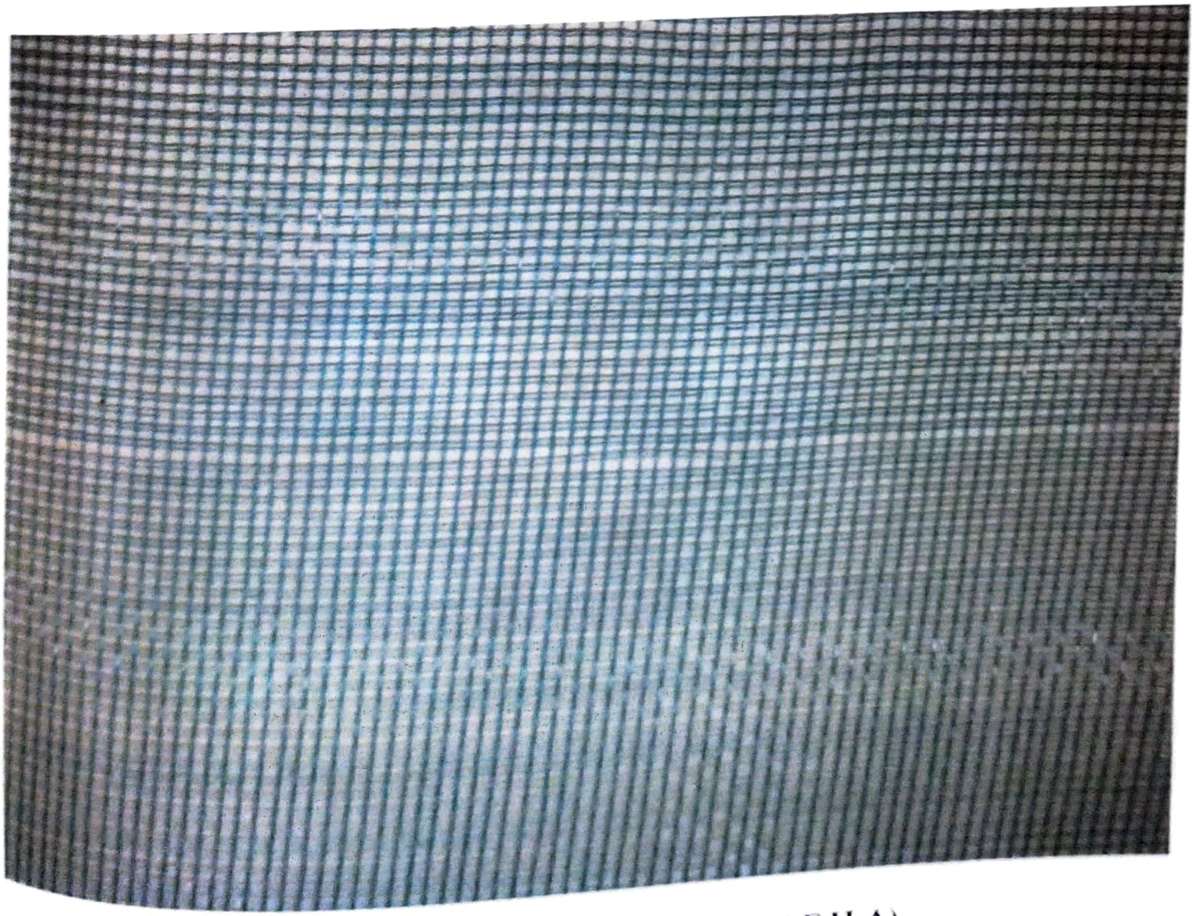


Fig 3.3 1mm screen (77.88% F.H.A)

3.5 BASIC CONCEPT AND FORMULAE USED

Bernoulli's principle is used in the calculations and for taking of the readings.

According to the principle,

The total pressure inside a closed section is a sum of total and static pressures.

Total pressure (P_t) = Static pressure (P_s) + Dynamic pressure (P_d)

From the above equation the dynamic pressures are calculated by taking the difference of total and static pressures from the tunnel.

The total pressure will be constant throughout the cross-section and it will be maximum at the centre. So the pressure taps are fixed along the central axis of the tunnel to measure total pressure. Two pressure taps are fixed infront of the screen and behind the screen to observe the flow variation.

The static pressure is the pressure along the surface of the tunnel which keeps on changing as the length of the tunnel changes. Here this is a variable parameter and hence around six pressure taps are fixed behind the screen to observe flow pressure and velocity changes with respect to total pressure.

Total and static pressures are calculated from the below equation:

$$P = (\rho w - \rho a)gh$$

where $\rho w, \rho a$ are the densities of water and air

h is the difference of liquid column in the manometer

g is the accelertion due to gravity

Respective Velocities are calculated by using the formula

$$V = \sqrt{2p/(\rho w - \rho a)} \text{ or } \sqrt{2gh}$$

Reynolds No is calculated by:

$$Re = \sqrt{\rho V L/\mu}$$

Where L is the characteristic length of the tunnel

μ is the dynamic viscosity of air

Depending upon the reynolds no the flow is classified either as laminar or turbulent.

CHAPTER-4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

According to the methodology described in the previous chapter after carrying out the experiment the results are analysed and plotted accordingly as shown in this chapter. Calculations are done by neglecting the flow losses.

4.2 SCREEN CHARACTERISATION

The following screens were tested the numbers assigned were arbitrary:

S.no	Wire Diameter (inches)	Mesh number (wires/inch)	Wire Spacing (inches)	Free hole area (in %)
1	0.0039	25	0.0353	77.88
2	0.0039	40	0.0206	67.89
3	0.0039	50	0.0157	61.62

It can be seen that the wire diameter is constant. This was done to minimise the effects of differences in wire diameter and the geometric effects of the wire, thus allowing the wire diameter to be ignored as a variable.

4.2.1 SAMPLE CALCULATION

For Mesh 1:

Wire diameter = 0.1 mm

= (0.1x0.0393) inches

= 0.0039 inches

Mesh number = 25 wires/inch

Wire spacing = 0.9 mm

= (0.9x0.0393) inches

= 0.0353 inches

Free Hole Area (FHA) = (Mesh number x Wire spacing)^2

Free Hole Area = $(25 \times 0.0353)^2$

= 0.7788 or 77.88%

In the similar way, the free hole areas of other two meshes are calculated.

Now lets observe the pressure variation for different meshes having different free hole areas. The readings so obtained from experiment are tabulated below:

4.3 Behaviour of Parameters in the mesh upstream :

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	14	137.17	0.524	7090
2	38	372.32	0.863	11700
3	74	725.05	1.204	16300
4	124	1214.94	1.559	21100
5	174	1704.84	1.847	25000

4.3.1 SAMPLE CALCULATION:

Pressure head in manometer (h) = 1.4cm or 14mm

Dynamic pressure so obtained (P) = $(\rho w - \rho a)gh$

= $(1000 - 1.225) \times 9.81 \times 14 \times 10^{-3}$

$= 137.17$ Pascals

Dynamic Velocity (V) $= \sqrt{2P/(\rho w - \rho a)}$

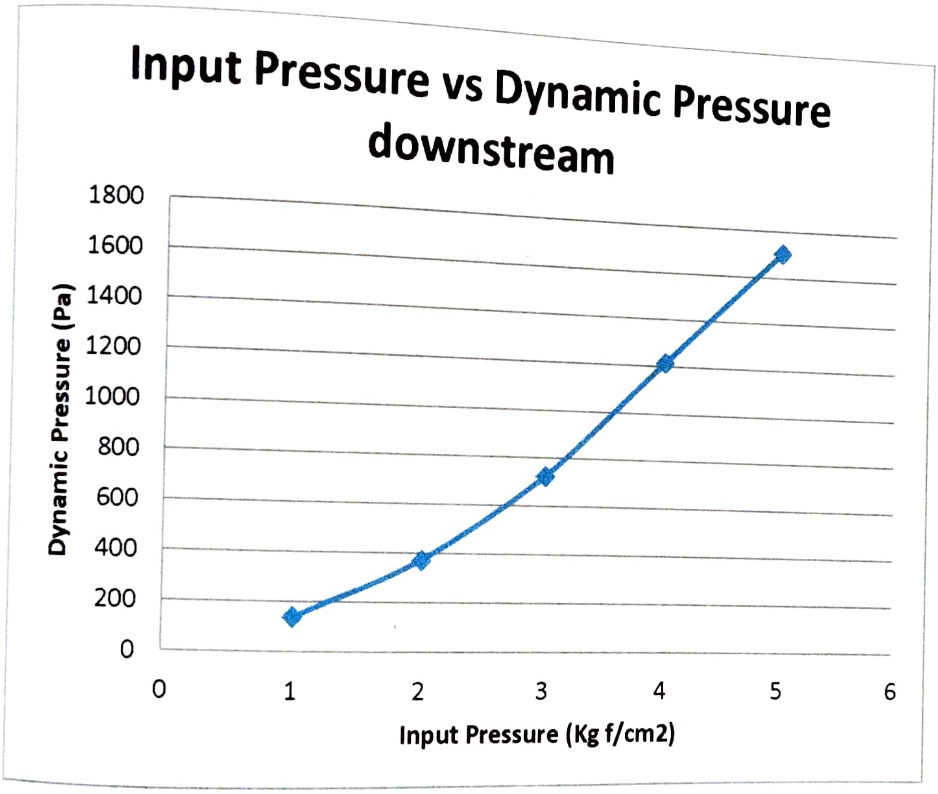
$= \sqrt{(2\, x\, 137.17)/(1000 - 1.225)}$

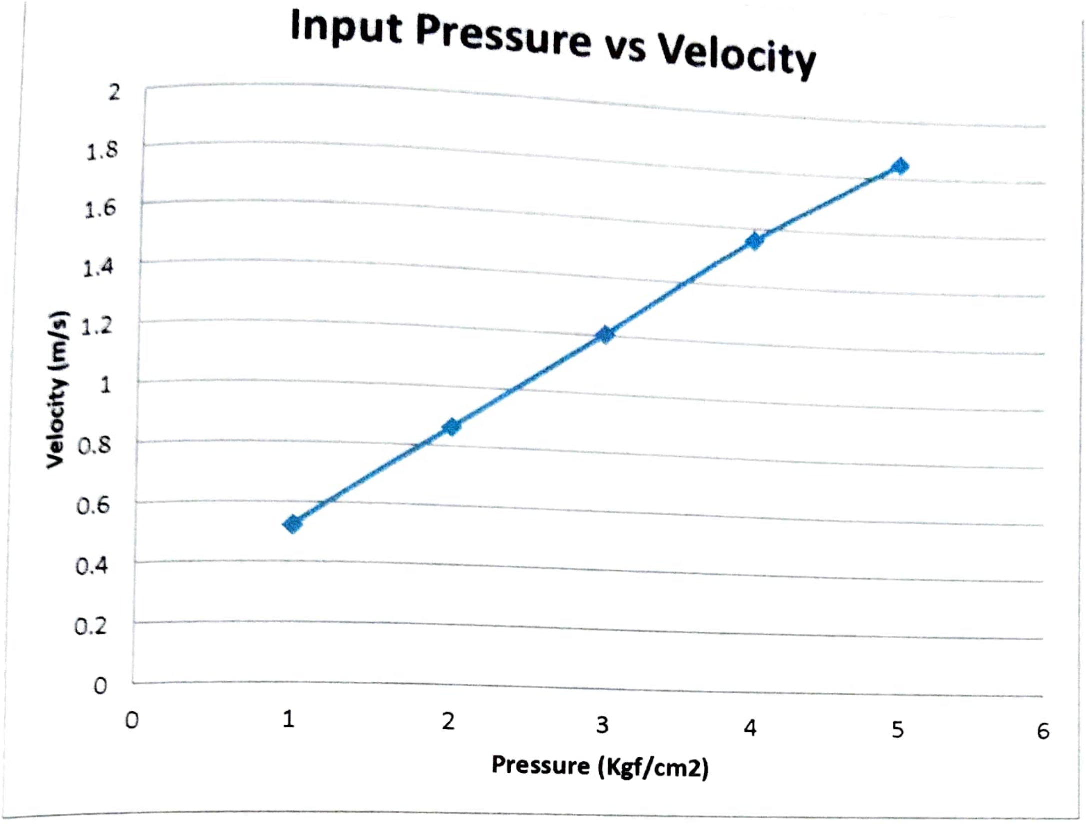
$= 0.524$ m/s

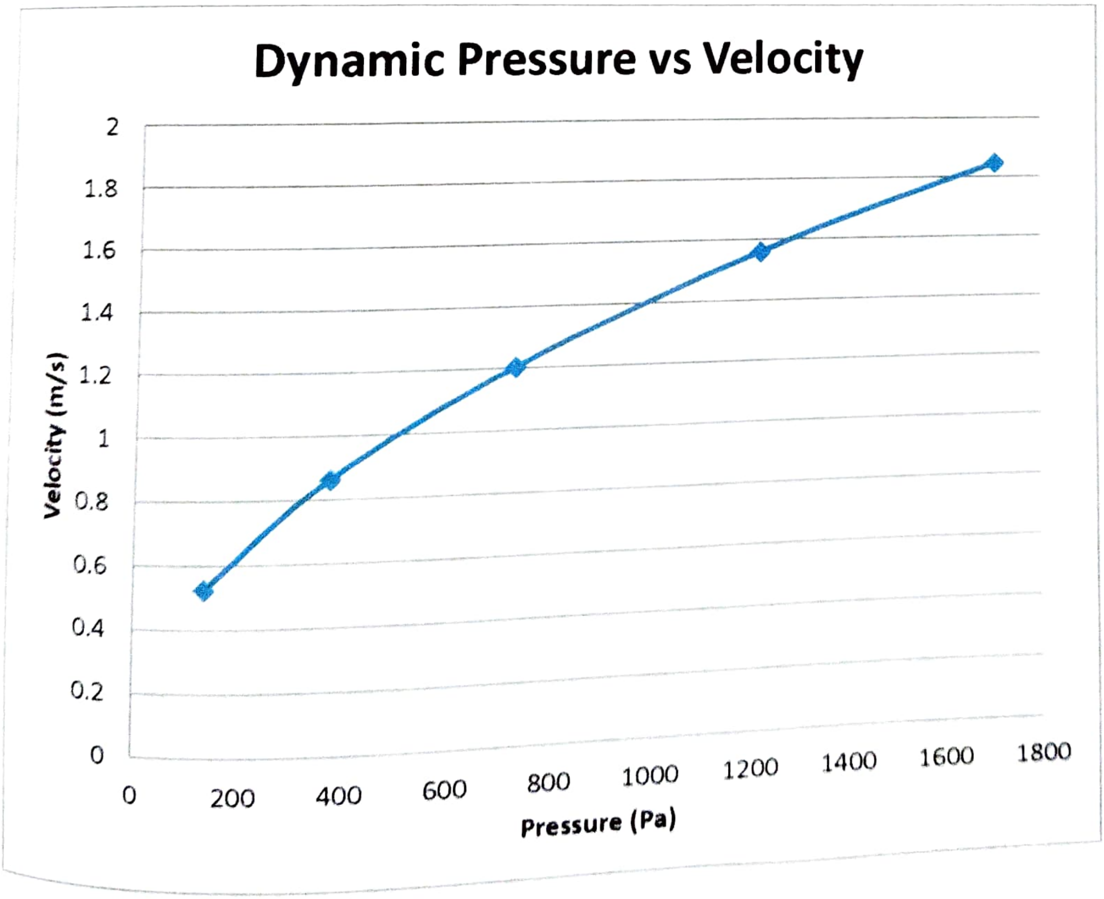
Reynolds No (Re) $= \sqrt{\rho V L/v}$

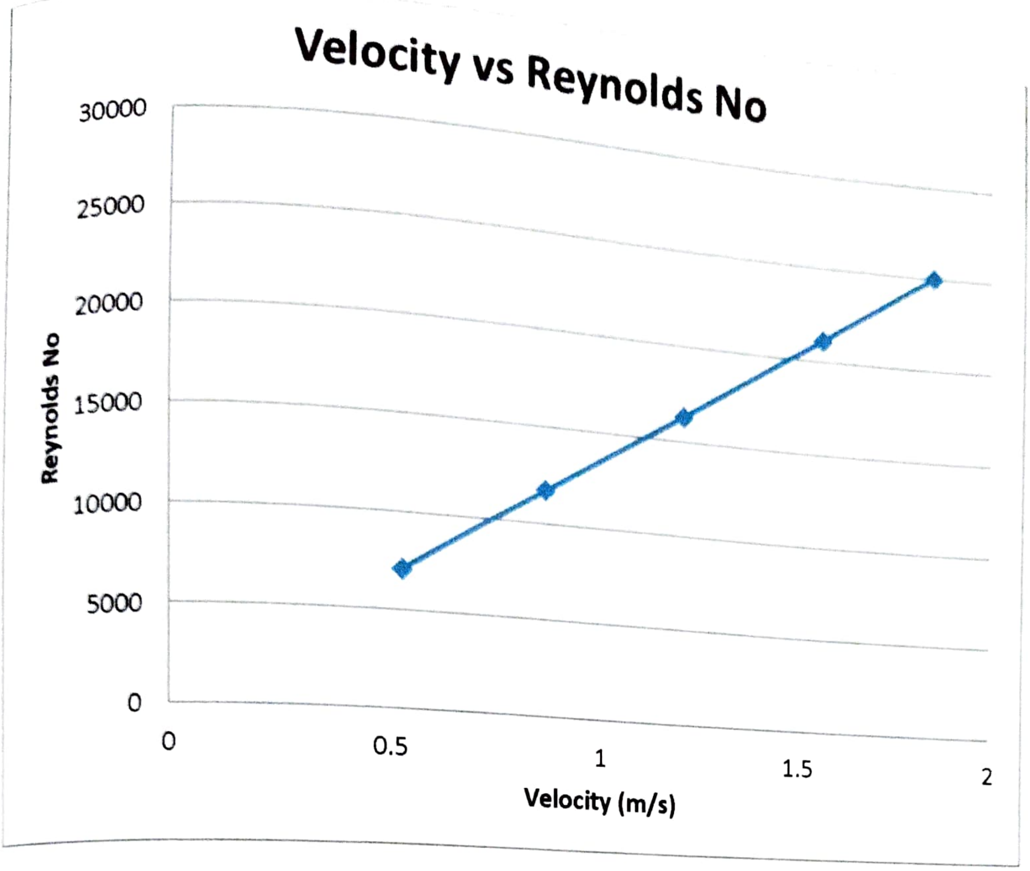
$= \sqrt{(1.225\, x\, 0.524\, x\, 0.2)/(1.81\, x\, 10\hat{} - 5\,)}$

$= 7090$




Input Pressure vs Velocity
Velocity (m/s)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Pressure (Kgf/cm2)


Dynamic Pressure vs Velocity
Velocity (m/s)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1000
1200
1400
1600
1800
Pressure (Pa)

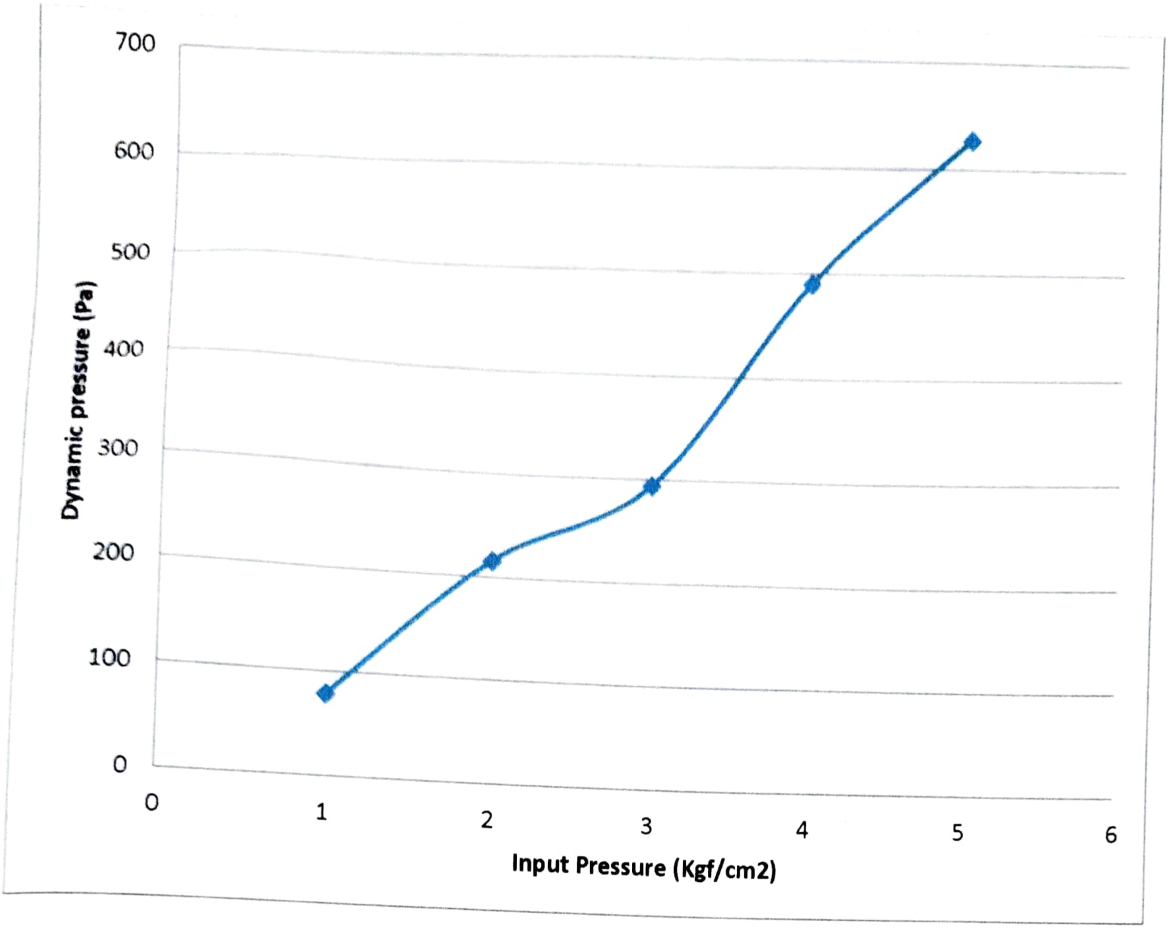


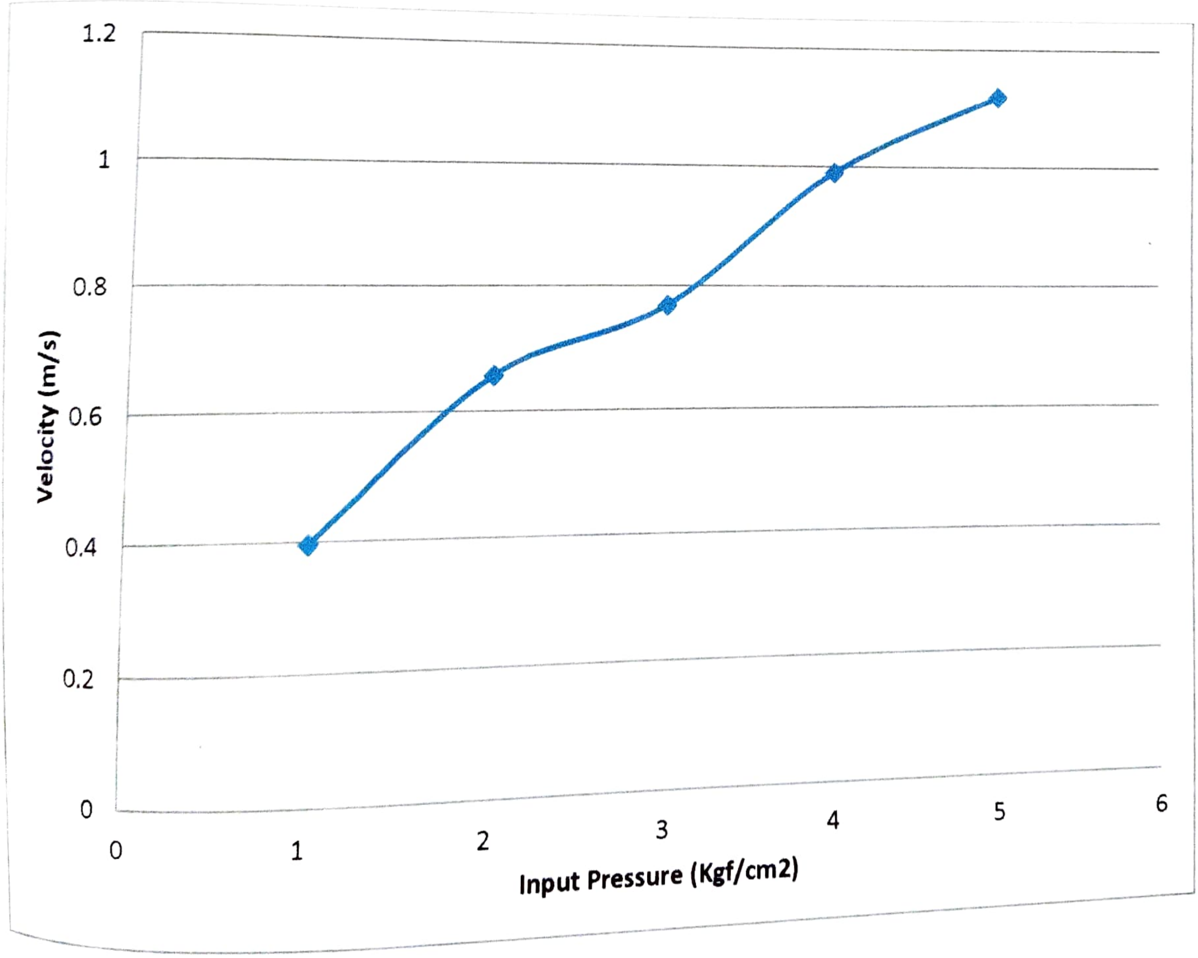
4.4 Behaviour of Parameters in the mesh downstream :

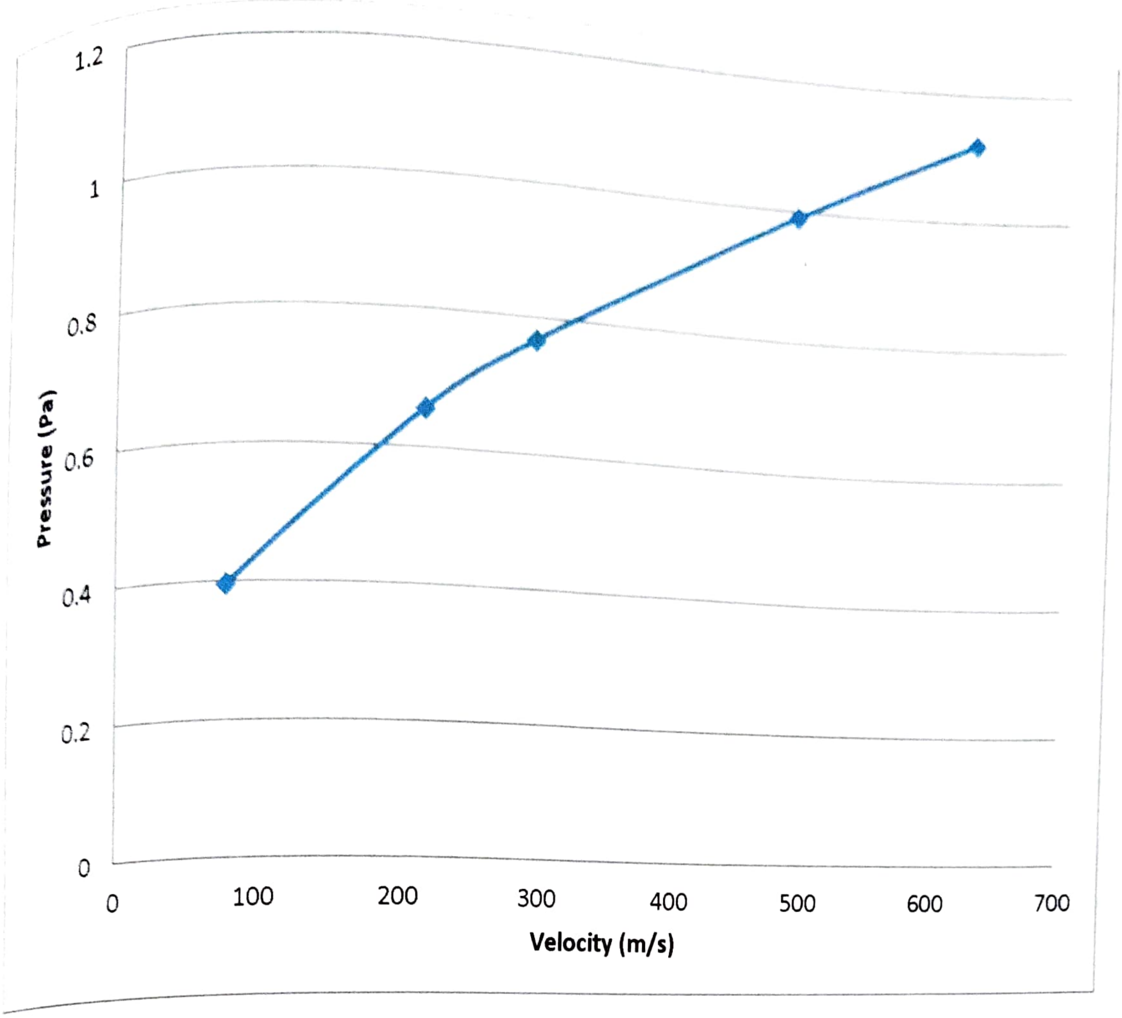
For Mesh 1 (1mm spacing & 77.88% FHA) :

(i) At a distance of 100 mm from the mesh downstream:

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	8	78.38	0.396	2680
2	22	215.55	0.656	4440
3	30	293.93	0.767	5190
4	50	489.89	0.990	6700
5	64	627.07	1.120	7580

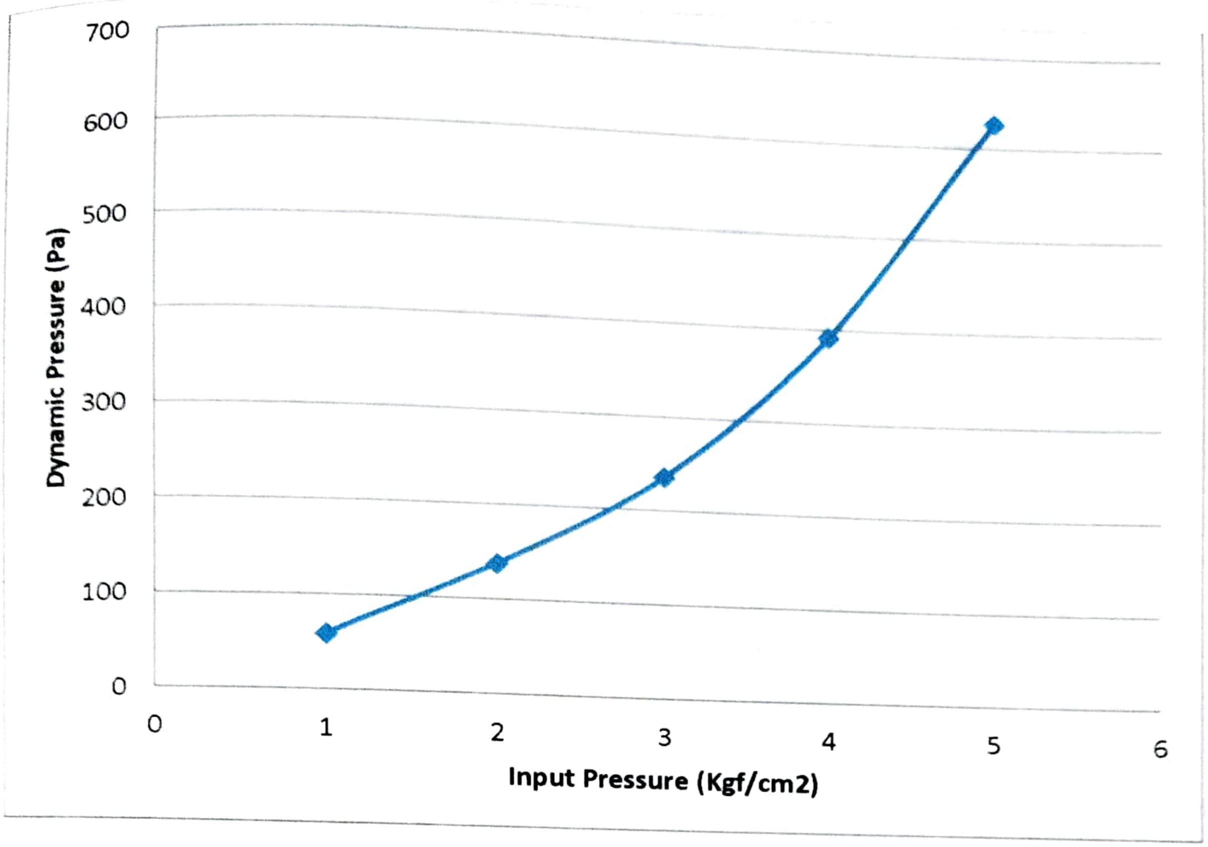

700
600
500
400
300
200
100
0
Dynamic pressure (Pa)
0
1
2
3
4
5
6
Input Pressure (Kgf/cm2)

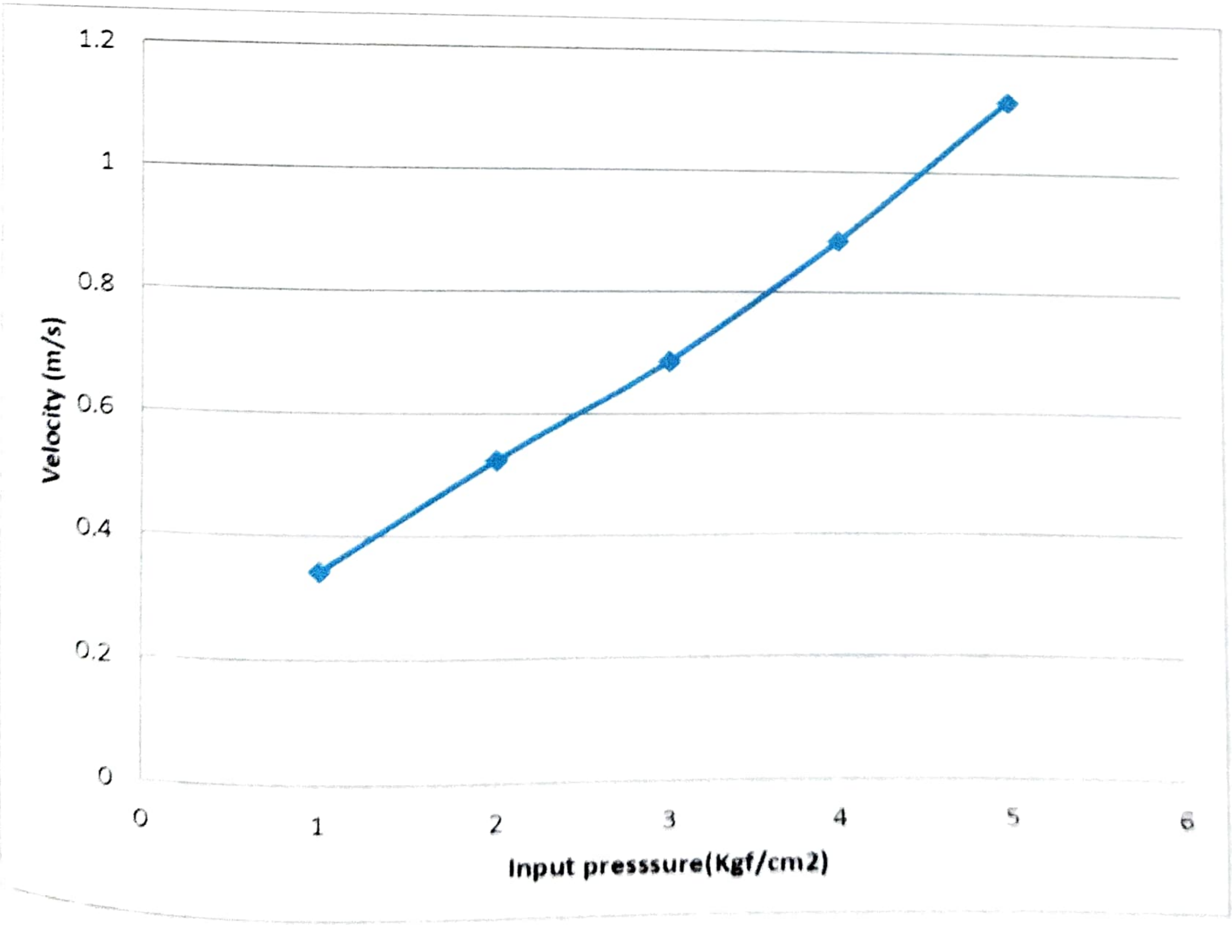

1.2
1
0.8
0.6
0.4
0.2
0
Velocity (m/s)
0
1
2
3
4
5
6
Input Pressure (Kgf/cm2)

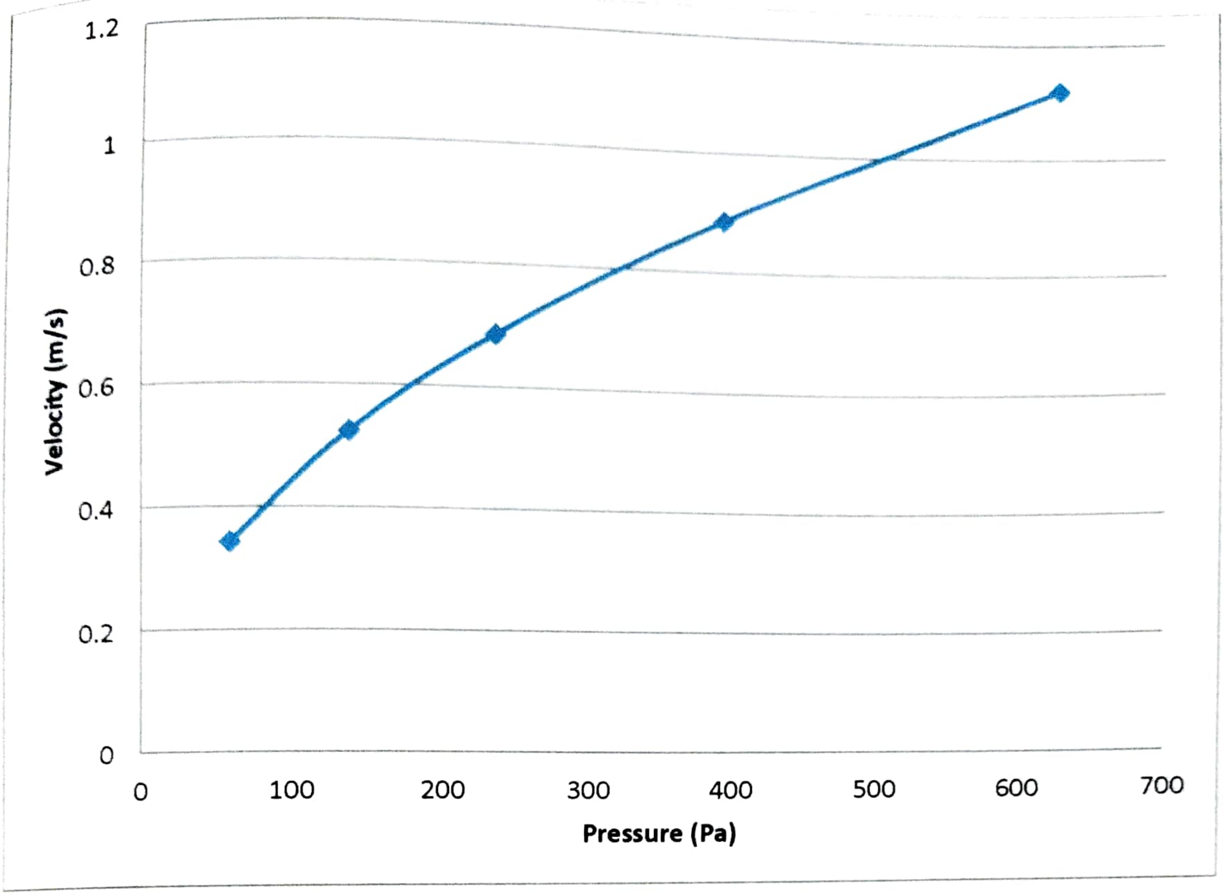


(ii) At a distance of 200 mm from the mesh downstream:

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	6	58.78	0.343	4642.82
2	14	137.17	0.524	7092.82
3	24	235.15	0.686	9285.64
4	40	391.91	0.885	11980
5	64	627.07	1.120	15160


Dynamic Pressure (Pa)
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
Input Pressure (Kgf/cm2)

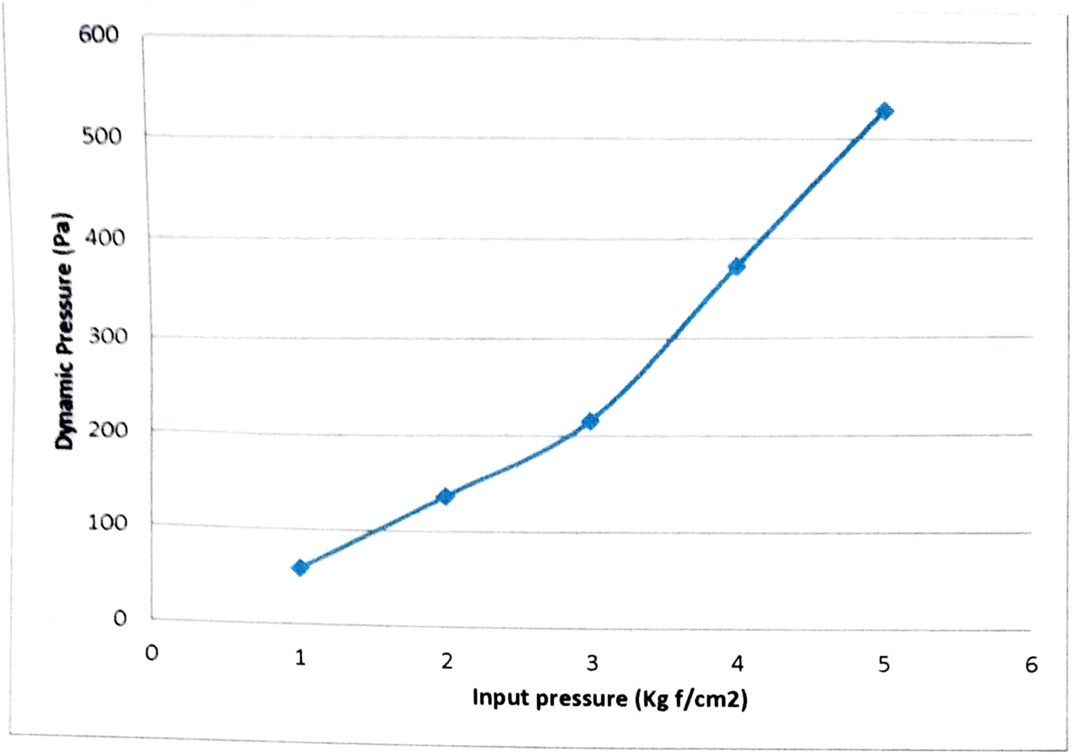

Velocity (m/s)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Input presssure(Kgf/cm2)

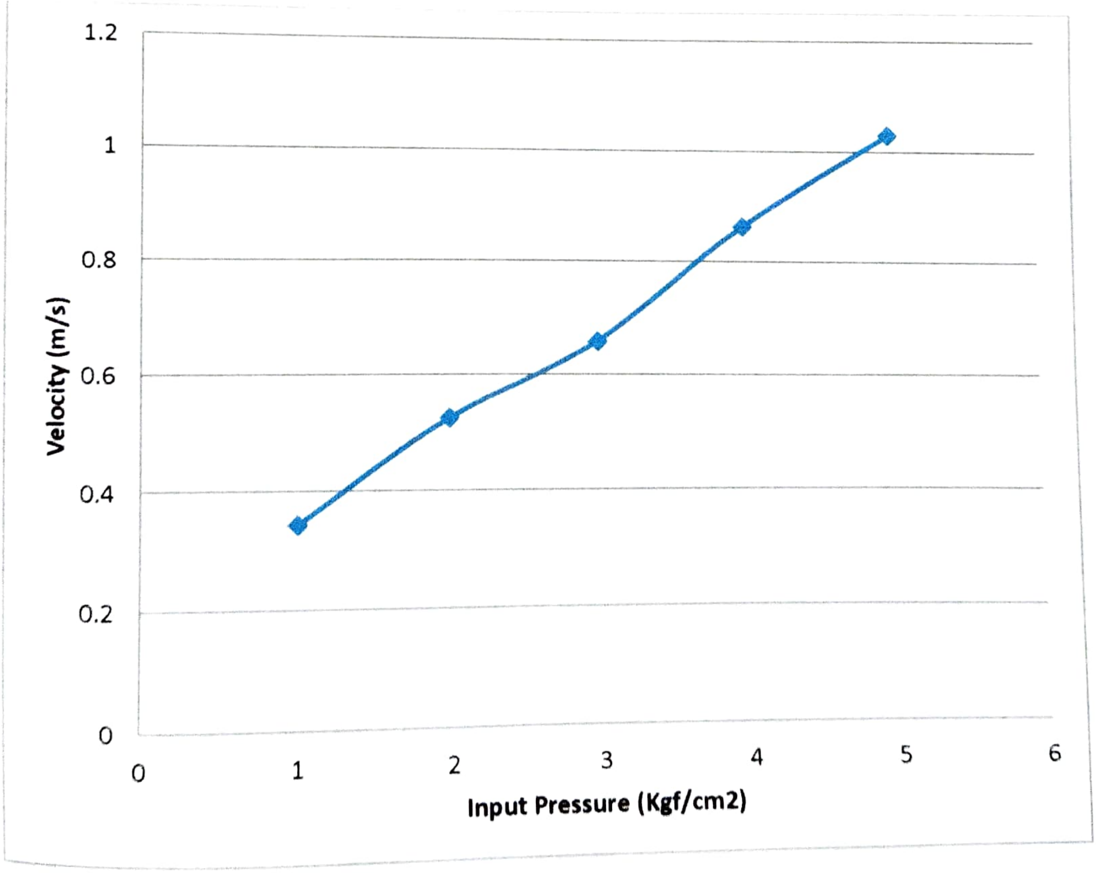


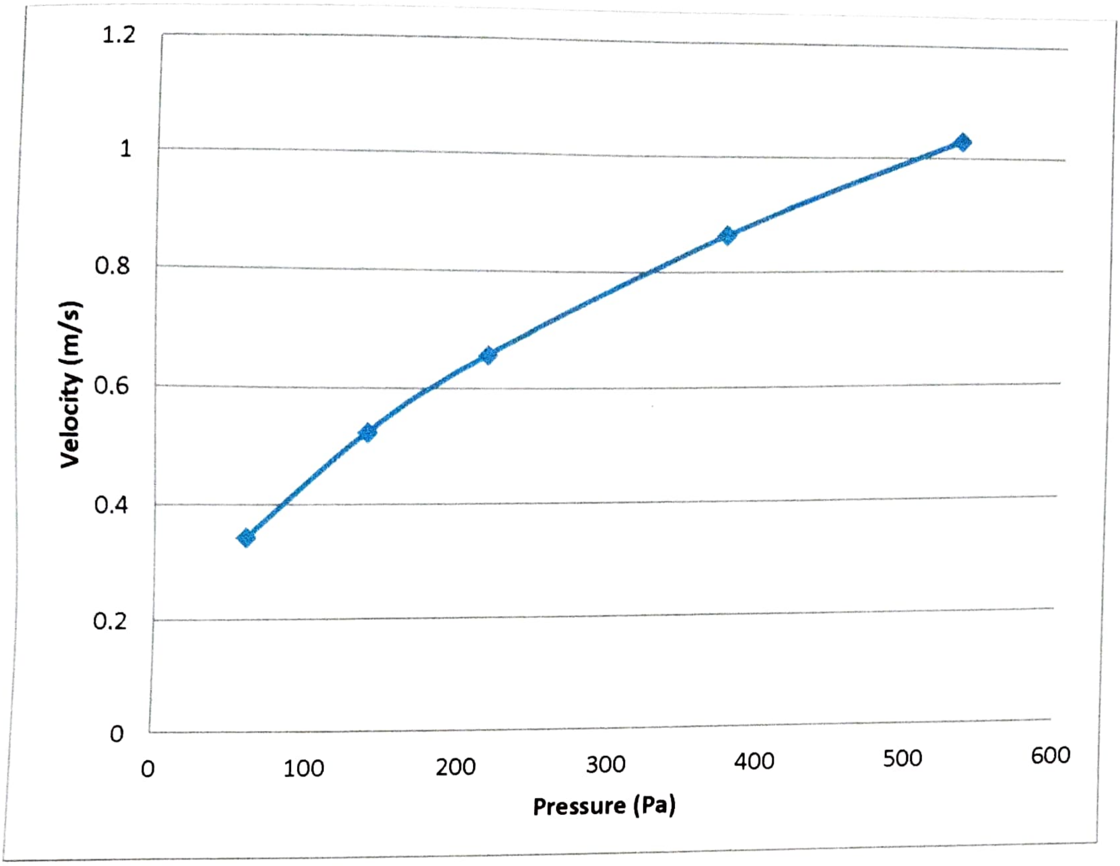
For Mesh 2(0.62 mm spacing & 67.89% FHA):

(i) At a distance of 100 mm from the mesh downstream:

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	6	58.78	0.343	2320
2	14	137.17	0.524	3546
3	22	215.55	0.657	4446
4	38	372.32	0.863	5840
5	54	529.09	1.03	6790

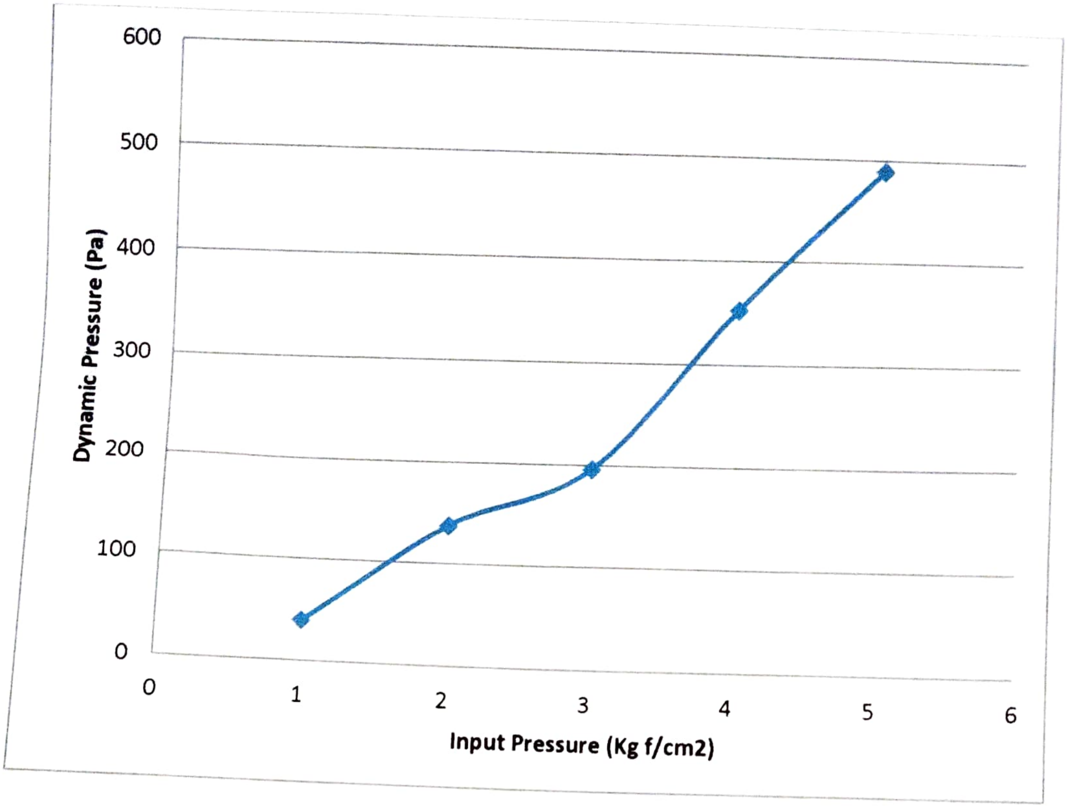

600
500
400
300
200
100
0
Dynamic Pressure (Pa)
0
1
2
3
4
5
6
Input pressure (Kg f/cm2)

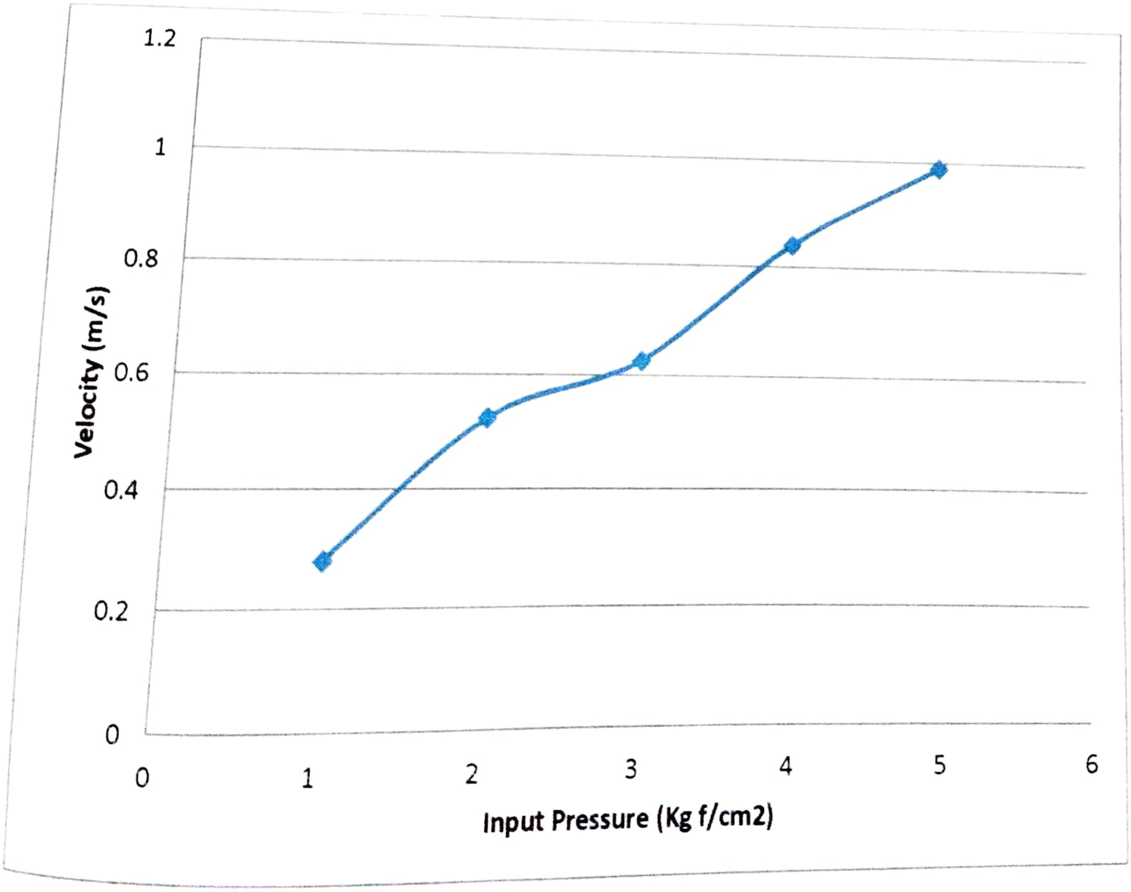

1.2
1
0.8
0.6
0.4
0.2
0
Velocity (m/s)
0
1
2
3
4
5
6
Input Pressure (Kgf/cm2)

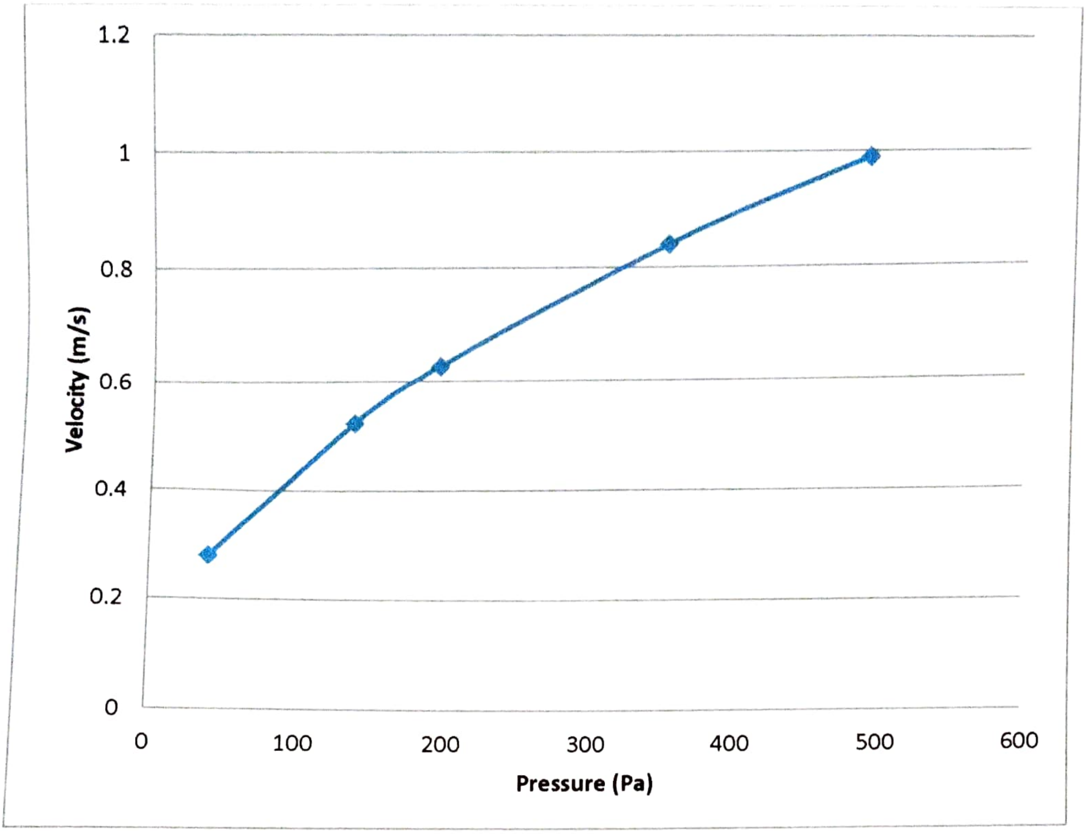


(ii) At a distance of 200 mm from the mesh downstream:

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	4	39.191	0.280	3790
2	14	137.17	0.524	7090
3	20	195.95	0.626	8470
4	36	352.72	0.840	11370
5	50	489.89	0.990	13400


Dynamic Pressure (Pa)
600
500
400
300
200
100
0
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)

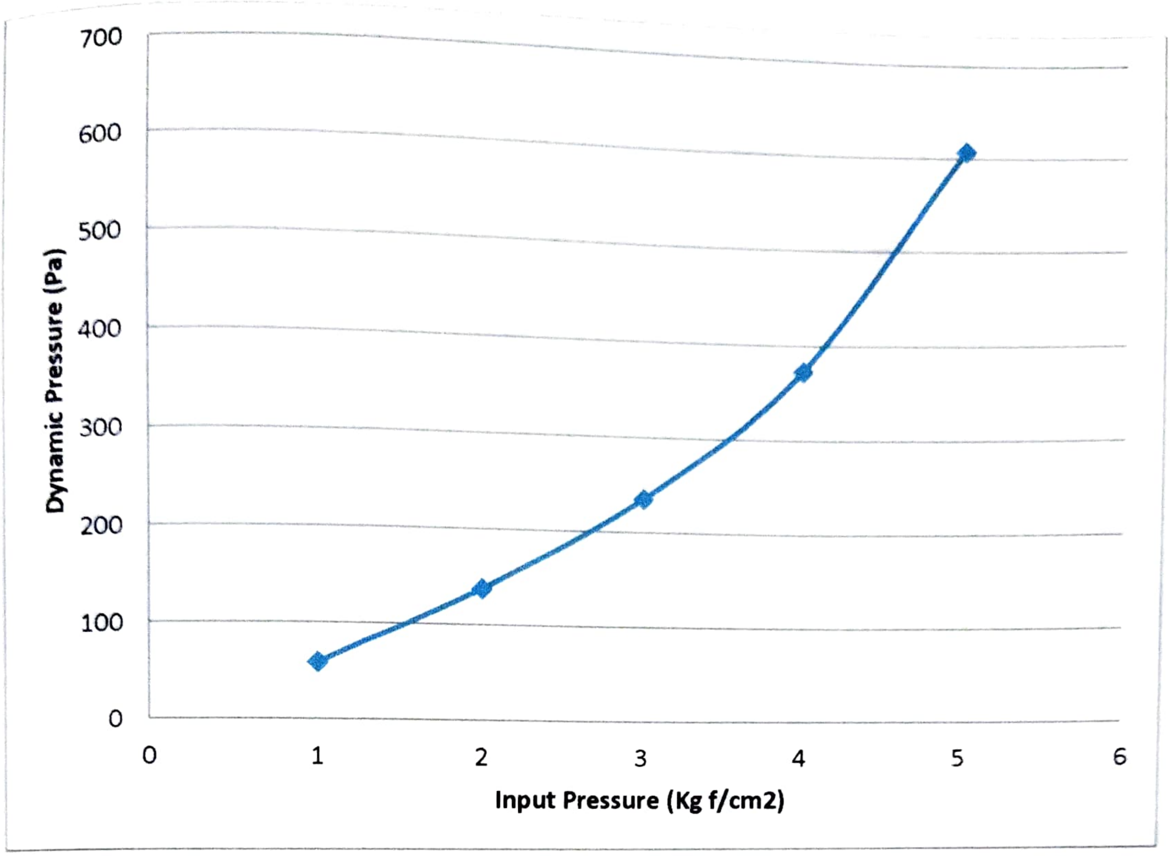

Velocity (m/s)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)



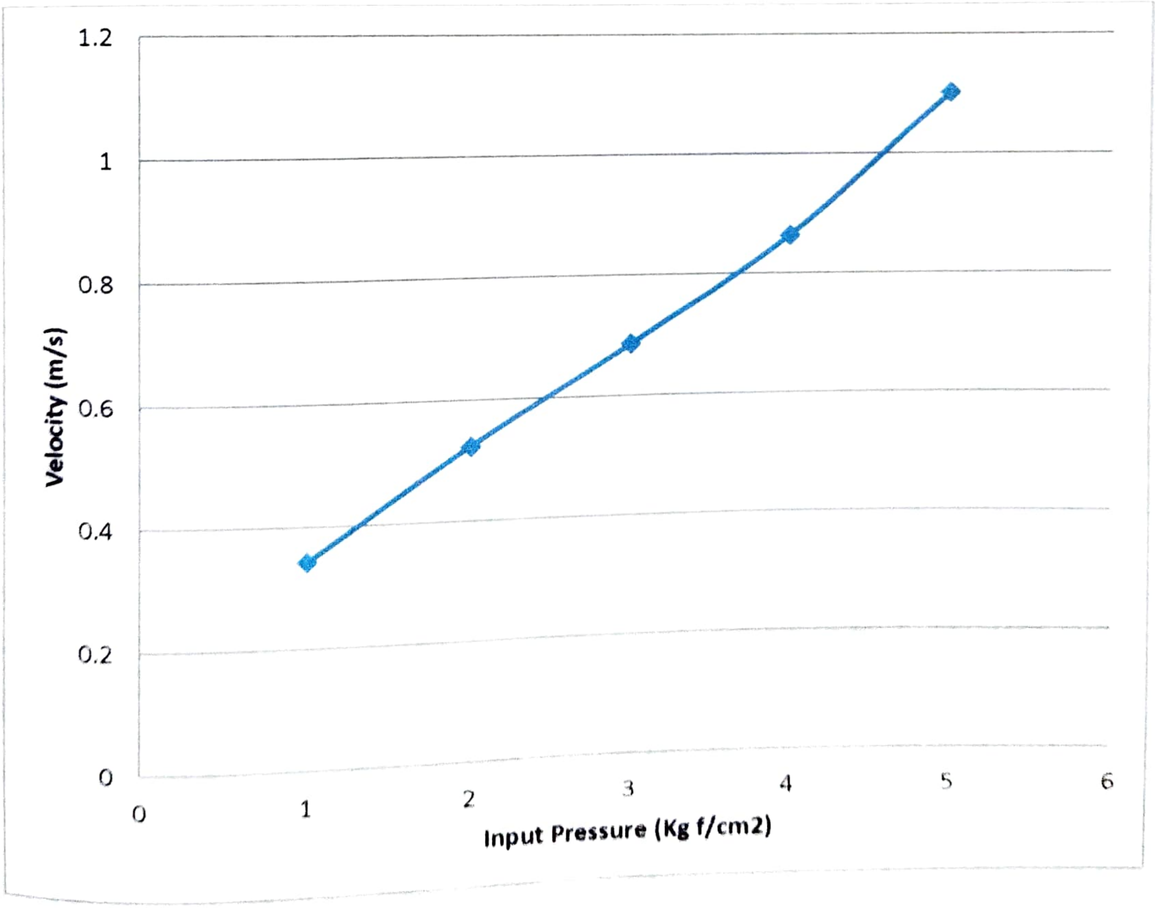
For Mesh 3(0.5 mm spacing & 61.62% FHA):

(i) At a distance of 100 mm from the mesh downstream:

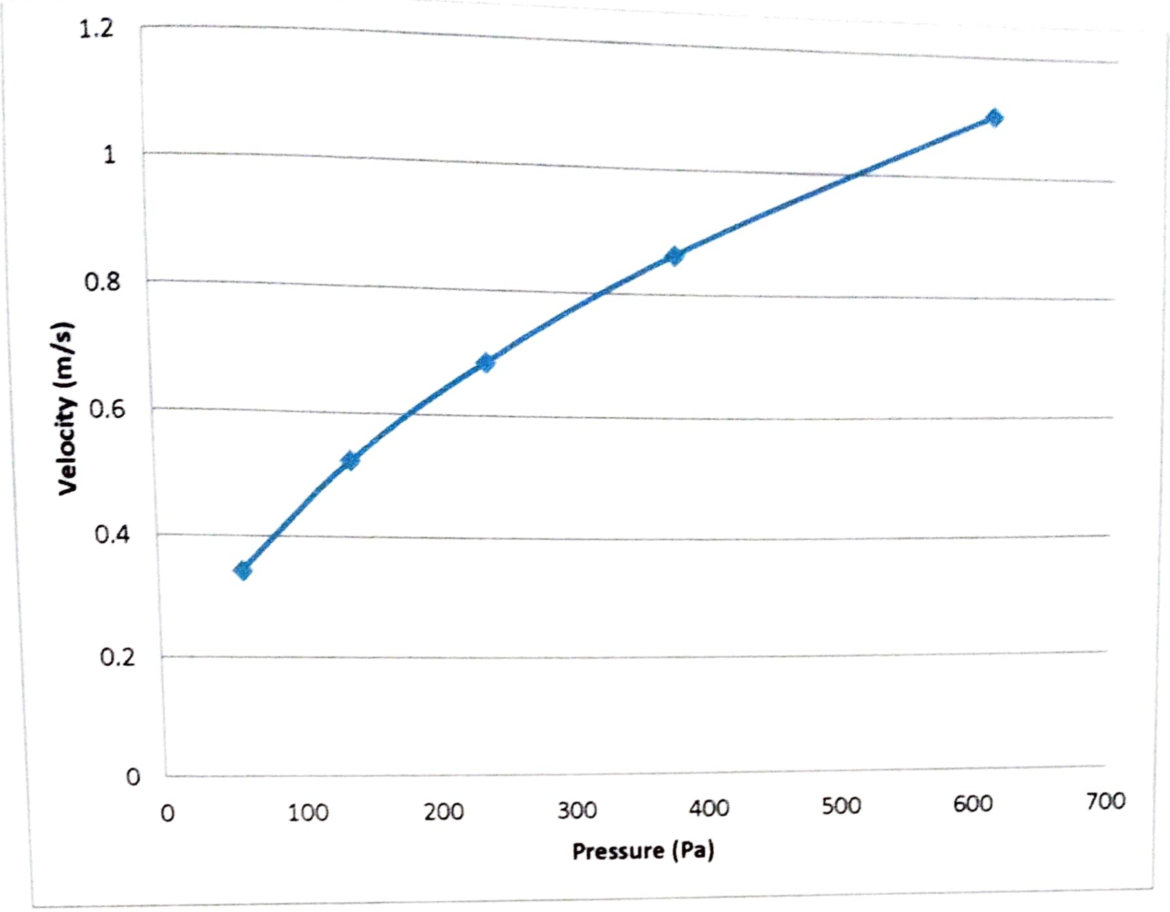
Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	6	58.78	0.343	2321
2	14	137.17	0.524	3546
3	24	235.15	0.686	4642
4	38	372.32	0.863	5840
5	62	607.47	1.102	7458



700
600
500
400
300
200
100
0
Dynamic Pressure (Pa)
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)

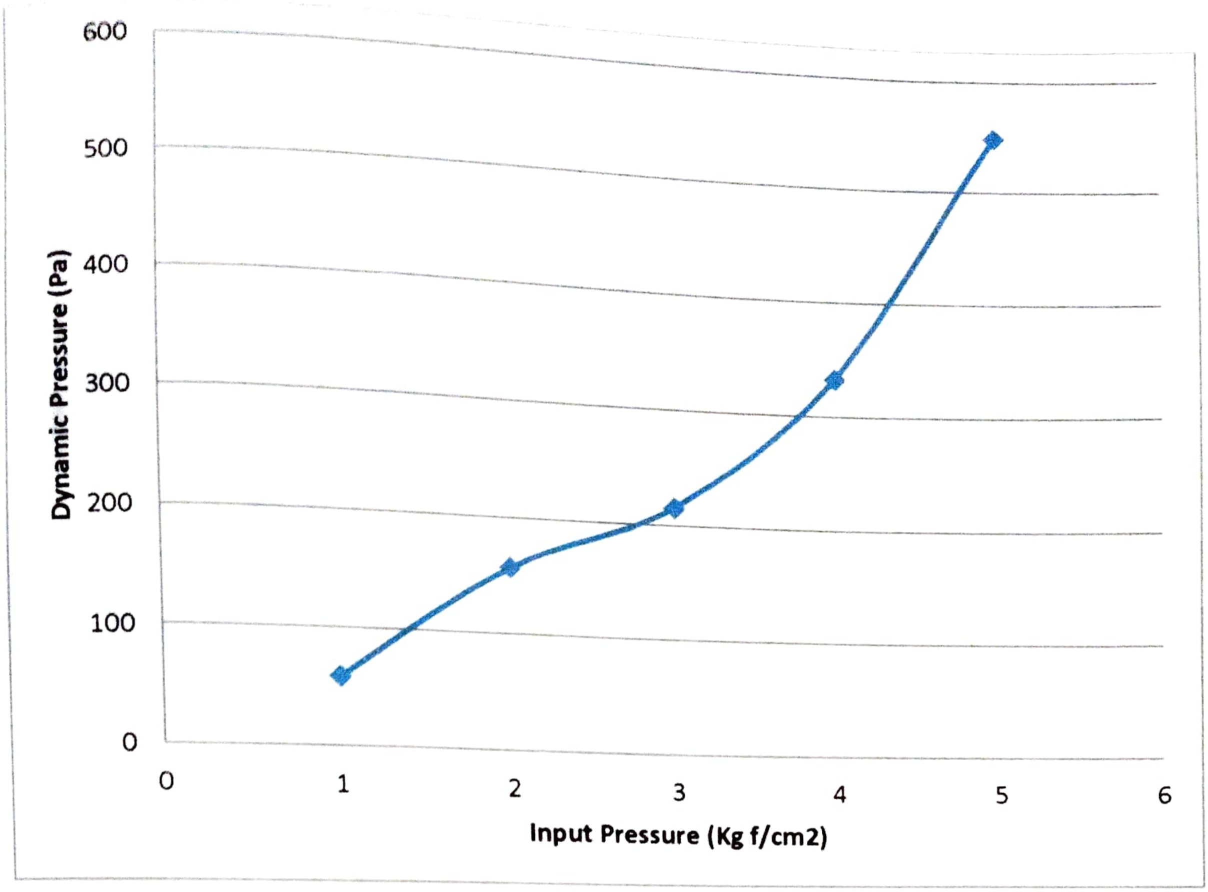


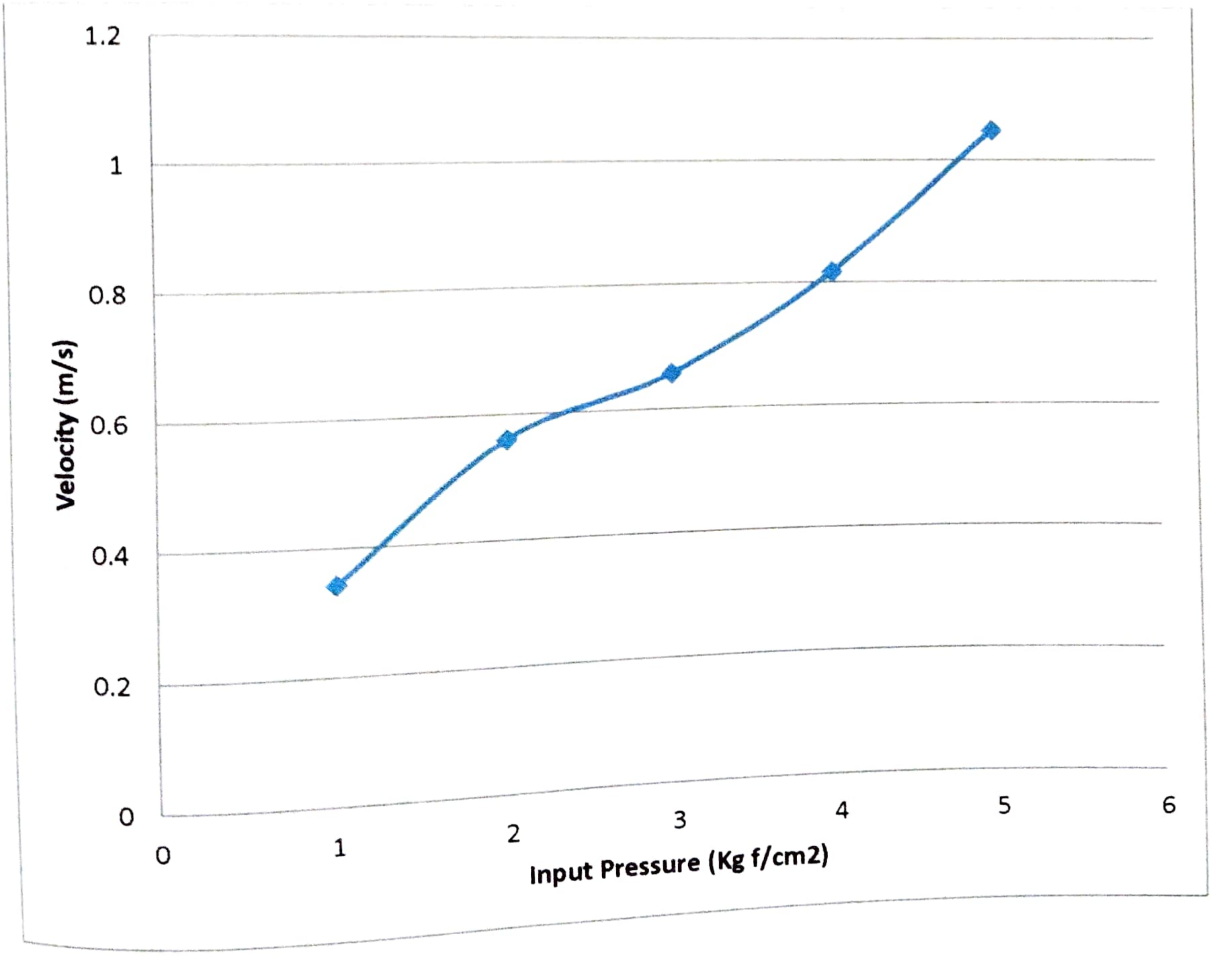
1.2
1
0.8
0.6
0.4
0.2
0
Velocity (m/s)
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)

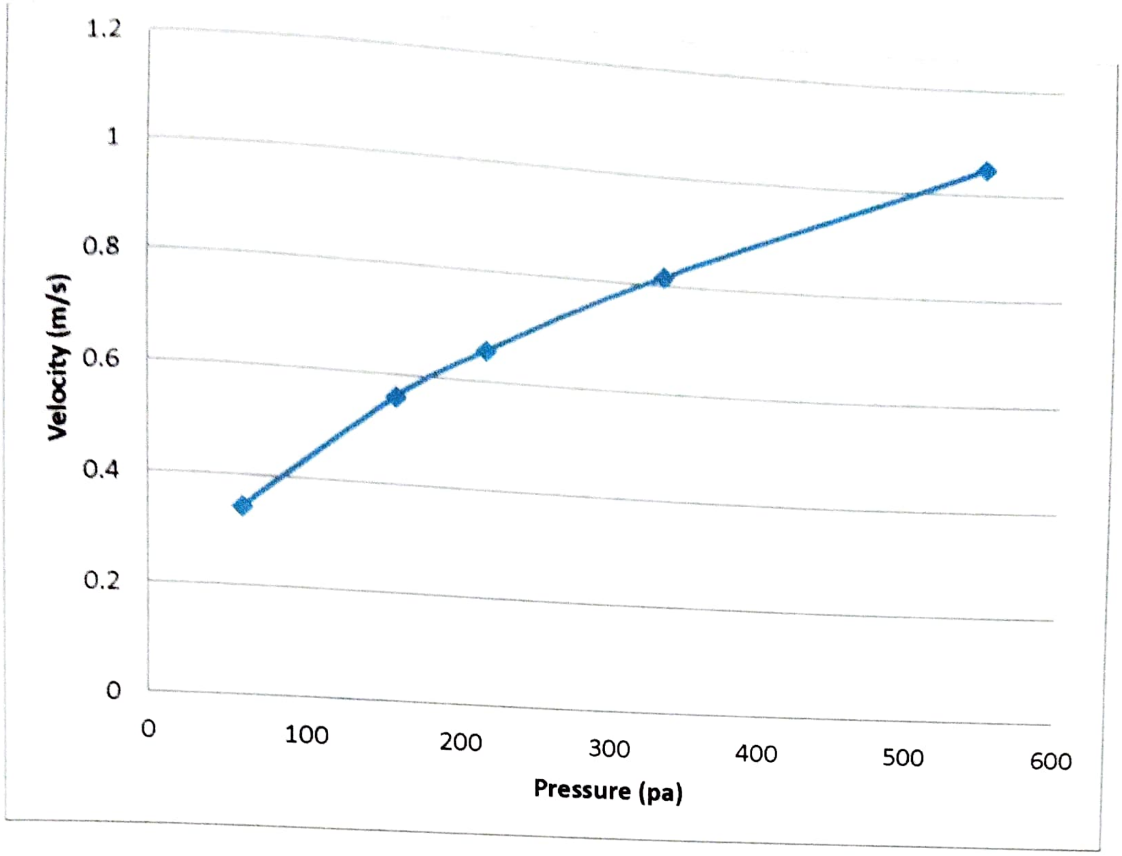


(ii) At a distance of 200 mm from the mesh downstream:

Input pressure at inlet (Kg f/cm2)	Pressure head (Dynamic head in mm)	Pressure (Pa)	Velocity (m/s)	Reynolds No (Re)
1	6	58.78	0.343	4642
2	16	156.76	0.56	7580
3	22	215.55	0.656	8880
4	34	333.13	0.816	11045
5	56	548.68	1.048	14186

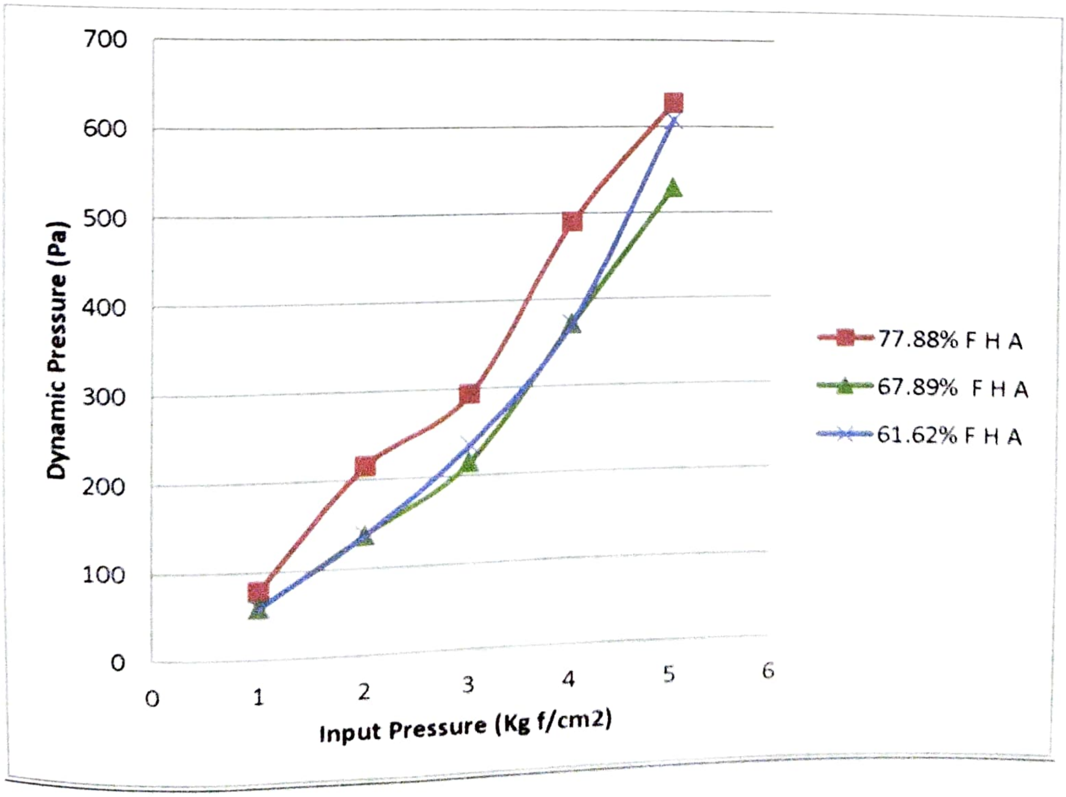

Dynamic Pressure (Pa)
600
500
400
300
200
100
0
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)


Velocity (m/s)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Input Pressure (Kg f/cm2)

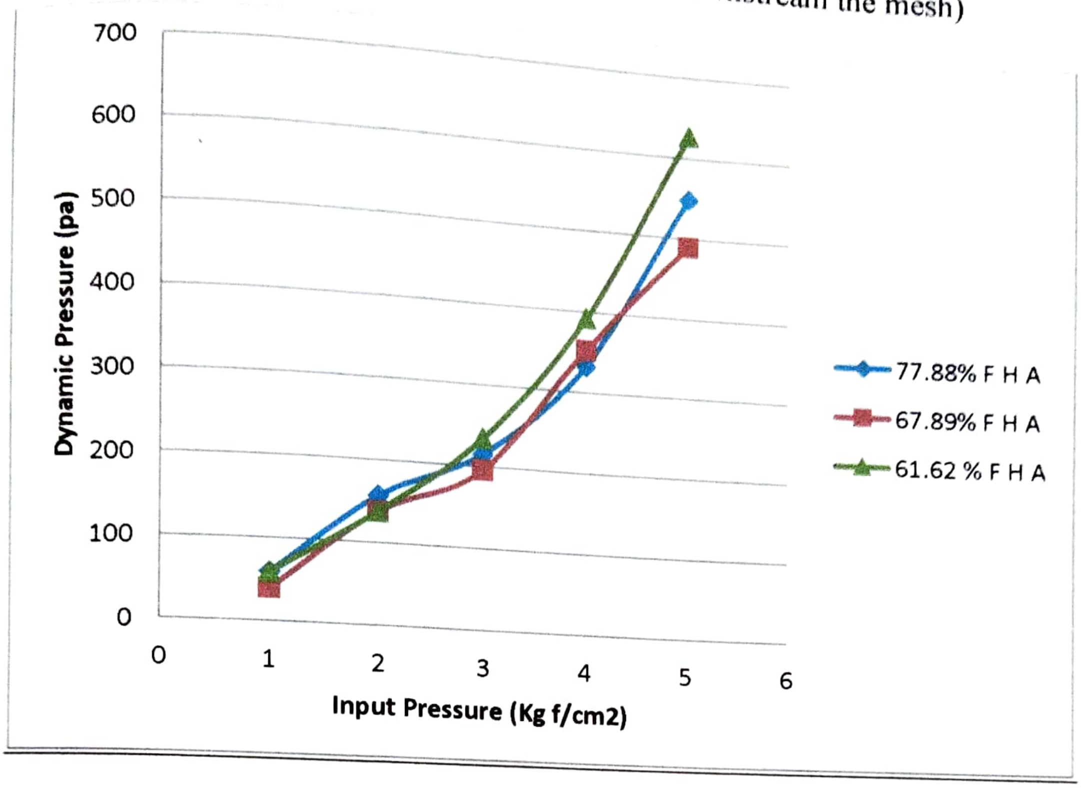


4.5 COMPARISON OF RESULTS

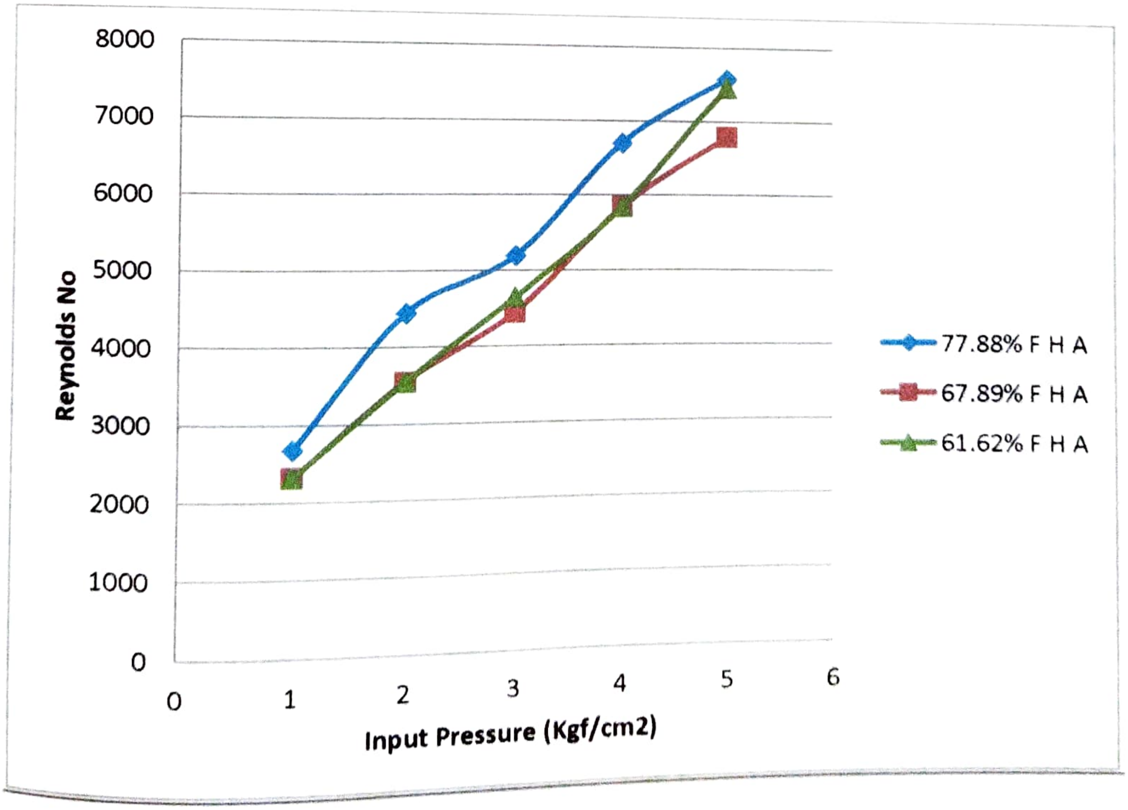
Input Pressure vs Dynamic Pressure (at 100mm downstream the mesh)



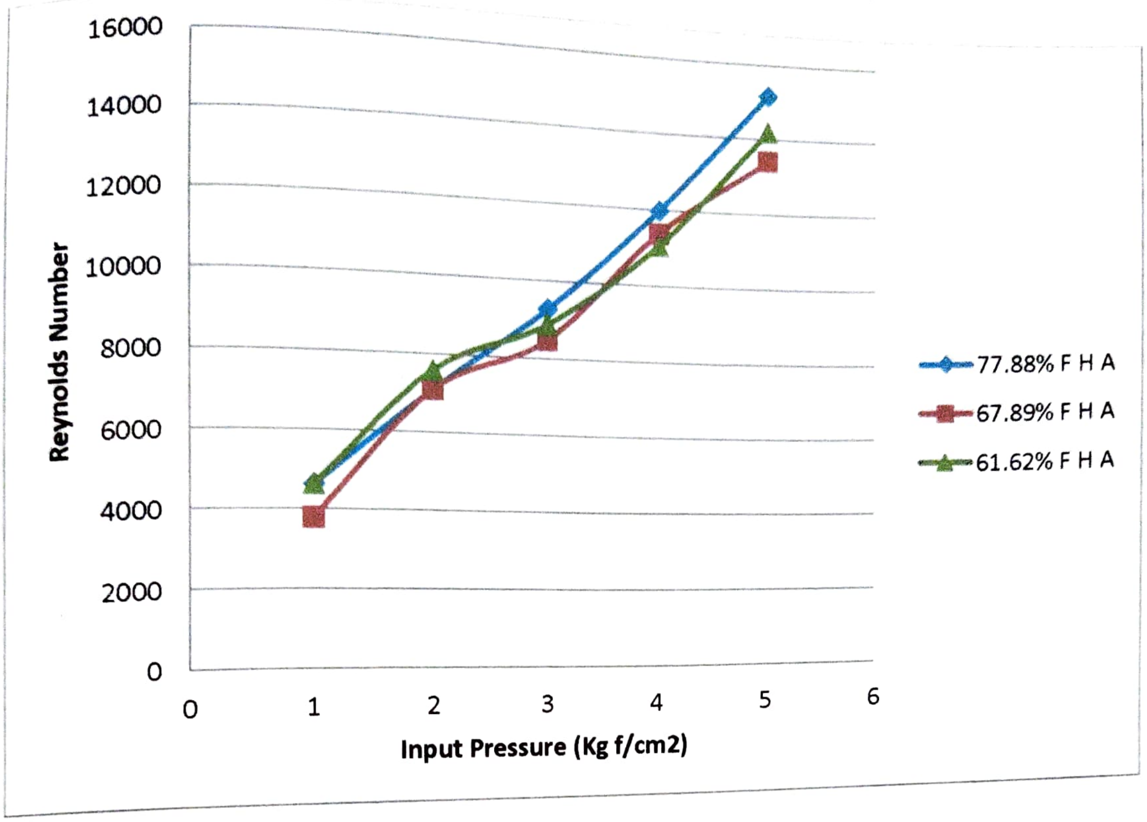
Input Pressure vs Dynamic Pressure (at 200mm downstream the mesh)



Input Pressure vs Reynolds no (at 100mm downstream the mesh)



Input Pressure vs Reynolds no (at 200mm downstream the mesh)



4.6 DISCUSSION

4.6.1 EXPERIMENTAL ERRORS

I believe there is only one significant source of error in the experiment and i.e., the effect of temperature changes on the airflow. We did not initially foresee the density / temperature problem as I did not expect the temperature at the lab to fluctuate as much as it did. During the weeks I was running tests it varied roughly a few degrees Fahrenheit. This temperature range represents a significant increase in the dynamic viscosity of the air. This represents a change in the relationship between viscosity and density and will affect the velocity at which the flow becomes turbulent. It is unknown how significant an effect this will have on the results, however none of the results seem to deviate very far from what was expected so the effect seems minimal.

4.6.2 MEASUREMENT AND METHOD

There were several factors that influenced the methodology of the experiment, these included the effects of auxiliary air flows in the room, difficulty in obtaining steady velocity measurements and the nature of the experiment itself. The first and last considerations had the greatest effect on the visualisation experiments. When the laboratory door was open, the flows were significantly disturbed and broke down into turbulence much more quickly.

Pressure measurements were difficult to take because the manometer had a very rapid response time, causing it to fluctuate wildly if the flow was not perfectly laminar. I believe a gauge type pressure measuring instrument which would have given better results due to its averaging effect.

4.7 CONCLUSION

The results so obtained from the experiment may not be so accurate as we have neglected the flow losses and other boundary effects. The plots are accurate according to the reading so obtained.

CHAPTER-5

CONCLUSION

Overall I believe the experiment was a limited success. I was able to obtain a pressure effects for screen pressure, velocity and free hole area that confirmed the expected results. The results so obtained for different free hole areas is a new discovery and raises many questions about the geometric exit effects. When the results with and without the screen are compared, it is clear that the presence of a screen causes the flow to remain collimated for a much greater distance before it disperses. The necessity of the screen will be determined by the application and this experiment provides a method of determining required flow capacity when screens are used.

The conclusions drawn are:

- ✓ The flow has approached laminar flow upto Reynolds no of 2300 when a screen of 0.5mm wire spacing is used.
- ✓ The pressure and velocities are becoming equal at a distance of about 300 mm behind the screen position.
- ✓ It is observed that there is a lot of pressure variation infront of the screen and behind the screen.
- ✓ The laminarity of the flow is achieved for a free hole areas less than 50%
- ✓ At downstream distance of 100mm, at Pressure 1kgf/cm2 , mesh 2(mesh size40) is observed to have minimum reynolds number and at pressure 5kgf/cm2 ,mesh 1(mesh size 25) is observed to have maximum reynolds number.
- ✓ At downstream distance of 200mm, ,at Pressure 1kgf/cm2 , mesh 2(mesh size40) is observed to have minimum reynolds number and at pressure 5kgf/cm2 ,mesh 1(mesh size 25) is observed to have maximum reynolds number.
- ✓ It is observed that there is a lot of pressure variation infront of the screen and behind the screen.

FUTURE SCOPE

There is a great deal of work that can still be done in this area. The addition of more screens with free hole areas in ranges other than 60% and 70% would improve the validity of the regression analysis and more tests with a consistent wire diameter would verify or disprove my assumption that it is irrelevant. No investigation was performed on the effects of different geometries of the exit, i.e. square outlets instead, or even on different sizes of outlet. Separate experiments are being carried out to investigate the directional properties of such screens.