



University of Southern Queensland

Faculty of Engineering & Surveying

# **Air flow through two layered mesh at varying porosity and spacing**

A dissertation submitted by

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In fulfilment of the requirements of

**ENG4111 and 4112 Research Project**

Towards the degree of

**Bachelor of Engineering (Mechanical)**

Submitted: November 2008

## **ABSTRACT**

Metal meshes have a number of applications such as security screens, fencing, screening, filtration, equalization of flow, heat processing etc. They are available in different materials, element shapes, sizes and weavings. The work presented here examines the drag force on the metal meshes as it is particularly important if a large size mesh is used at high wind velocities. The flow of air through cells in a mesh such as perforated (holes drilled in a sheet metal) or woven wire encounters drag force and a pressure drop. This effect of pressure drop associated with the mesh is not desirable in certain applications such as uniform supply of hot air in turbine using the resistance of wire mesh to increase the internal energy of air molecules as an attempt to increase the overall efficiency of turbine. But the added wire mesh faces large drag force at higher wind velocities and since it is at high temperature that makes it vulnerable to tear apart. Various researches have carried work to establish empirical relationships of flow around cylinders when placed in wind tunnel, but hardly any attempt has been made to study air flow through two layers of mesh separated by a finite distance. The work presented here is experimental and intended to investigate the effect of using two layers of mesh on the drag force by using mesh of varying porosity and at different spacing, with a probability to lower the net drag force than that obtained by using single mesh.

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**Ranjit Singh Padda**

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Signature

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Date

# Acknowledgements

I take this opportunity to sincerely and deeply express my gratitude to my project supervisor, **Dr.Ahmad Sharifian**, University of Southern Queensland for his invaluable guidance, kind support, expert advice, and encouragement throughout my project work.

I would also like to thank Mr. Mohan Trada and the workshop staff for their valuable assistance and advice. I am also indebted to my colleagues and friends for their encouragement and support.

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*November, 2008*

# Contents

Abstract	i
Acknowledgements	vi
List of figures	xi
List of tables	xiii
<b>Chapter 1 Introduction</b>	<b>1</b>
1.1 Chapter overview .....	1
1.2 Potential application .....	1
1.3 Background to fire prevention .....	2
1.4 Terminology and definitions .....	3
1.5 Methodology .....	6
1.6 Overview of dissertation .....	8
<b>Chapter 2 Literature review</b>	<b>10</b>
2.1 Chapter overview .....	10
2.2 Screen properties .....	10
2.3 Resistance loss coefficient .....	11
2.4 Flow through multiple meshes .....	12

2.5 Flow instability .....	12
2.6 Boundary layer dependency .....	13
2.7 Computational analysis for a single mesh .....	14
2.8 Chapter summary .....	14
<b>Chapter 3 Experimental setup and risk assessment</b>	<b>15</b>
3.1 Chapter overview .....	15
3.2 Instruments and equipments .....	15
3.2.1 Woven wire mesh .....	15
3.2.2 Frame .....	17
3.2.3 Wind tunnel .....	19
3.2.4 Manometer .....	21
3.2.5 Pitot tube .....	22
3.2.6 Other instruments .....	24
3.3 Risk assessment	25
3.3.1 Risk during the execution of present work .....	25
3.3.2 Risk after the execution of present work .....	26
3.4 Chapter summary .....	27
<b>Chapter 4 Experiments</b>	<b>28</b>
4.1 Chapter overview .....	28



4.2 Experimental procedure .....	28
4.3 Data collected .....	31
4.4 General sources of error .....	37
4.5 Chapter summary .....	39
<b>Chapter 5 data conversion and error analysis</b>	<b>40</b>
5.1 Chapter overview .....	40
5.2 Data processing .....	40
5.2.1 Pressure drop due to mesh only .....	44
5.2.2 Measurement of density of air .....	46
5.2.3 Calculation of air density .....	46
5.2.4 Calculation of Reynolds number .....	47
5.2.5 Calculation of pressure ratio .....	48
5.2.6 Calculation of coefficient of drag .....	49
5.3 Error analysis .....	49
5.3.1 Error associated with the measurement of density of air .....	50
5.3.2 Error associated with the measurement of pressure drop .....	51
5.3.3 Error associated with the measurement of air velocity .....	52
5.3.4 Error associated with the measurement of coefficient of drag .....	53
5.4 Chapter summary .....	54

<b>Chapter 6 Results and discussion</b>	<b>55</b>
6.1 Chapter overview .....	55
6.2 Results .....	55
6.2.1 For wire mesh of 0.45 mm diameter and open area of 34%. .....	55
6.2.2 For wire mesh of 0.40 mm diameter and open area of 47%. .....	58
6.2.3 For wire mesh of 1.6 mm diameter and open area of 57%. .....	60
6.2.4 For wire mesh of 1.18 mm diameter and open area of 61%. .....	62
6.2.5 For wire mesh of 0.56 mm diameter and open area of 67%. .....	64
6.2.6 For wire mesh of 1.6 mm diameter and open area of 67%. .....	66
6.2.7 For wire mesh of 1.6 mm diameter and open area of 67%. .....	68
6.2.8 Coefficient of drag VS porosity .....	68
6.3 Discussion .....	70
6.4 Chapter summary .....	75
<b>Chapter 7 Conclusion and future work</b>	<b>76</b>
7.1 Conclusion .....	76.
7.2 Future work .....	77
<b>References</b>	<b>78</b>
<b>Appendix A Corrected data for experiments</b>	<b>81</b>
<b>Appendix B Error analysis for the experimental data</b>	<b>106</b>



# List of figures

1.1 a typical mesh explained .....	4
1.2 two layers of mesh in tandem .....	6
1.3 two layers of mesh not in tandem .....	6
3.1 A typical mesh .....	16
3.2a Frame used for holding the mesh .....	18
3.2b Spacers .....	18
3.2c Supporting plate with dowels pins attached .....	19
3.3a open circuit subsonic wind tunnel .....	20
3.3b By-pass arrangement .....	20
3.3c Testing section of wind tunnel .....	20
3.4 Manometer attached to the testing section of the wind tunnel .....	22
3.5a Front view of the installation of Pitot tube into the testing section. ....	23
3.5b Top view of the installation of Pitot tube into the testing section. ....	24
4.2a mounting mesh on the frame .....	29
4.2b frame assembly mounted into wind tunnel's testing section .....	30
4.3a shows various points used for the experiments .....	32

4.3b shows point A before mesh assembly .....	32
4.3c shows point B after mesh assembly .....	32
5.1 quadratic fit data of $\Delta h_1$ and $V_{air}$ both measured for single mesh. ....	45
6.1 results for wire diameter of 0.45mm and open area of 34%. ....	56
6.2 results for wire diameter of 0.40mm and open area of 47%. ....	59
6.3 results for wire diameter of 1.6 mm and open area of 57%. ....	61
6.4 results for wire diameter of 1.18 mm and open area of 61%. ....	63
6.5 results for wire diameter of 0.56 mm and open area of 67%. ....	65
6.6 results for wire diameter of 1.6 mm and open area of 67%. ....	67
6.7 results for wire diameter of 1.6 mm and open area of 77%. ....	69
6.8 drag coefficient VS porosity at 5mm spacing .....	71
6.9 comparisons between current work and experimental research of others. ....	72
6.10 compares two layered mesh using the equation developed for single mesh. ....	74

# List of tables

4.1 data collected for woven wire mesh of wire diameter 1.6mm and an open area of 67%.	
.....	34
5.1 corrected data collected for woven wire mesh of wire diameter 1.6mm and an 67% open area.	
.....	41

# Chapter 1

## **INTRODUCTION**

### ***1.1 CHAPTER OVERVIEW***

Metal meshes have countless applications such as screening, filtration, equalization of flow, heat processing etc. The biggest problem with the meshes installed in the aerodynamic facilities and even in the open spaces is drag force which is especially important at high wind velocities. The work presented here is intended to investigate the effect of using two layers of mesh on the drag force by at different spacing with a probability to lower the net drag force than that obtained by using single mesh. The meshes used in this work have a porosity range of 34% to 77%.

The wind tunnel at the facility of University of Southern Queensland has been used as the main equipment to carry out these experiments. This section of the dissertation details a potential application of the outcome of these experiments, defines the terms used in this report, and throws some light on the background of the project and the methodology used to achieve the required results.

### ***1.2 POTENTIAL APPLICATION***

The outcome of this project work coned to lead a potential application of fire prevention in the fire prone areas. The Australian Standard for construction of the building in bushfire prone areas AS 3959-1999 (Standards Australia, 1999) recommends the use of wire mesh of aperture size of 1.8 mm or less on all openings to the house. During the experiment different aperture sizes have been used to establish the trend that drag force follows with the varied spacing between two layers of mesh of different porosities.

### ***1.3 BACKGROUND TO FIRE PREVENTION***

There have been occasional reports that mesh fencing may prevent fire propagation and such properties are apparent from the use of Bunsen burner in many chemical labs. An army firing range in Surrey (UK) during a fire in summer season of 1976 based on such observation Dr. Grantham (From miner's lamp to bushfire protection, vol4, no4, pp.346-347, 1984):commented in1984 that it is worthy to investigate the fire protection properties of wire meshes. A bushfire spreads in three modes as discussed hereunder.

#### **EMBER ATTACKS**

Previous studies have identified that embers (burning debris that flies with air) are the predominant cause of spread of a fire. These embers are carried by strong winds ahead of the fire front and it is because of these embers that spot fire begins which in the vicinity of fire fuels such as dry grass turns out to be a major fire.

#### **DIRECT CONTACT**

This mode of fire allows the fire to spread if comes in contact with the fuel such as dry grass directly and constitutes the fire front. The fire front advances further depending on the wind velocity and direction. The application of metal mesh such as lid of a Bunsen burner and Davey Safety Lamp indicated that metal mesh has the potential to prevent direct flame contact. Other researchers have observed that small fires cannot transverse fire meshes with aperture less than 1.8 mm at low speeds.



## RADIATION HEAT FLUX

The heat radiated from the fire is the main cause of casualties. The metal mesh has the ability to reduce RHF (Radiant Heat Flux) if employed between an object and fire. Radiation at bushfire zone has been measured at 80 – 100 kw/m<sup>2</sup> (Australian surveying and land information group), which shows that the metal mesh need to block 90% of RHF ( New Soth Wales Government, 2006) to prevent spread of fire. If we put a single mesh at this RHF, the mesh would lose its strength and if the wind velocity is high the mesh can be torn because of high drag force.

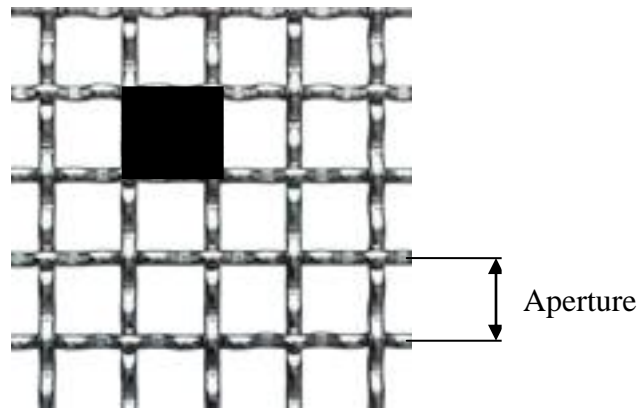
There is a lot of data available for drag force on a single layer of mesh and according to those results the drag force on a single layer of mesh relates only to porosity of mesh and Reynolds number of the flow. Therefore we can reduce this drag force either by increasing wire diameter which is undesirable here as Australian standard AS3959-1999 allows a maximum aperture size of 1.8mm or we can increase the porosity. This means that we need to increase the number of layers. To address the issues mentioned above we can employ two layers of mesh instead of one. If we use two layers of mesh, that would protect the direct contact of the fuel such as dry grass to protrude through two layers of mesh and hence burnt ends of the grass in case of fire would not start a spot fire on the other side of the second layers, provided the area between two layers at the base is clear and does not have any debris. The RHF has been proved to decrease if we use two layers of mesh instead of one in such a way that finer the mesh the more is the radiation blockage we can achieve but an inherent drawback of this is the increased drag force on such a fine mesh especially due to high wind velocity.

### ***1.4 TERMINOLOGY AND DEFINITIONS***

Various terms used in this project work have been explained hereunder.

## MESH

A mesh is a structure used to block some particles mixed in a fluid (eg. Sieve) or to increase or decrease the turbulence of flow, see figure 1.1 (<http://www.bopp.ch>, viewed 15/07/2008). Meshes are available in the market in different sizes and they differ in the methods used to make them, such as performed meshes are made by punching holes in thin sheets of metal welded meshes and woven meshes. For the work presented here, all meshes are of square opening with plain weave.



**Figure 1.1 a typical mesh explained**

## CELL

The smallest structure (in this case is a square) that is replicated in the entire structure of mesh; it is also called an element. This is shown in figure (1.1) with a solid black square.

## APERTURE

The distance between the centers of two consecutive wires (in case of a square opening) of a cell along length or width of the mesh is called Aperture and is measured in mm, see figure (1.1).

### POROSITY OR OPEN AREA

It is defined as the ratio of open area to the total area of mesh. It measured the percentage of area available for a fluid to pass through the mesh and is given by the relation

$$\beta = \left(1 - \frac{d}{L}\right)^2$$

Where L is the aperture and d is the wire diameter both measured in millimeters in this case.

### DRAG FORCE

Drag force is the force experienced by an object as it moves in a fluid (air in this case) or fluid moves over a stationary object and is measured in S. I. Units of Newton's (N). The drag force is given by the following relation (Anthony Esposito, Oxford Ohio)

$$C_D = \frac{P_2 - P_1}{\frac{1}{2} \rho_{air} w_1^2 (1 - \beta)}$$

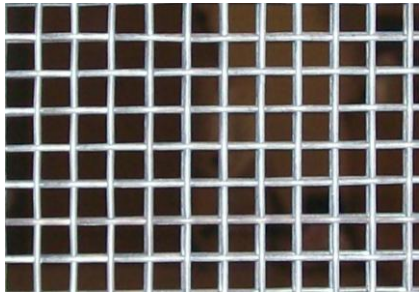
Where  $C_D$  in an experiment determined parameter called the drag coefficient and  $A$  is the frontal area of the body,  $P$  and  $V$  are density and velocity of the fluid (air in this case).

### SPACING

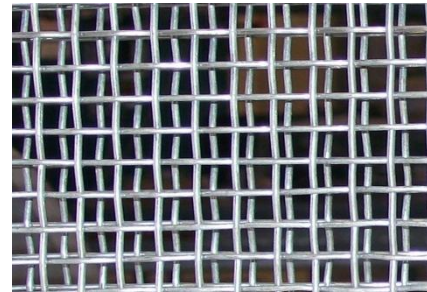
The distance between a wire on first mesh and a wire on the second mesh corresponding to the weaving pattern such that at zero spacing second wire touches the first wire along all the curves in the weaving pattern at all times. The spacing for the work presented here has been varied from zero to 25mm depending until the required results were achieved.

## TANDEM

Two meshes are said to be in tandem when a cell of first mesh is exactly in front of a corresponding cell on the other mesh such that at zero spacing between the two meshes these cells overlay. In general words if look at the mesh in front, we should not be able to see the other mesh behind the first one. Figure 1.2 shows two layers of mesh in tandem while figure 1.3 shows two layers that are not in tandem.



**Figure 2.2 two layers of mesh in tandem**



**Figure 1.3 two layers of mesh not in tandem**

### ***1.5 METHODOLOGY***

A. Sharifian and D. Buttsworth (FOES, University of Southern Queensland, Australia) et.al have used computational simulation to correlate the drag force of a single mesh in terms of its porosity using software package called GAMBIT and FLUENT. They used 2.5 million elements in their work to successfully model a single cell. In the work presented to successfully model all the cells of two layers it would take a lot of computed memory and the computational time would be so large to prove its validity in the work presented. Hence the experiment technique was the option to study the behavior of two layers of mesh in the time allotted.

The experiment technique is based on testing the two layers of mesh in wind tunnel. The other apparatus used is manometer to take the pressure difference, barometer to measure atmospheric pressure and thermometer to measure air temperature. A frame is designed to hold the mesh in

place inside the wind tunnel's testing section as the testing section itself does not have any mechanism to hold mesh.

The raw data is collected using the pressure difference reading and then converted to the desirable form to achieve the results by applying various formulae. The results are programmed using software called MATLAB and variation of the drag coefficient, pressure drop; pressure ration, Reynolds number etc. have been plotted. The final conclusion is based on the output of the programmers.

The present work is based on the experimental results for the effect of spacing between two layers of wire mesh on the drag force as air flows through them. The present work builds upon the work of previous researchers who have done similar work especially the empirical relations obtained by them for flow around cylinders and wires kept in a flow stream are used. The present work would began with a literature review of the related theory involved and the study of instrumentation such as wind tunnel, manometer, digital read out system etc. to assist in taking accurate readings.

The first stage involved designing a fixture to hold wire mesh inside the test section of wind tunnel to ensure minimal effects on the test section after the experiments were finished. The researchers who have done similar experimentation have done so, by putting meshes in the path of air flow without the use of a fixture to hold them inside the wind tunnel. But because of non availability of such an option and the fact that no modifications (cutting test section and putting mesh across) are allowed on the test section, I have decided to hold wire mesh inside the test section using a fixture. Now, this fixture itself provides resistance to the air flow, as a sudden reduction in flow area would occur.

The next stage involved searching for the required mesh available in the market and once these resources were acquired, the experimentation began at the hydraulic lab of USQ (University Of Southern Queensland, Australia) using the apparatus such as wind tunnel, manometer, barometer, thermometer etc.

For the experiments to be accurate, the wire meshes were aligned perpendicular to the direction of air flow with the cells of one mesh aligned with those of other (in tandem), so that at zero separation/spacing the cells superimpose on each other. The meshes were stretched sufficiently to stop them curling when air flows through them, and the care was taken not to distort the cell geometry.

The results were then accumulated to form a mathematical model to determine the minimum drag force that occurs between two layers of mesh at a finite spacing. The results obtained here were reviewed in the light of existing literature and the work of earlier researchers.

## ***1.6 OVERVIEW OF DISSERTATION***

This section of chapter 1 gives a broad idea of what to expect in the subsequent chapters. This report will have the following organization structure:-

**Chapter 1** This chapter introduces the reader to the topic of the project and some reasons of doing this particular project and how they would be done. A potential application of the project would also be discussed.

**Chapter 2** This chapter covers the literature review associated with this project. Various equations would be discussed to assist in the conclusion of the preset work

**Chapter 3** Experimental setup will be explained in this section including various instruments used. A risk assessment would also be detailed.

**Chapter 4** Chapter 4 covers the experimental part, the procedure followed, raw data collected and the general errors associated with the experiments

**Chapter 5** This chapter covers the data conversion into the useful form required for analysis. A detailed error analysis would also be carried out in this chapter.

**Chapter 6** The plot results of different MATLAB programs are described here on individual basis; this would follow discussion of the results obtained.

**Chapter 7** This chapter concludes the outcome of the project and gives few guidelines to follow for future work.

## Chapter 2

### **LITERATURE REVIEW**

#### ***2.1 CHAPTER OVERVIEW***

A mesh can be thought of as resistance that causes the pressure drop as a fluid passes through it and has the ability to change the direction of flow. Meshes in a flow stream act both as turbulence suppressors or turbulence generators (E. M. Laws and J. L. Livesey). As a suppressor (typically fine mesh), they reduce the intensity and scale of turbulence than the upstream value. As a generator (typically coarse meshes), they increase the turbulence (by 10% or higher) than the upstream flow. A screen may be used for both of these modes to remove or create time mean velocity distributions.

#### ***2.2 SCREEN PROPERTIES***

The weaving process used to manufacture wire mesh can cause variation in the dimensions of mesh and presence of contamination such as dirt particles can further distort the uniformity of flow. In present work, the dimensions of the mesh are considered uniform. The drag force on the mesh is due to pressure drop across the mesh as air flows through it. The coefficient of drag (E. M. Laws and J. L. Livesey)  $C_d$  is given by the following equation:-

$$C_d = \frac{P_2 - P_1}{\frac{1}{2} \rho_{air} w_1^2 (1 - \beta)}$$

Where  $P_2 - P_1$  is the pressure drop across wire mesh,  $\rho_{air}$  is the density of air,  $w_1$  is the velocity of air incident on mesh and  $\beta$  is the porosity or percentage open area which is given by



$$\beta = \left(1 - \frac{d}{L}\right)^2$$

Where  $d$  is the diameter of wire and  $L$  is the distance between the centers of two consecutive wires of any single cell/element.

### **2.3 RESISTANCE LOSS COEFFICIENT**

The resistance or pressure loss coefficient  $K_o$ , when air is incident perpendicular to the mesh i.e  $\theta=0$  is a function of Reynolds number 'Re' and porosity ' $\beta$ ' for an incompressible flow (zero Mach number).  $K_o$  decreases with Reynolds number based on wire diameter and incident velocity until  $Re > 250$  after which  $K_o$  is a function of porosity alone. Pinker and Herbert (1967) found the functional relationship between resistance coefficient  $K_o$ , Reynolds number  $Re$  and porosity  $\beta$  is given by

$$K_o = \frac{A_1 (Re)(1-\beta_2)}{(\beta_2)}$$

where  $A_1$  is a constant number whose value can be found from figure 2 (E. M. Laws and J. L. Livesey). At higher Mach numbers the resistance coefficient increases at a rate dependent on porosity until choking occurs.

A rippled screen gives high irregularities in the variations in local transverse velocity which could be quite different from the analytical results.

## **2.4 FLOW THROUGH MULTIPLE MESHES**

Davis (1957) and Elder (1959) have considered flow through two shaped gauge meshes that cause interference (though no experimental comparisons were included), and have shown that two aerodynamically interfering meshes cannot completely remove the upstream velocity variation and will not produce uniformity unless the meshes are positioned sufficiently far apart. For a single gauge mesh, a uniform profile is produced irrespective of the profile upstream if

$$K = \frac{(2 - B)}{(1 - B)}$$

Where K is the resistance coefficient and B is deflection coefficient. However, in case of two overlaid meshes with  $K_1$ ;  $B_1$  and  $K_2$ ;  $B_2$  respectively a individual resistance and deflection coefficients, the relation becomes

$$2(K_1 + K_2) = 1 + \frac{1}{(1 - B_1)(1 - B_2)}$$

Any two meshes satisfying the above equation would produce uniform velocity profile at zero separation. In some circumstances, it is possible to have combined resistance coefficient lower than either of the individual meshes, but would always incur a higher pressure loss than the single gauge mesh. The velocity distribution will decay further from the mesh as the shears within the profile establish a turbulence that interacts with the mean or average flow.

## **2.5 FLOW INSTABILITY**

Baines and Parson (1951) observed that flow instability occurs because of local minute variations in wire diameter owing to contamination and spacing between the wires in a mesh which

produces significant local variation in velocity and pressure. The jet flow through different cells could diverge or converge especially if the porosity  $\beta < 0.5$  that is 50% open area. Bradshaw (1964) suggested the use of multiple meshes to regain the pressure lost by flow through a single mesh. Cowdrey (1968) further supported the argument that in certain cases the instability could be eliminated by displacing certain rods a small distance downstream the flow.

## **2.6 BOUNDARY LAYER DEPENDENCY**

The drag force on the mesh cannot be calculated properly if boundary layer around the wires is ignored. The thickness of the boundary layer around a cylinder depends on Reynolds Number and can be calculated from the following equation (White. F. M, 1974):-

$$\delta \sqrt{\frac{B}{\nu}} = 2.75$$

Where  $\delta$  is the thickness of the velocity boundary layer,  $\nu$  is the kinematic viscosity of air and  $B$  is the stagnation point velocity gradient which can be estimated by the following equation

$$B = 4 \times \frac{V_{\infty}}{d}$$

Where  $d$  is the wire (Cylinder) and  $V_{\infty}$  is the far field velocity of the fluid (air in this case). These two equations can be combined together to obtain the following expression

$$\frac{\delta}{d} = 1.375 \text{ Re}^{-0.5}$$

This indicates that the thickness of the velocity boundary layer decreases with increasing Reynolds number.

## **2.7 COMPUTATIONAL ANALYSIS FOR A SINGLE MESH.**

Some work has been done to analyse wind force on a single mesh by A. Sharifian and D. Buttsworth and they have found the following relation between coefficient of drag ( $C_{dc}$ ), Reynolds number ( $Re$ ) and the porosity of the mesh ( $p$ )

$$C_{dc} = -0.491 + \frac{0.47}{p^{1.773}} - \frac{7.49}{Re^{0.661}} + \frac{6.475}{p^{2.244} Re^{0.661}}$$

for the range  $10 \leq Re \leq 1000$  and  $0.27 \leq p \leq 1000$ . The error associated with the above equation is 6.5%.

Their work suggests that  $C_d$  is largest at low Reynolds number and sharply decreases as the Reynolds number increases. But at higher Reynolds number (around 200) the change of  $C_d$  with Reynolds number is relatively small and reaches an almost constant value at Reynolds number further up the range.

## **2.8 CHAPTER SUMMARY**

This chapter describes the Literature involved in this project work. It covers the information that is currently available to compare the results with. Screen properties, flow through multiple screens and a computational work is also presented in this section.

## Chapter 3

### **EXPERIMENTAL SETUP AND RISK ASSESSMENT**

#### ***3.1 CHAPTER OVERVIEW***

This chapter details the instruments and the equipment used for the experiments which include wind tunnel, manometer, barometer, thermometer etc. Each of these instruments used have an error associated with them which would be discussed in the latter chapters. While performing these experiments all the safety measures were taken care of and this chapter also discusses the risk assessment undertaken for these experiments.

#### ***3.2 INSTRUMENTS AND EQUIPMENTS***

The experimental technique is selected to achieve the aim of this project; the basic purpose of the experimental setup is to hold mesh in place in wind tunnel's testing section to take the pressure drop readings at different points of interest. This section describes the equipments, instruments and apparatus used.

##### ***3.2.1 WOVEN WIRE MESH***

Meshes come in different materials and are made using different techniques such as perforated meshes (by punching holes in a thin sheet of metal), welded meshes (rods of small diameter welded together) and wire mesh (weaved from wires), see figure 3.1 of a typical mesh. These meshes have different shapes of the openings. For this project woven wire meshes of square opening and made of different materials such as stainless steel, mild steel, galvanized steel, etc. (depending on the availability from the manufacturer) have been used. Meshes used are:



**Figure 3.1 A typical mesh**

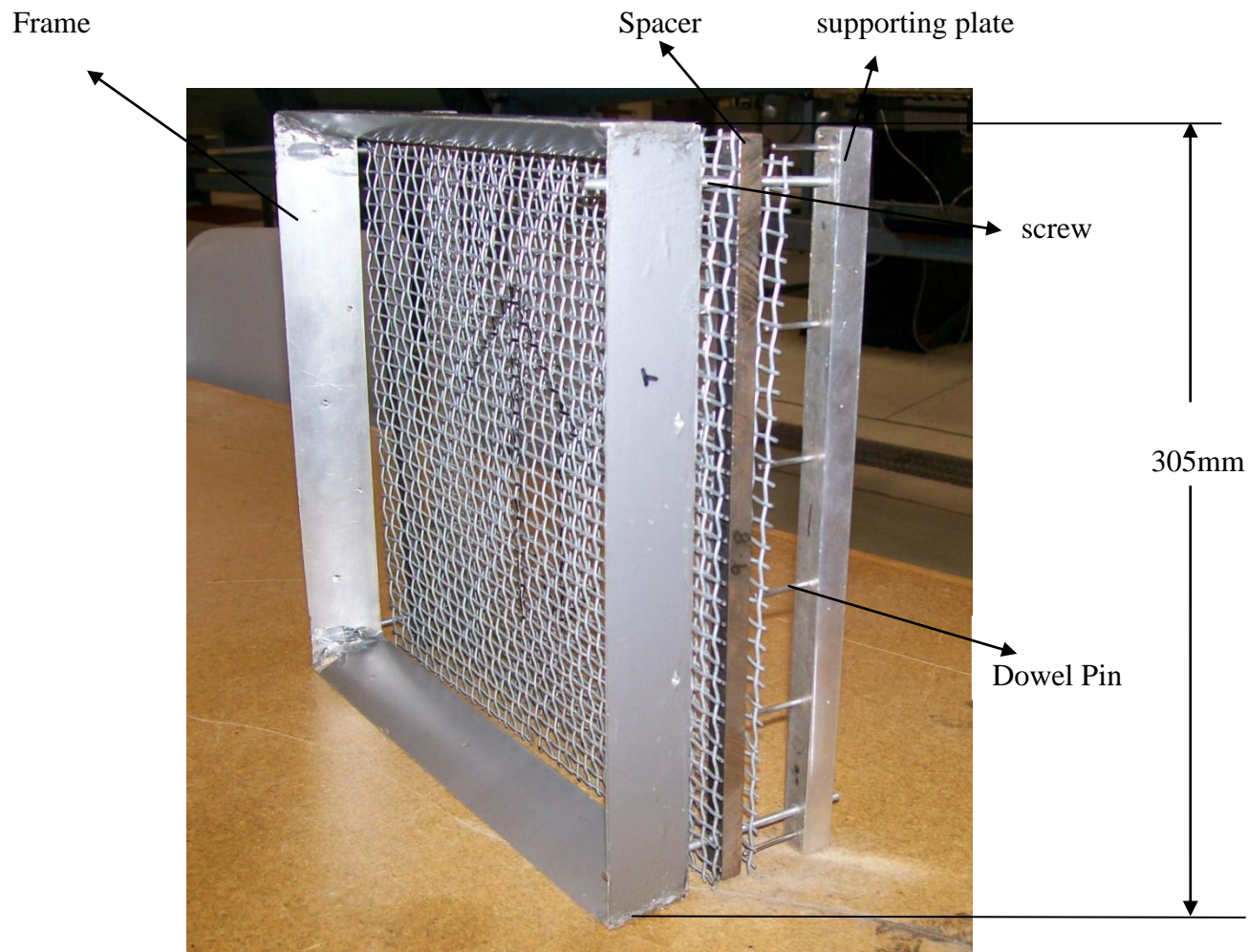
- 1) Wire diameter 0.45mm and open area 34%
- 2) Wire diameter 0.44mm and open area 47%
- 3) Wire diameter 0.56mm and open area 67%
- 4) Wire diameter 1.18mm and open area 61%
- 5) Wire diameter 1.60mm and open area 67%
- 6) Wire diameter 1.60mm and open area 57%
- 7) Wire diameter 1.60mm and open area 77%

The Cost of these meshes varies from \$ 11 to \$ 91 per linear meter of length which is normally 1200mm wide.

### 3.2.2 FRAME

The wind tunnel's testing section itself does not have a facility to hold mesh in place hence a piece of equipment which has been termed as frame in this project was required to hold mesh in place inside the testing section of wind tunnel. A frame Figure 3.2a made of aluminium has been designed for this purpose. The material specified is aluminium because of its light weight to reduce wear and tear on the testing section.

The outside dimensions of the frame are  $305 \times 305 \text{mm}^2$  to have a slide fit inside the testing section so that leakage of air can be blocked. Each wall of the frame is 40mm wide and 15mm thick. A radius of curvature of 85mm is provided on all sides at the inlet as shown in Figure 3.2a to reduce the turbulence at the inlet to reduce error in the measurement of readings. Dowel pins are mounted on the supporting plates Figure 3.2c that go into the corresponding holes at the back of the frame to clamp the meshes in place using long screws of M4(metric screw of diameter 4mm). The gap/space between the meshes was varied using spacers Figure 3.2b of different thickness varying from 0.5mm to 10mm. The frame and mesh assembly was put into place and clamped from the sides of the testing section using two screws on either side of the frame (see Figure 3.5a for assembly).



**Figure 3.2a** Frame used for holding the mesh



**Figure 3.2b** Spacers





**Figure 3.2c Supporting plate with dowels pins attached**

### 3.2.3 WIND TUNNEL

The most important piece of equipment used is the wind tunnel. Wind tunnels have been used all over the world to test aerodynamic properties of the vehicles, to study flow pattern across different shapes of objects. The wind tunnel used for these experiments Figure 3.3a is an open circuit subsonic wind tunnel at the facility of University of Southern Queensland, Australia. The air in the wind tunnel is sucked in through a honey comb structure followed by a fine wire mesh to even the flow profile. The suction is caused by a cent-axial type blower mounted at the opposite end.

For this wind tunnel the velocity profile is flat over more than 95% of the testing section Figure 3.3c which is made of high quality laminated fiber glass to have the visibility and the inside cross-section of the testing area is  $305 \times 305 \text{mm}^2$ . The turbulence within the test section is less than 0.25%. Speed control is accomplished by a simple by-pass arrangement Figure 3.3b by rotating a screw that bleeds the vacuum created by the blower and permits continuous velocity variation down to  $\frac{1}{4}$  of the maximum (Engineering Laboratory Design, Minneapolis, Minnesota, 55427). Convenient access to the interior of the testing section is provided through a lid at the top of the section.



**Figure 3.3a** open circuit subsonic wind tunnel

Screw to expand the spacing



**Figure 3.3b** By-pass arrangement

Lid of testing section for easy access

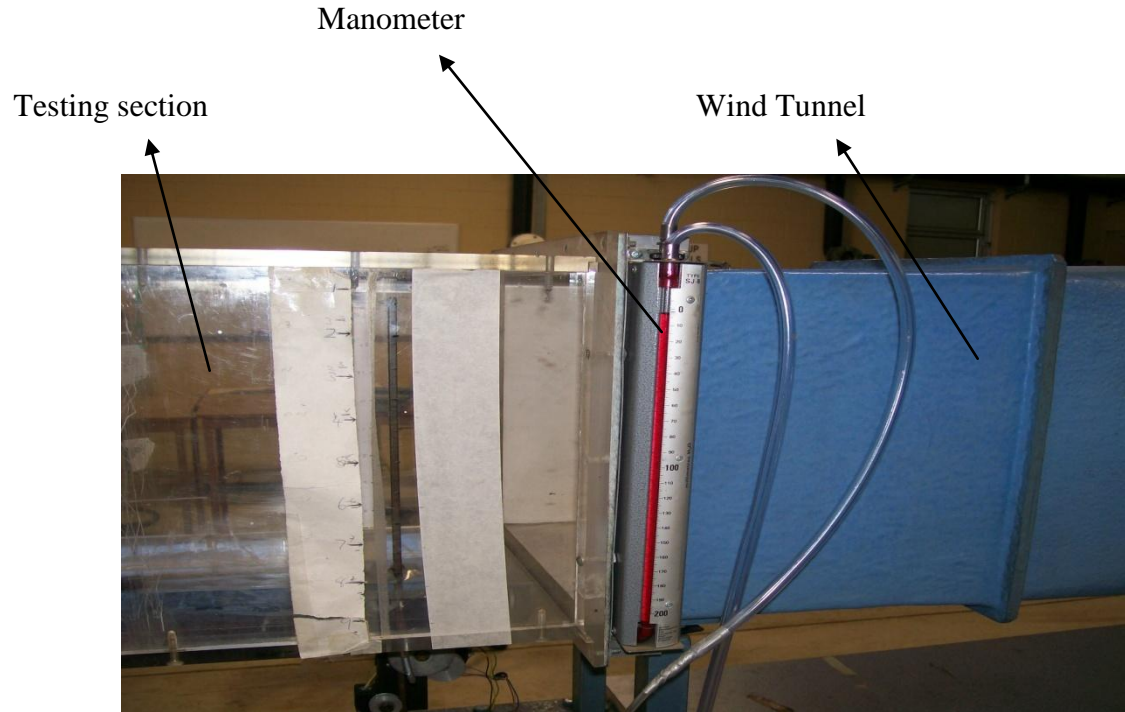


**Figure 3.3c** Testing section of wind tunnel

### 3.2.4 MANOMETER

The manometer is a device used to measure pressure difference between two points using static fluid properties. The manometer Figure 3.4 used for these experiments is a type SJ8 (Manufactured by Airflow Developments Ltd. England) U-tube filled with a gage fluid called Narrow cut petroleum distillate (Fluxelf'S'). A scale is attached to the manometer which is calibrated to read off the distance between the fluid levels on two sides of the U-tube as millimeters of water instead of the real gage fluid. Both the open ends of manometer have been connected to rubber tubes that can be connected subsequently to two points to measure the pressure difference between them. The high pressure side would push the level of fluid down and vice-versa, and the difference in the levels 'h' could be read from the scale. The pressure 'P' can then be calculated using the relation,  $P = \gamma_{\text{water}} \times g \times h$ , where  $\gamma_{\text{water}}$  is the specific weight of water in units of  $\text{N/m}^3$  and h is measured in millimeters. A manometer can measure suction pressures and larger pressures than a piezometer.

The manometer is mounted on the testing section of the wind tunnel. The relative density of the fluid is 0.784 at 20°C. The connections to the manometer were broken many times to have pressure readings at the required points, but a due care was taken to ensure that the wind tunnel is not operating while these connections were made as that would cause the fluid to be blown out of the manometer or sucked into the wind tunnel.



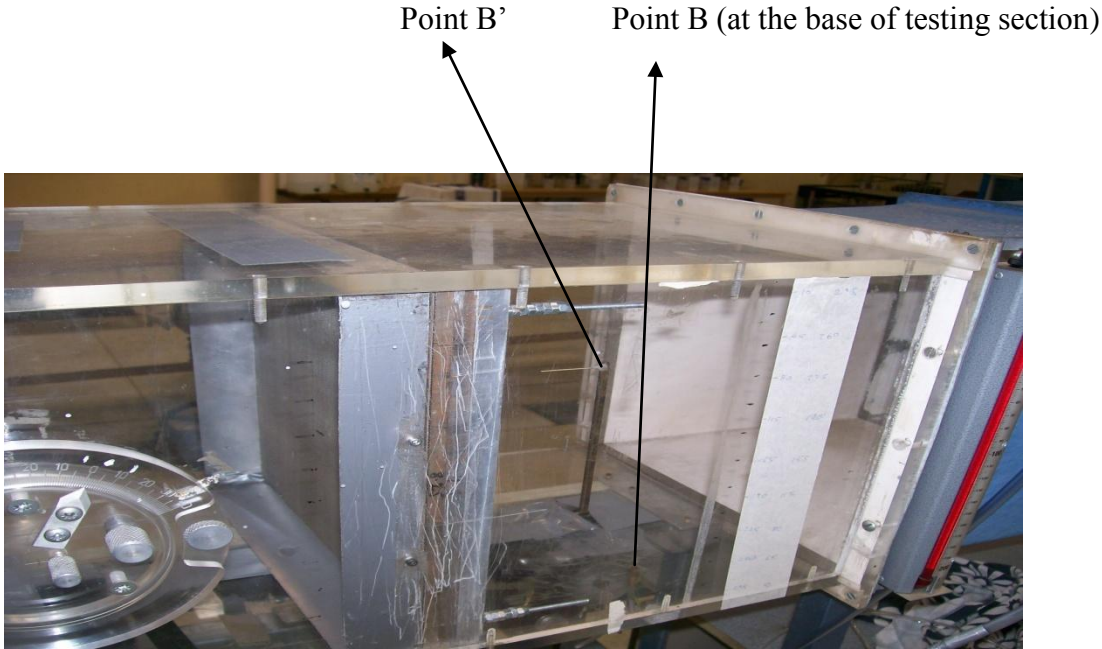
**Figure 3.4 Manometer attached to the testing section of the wind tunnel**

The manometer shown in Figure 3.4 (only one side of the U-tube is visible) has a least count of 1mm on the scale that has a range of 0mm to 200mm. This manometer has an error of 3mm in the readings because an amount of fluid equivalent to 3mm height of the manometer has already been lost because of previous experiments. This error has been taken into consideration by subtracting 3mm from each of the readings obtained.

### 3.2.5 PITOT TUBE

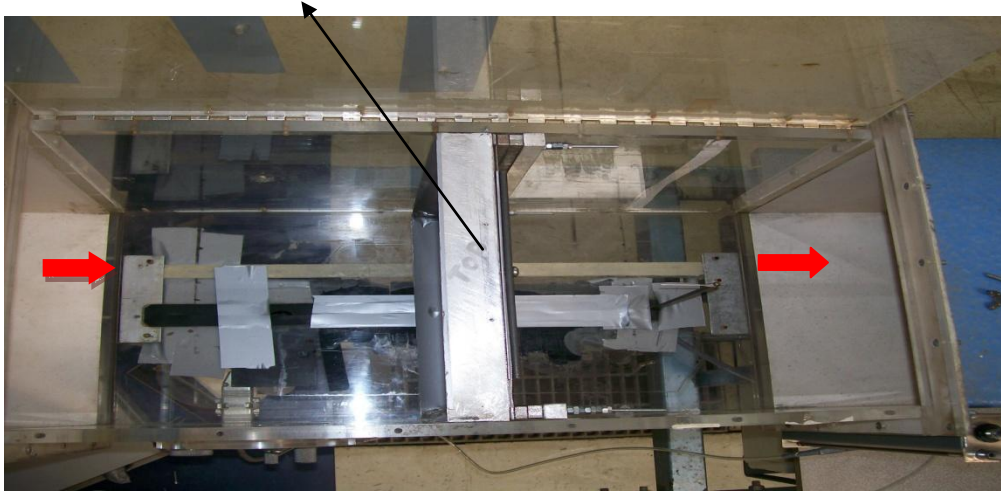
Pitot tube is a velocity measuring device by using Bernoulli's equation 5.19 (Anthony Esposito, pp.219) between a static point B at the base of test section and a point B' in the air stream. The Pitot tube figure 3.5a and 3.5b is of inverted L-shape with a small opening that protrudes through the testing section and makes a right angle turn to face the air flow. In figure

3.5a and 3.5b the air flows from left to right shown by arrows in figure 3.5b and enters through this small opening and stagnates. The Pitot tube is connected to one end of the manometer and a tube connects the static point to the other end of the manometer. Since the pitot tube stagnates the fluid, it senses a higher pressure and thus registers a larger head than does the tube connecting static point with the manometer. This difference in these two heads is labeled as  $(h_{B'}-h_B)$ . By applying Bernoulli's equation between these two points we can obtain the velocity of the fluid  $V_{air}$  (which is air in this case) using the



**Figure 3.5a Front view of the installation of Pitot tube into the testing section.**

Mesh frame assembly



**Figure 3.5b** Top view of the installation of Pitot tube into the testing section.

following relation.

$$V_{air} = \sqrt{\frac{(h_{B'} - h_B) \times \gamma_{water} \times 2 \times 10^{-3}}{\rho_{air}}}$$

Where  $\gamma_{water}$  is the specific weight of water in units of  $N/m^3$ , velocity of air  $V_{air}$  is measured in units of  $m/s$  and  $(h_{B'} - h_B)$  is measured in millimeters. The volume flow rate of air can also be obtained using the relation  $Q = V_{air} \times A$ , where  $Q$  is the flow rate and  $A$  is the area of the testing section. Another application of the Pitot - static tube is to measure the velocity of an airplane with respect to the surrounding air, in which case the Pitot-static tube is mounted straight on the wings of the airplane.

### 3.2.6 OTHER INSTRUMENTS

Some other instruments such barometer to measure the atmospheric pressure in units of kpa and thermometer to measure the air temperature before every experiment. Vernier callipers and

profile projector were also used to measure the cell size accurately.

### 3.3 RISK ASSESSMENT

Risk assessment is a two stage process that involves assessment of the risk both before as well as after the project is finished. These stages for the present work are discussed hereunder:

#### 3.3.1 RISK DURING THE EXECUTION OF PRESENT WORK

**Hazard:** Excessive noise when wind tunnel is running (>90 dB).

**Parts of body at risk:** Hearing ability.

**Exposure:** Frequently (during the period of experimentation).

**Risk level:** Low (exposure time is less).

**People at risk:** All, working in the lab at the time when wind tunnel is running.

**Control:** With the use of ear muffs/plugs (a personal protective equipment), the risk could be avoided.

**Hazard:** Frame, nuts, mesh etc. can fall on feet.

**Parts of body at risk:** Feet.

**Exposure:** Rare.

**Risk level:** Low.

**People at risk:** self.

**Control:** Wearing enclosed shoes/steel cap shoes would eliminate the risk.

**Hazard:** Lid not closed properly before turning wind mill on.

**Parts of body at risk:** Fingers (pinch point).

**Exposure:** very rare (during the period of experimentation).

**Risk level:** moderate.

**People at risk:** Self.

**Control:** Care must be taken to ensure that the lid of the test section is closed properly before switching on the wind tunnel.

**Hazard:** Sharp edges of the mesh.

**Parts of body at risk:** Hands.

**Exposure:** Frequently (during the period of experimentation).

**Risk level:** Low (exposure time is less).

**People at risk:** Person working with the mesh (myself in this case).

**Control:** With the use of tough work gloves the risk could be avoided.

**Hazard:** Any part left loose in the wind tunnel.

**Equipment at risk:** suction unit of wind tunnel and velocity probe.

**Exposure:** Very rare.

**Risk level:** moderate (equipment damage)

**People at risk:** None.

**Control:** Ensuring that no loose items are left in the test area before closing the lid.

### 3.3.2 RISK AFTER THE EXECUTION OF PRESENT WORK

**Hazard:** Holes left in the test section left unplugged after the experimentation is finished.

**Equipment at risk:** Test section of the wind tunnel.

**Consequences:** Improper experimental readings for the following researchers.

**Control:** Holes drilled in the test section to put frame inside the test section must be plugged back to prevent the leakage of suction and thus to maintain the accuracy of work



that follows.

The fixture and the wire meshes could further be used by other researchers for similar experiments as required hence need not be discarded.

### ***3.4 CHAPTER SUMMARY***

The experimental setup is discussed in this chapter including different equipments and instruments used to carry out the experiments such as wind tunnel, manometer, pitot tube etc. A risk assessment is also carried out in this chapter, identifying the hazards and measures to control them are also detailed.

## Chapter 4

### **EXPERIMENTS**

#### ***4.1 CHAPTER OVERVIEW***

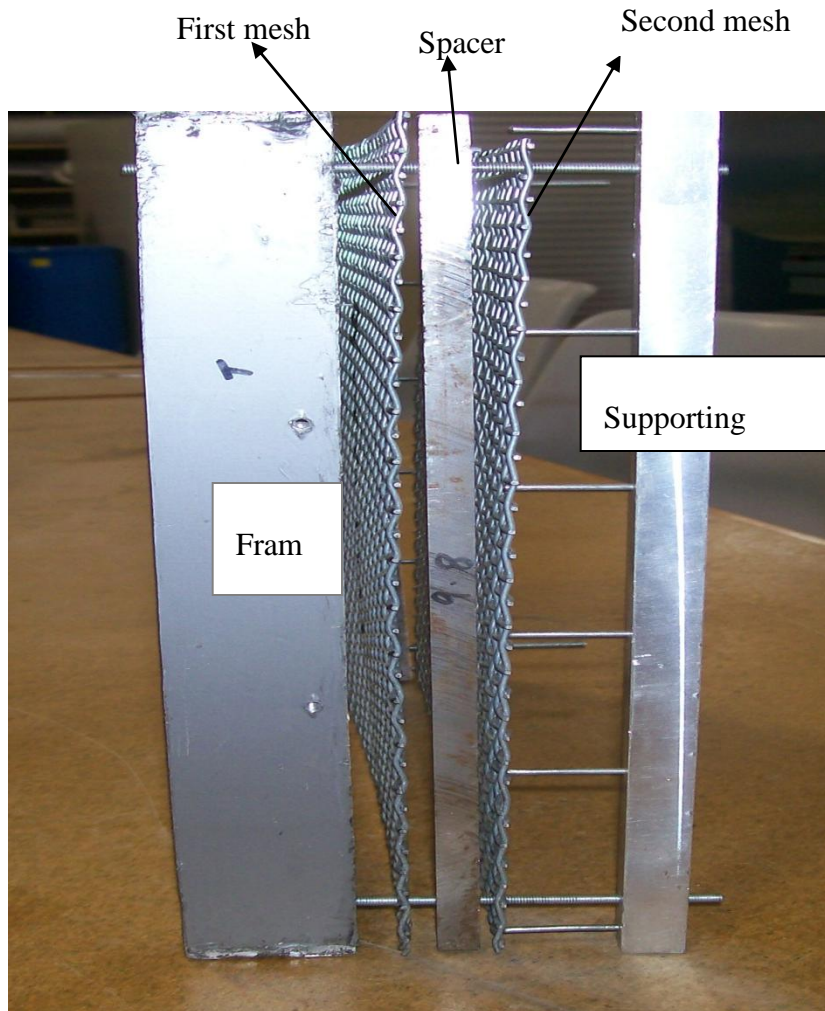
This section of the present work explains how the experiments are conducted starting from mounting the setup into the wind tunnel to data gathering. Various sources of error that could alter the outcome have also been outlined. This section deals only with data gathering and further analysis is carried out in the subsequent chapters. A typical example of the data is given in this section to assist the reader in understanding as to how the readings are taken, however the conversion of the raw data to the useful information is covered in the following chapter.

#### ***4.2 EXPERIMENTAL PROCEDURE***

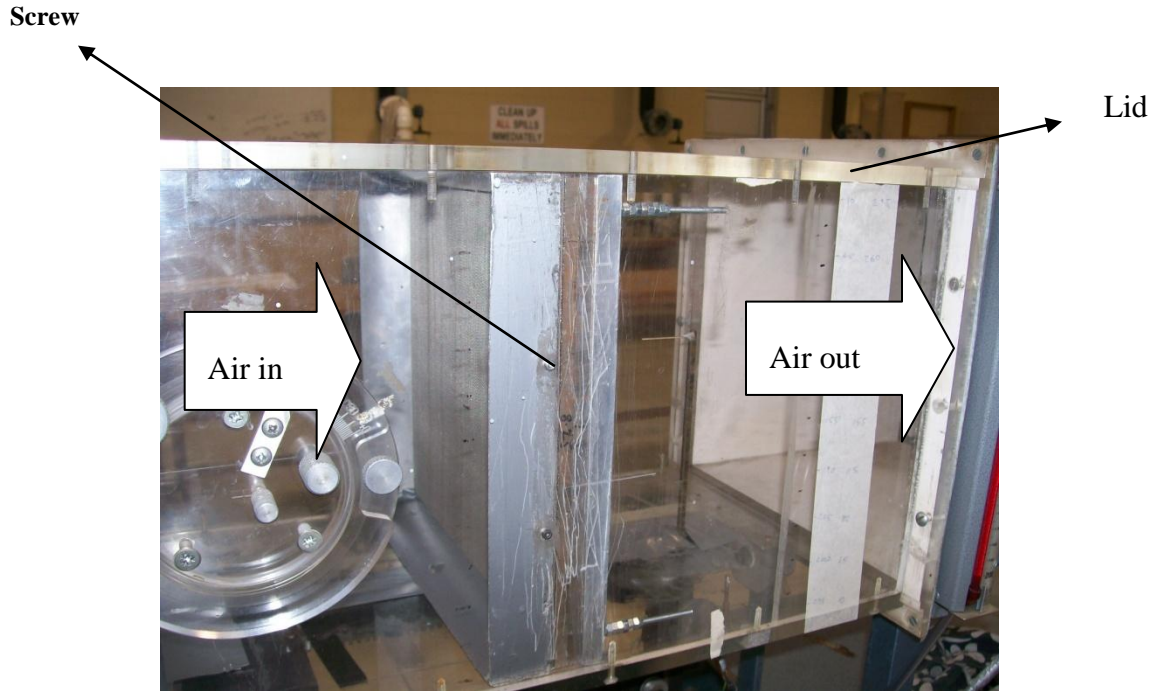
Mounting the mesh inside the wind tunnel has proved to be the main task as the accuracy of the results depends on it. A frame is designed as explained in chapter 3 figure 3.2a to hold the mesh in place inside the wind tunnel along with spacers to vary the gap between the meshes and supporting plates with dowels fitted to properly align and evenly stretch the mesh. A hole at the base of the testing section after the mesh and frame assembly point is drilled to calculate the velocity of air exiting the mesh. Following is a step by step procedure followed to perform the experiments, see figure 3.2a, 4.2a and 4.2b.

- First layer of mesh is first mounted on the frame followed by a spacer of certain known thickness, see figure 4.2a.

- The second layer of mesh is then mounted and these two layers including spacer are clamped into position using M4 (metric thread, 4mm diameter) threaded rods. While clamping due care is given to ensure the meshes are in tandem.



**Figure 4.2a mounting mesh on the frame**



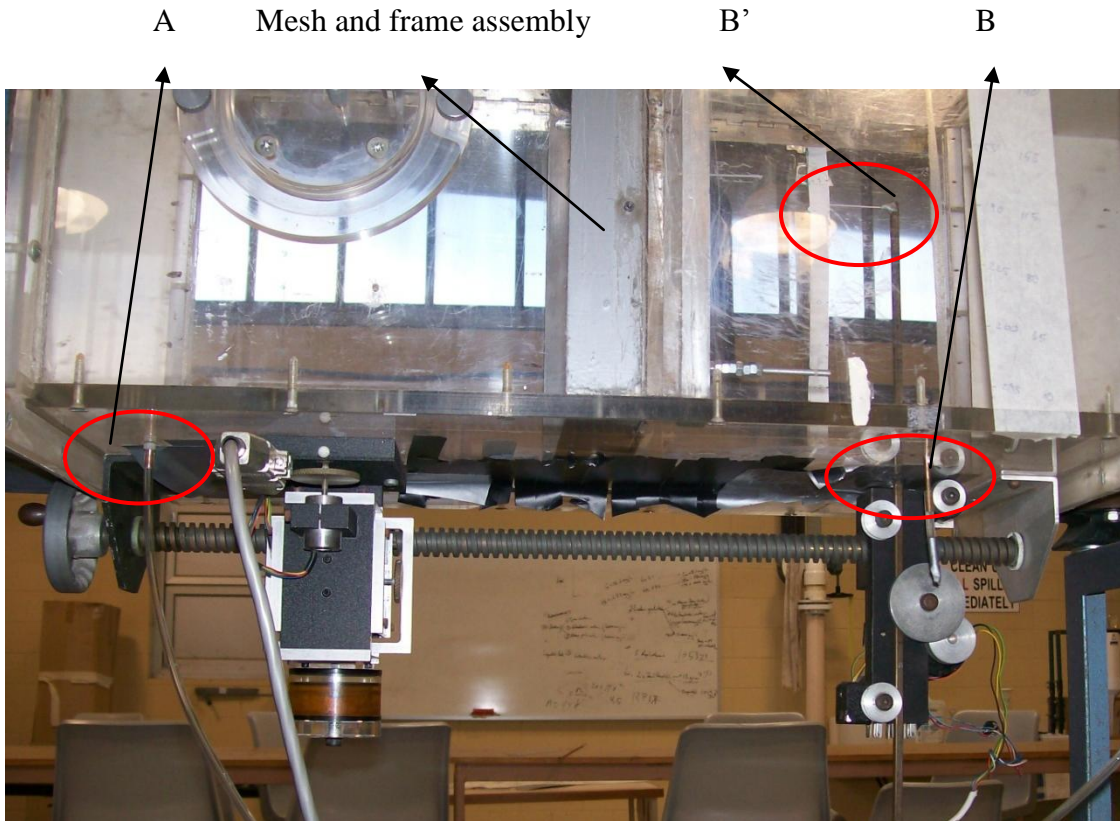
**Figure 4.2b frame assembly mounted into wind tunnel's testing section**

- The assembly is then mounted into the testing section and clamped in place to the walls of the testing section by using M3 screws, see figure 4.2b.
- The lid is closed after ensuring that the Pitot tube lies parallel to the base of the testing section as that would ensure that Pitot tube is parallel to the flow stream and hence would give accurate readings, failure to do so would spoil the accuracy of the results.
- The atmospheric pressure and temperature of air at the testing facility is measured using thermometer and barometer respectively to calculate the density of air that is used to calculate the velocity of the air exiting the mesh and frame assembly.
- The pressure drop due to mesh and frame assembly is measured first as the difference between the static pressure before (point A) and after (point B) the assembly.

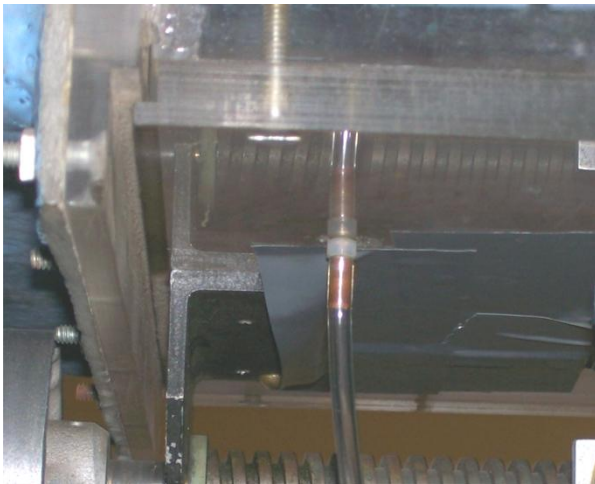
- The pressure drop due to frame alone is measured once and for all experiments over a range of Reynolds number. Hence the pressure drop because of mesh only is calculated as the difference between this step and the step above
- The pressure drop due to frame alone is measured once and for all experiments over a range of Reynolds number. Hence the pressure drop because of mesh only is calculated as the difference between this step and the step above.
- The new hole drilled at the base of the testing section is used to calculate the difference between the static (point B) and stagnation (point B') pressures once the air exits after the assembly point. This pressure difference ( $B' - B$ ) is used to calculate the velocity of air after the mesh and frame assembly.
- The Reynolds number is then varied by rotating a screw to widen the opening as that would decrease the velocity of air inside the testing section and hence the Reynolds number by sucking some air through the opening, see figure 3.3b for bypass arrangement.
- The wind tunnel is turned off after reading to normalize the level of fluid inside the manometer and before making or breaking the manometer connections as otherwise the fluid could bleed into the testing section or outside the manometer depending upon the pressure difference.
- The frame is taken out after the required number of readings is collected to change mesh spacing.
- The process shown above is followed throughout the present work for all the meshes considered while noting that the liquid in the manometer under no use condition is at a level of 3mm and is never zero. This error has been taken into account while taking all the readings.

### ***4.3 DATA COLLECTED***

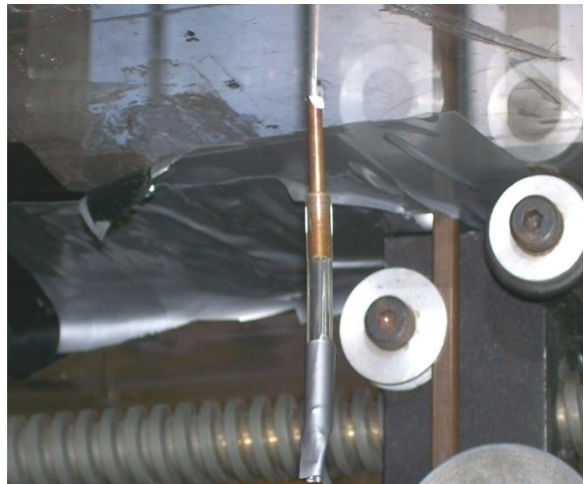
By following the procedure described above the data for all the meshes is collected and tabulated. The points between which the readings have been taken are shown in figure 4.3a and are detailed in figures 4.3b and 4.3c.



**Figure 4.3a shows various points used for the experiments**



**Figure 4.3b shows point A before mesh assembly**



**Figure 4.3c shows point B after mesh assembly**

**Point A** lies at the base of the testing section before the mesh and frame assembly, see figure 4.3a for general location and figure 4.3b for point A only. Point A is attached to the manometer through a transparent tube as can be seen from figure 4.3b and acts as a static point.

**Point B** lies at the base of the testing section as well but after the mesh and frame assembly, see figure 4.3a and 4.3c. Point B also acts as a static point and attached to the manometer using another tube.

**Point B'** is a stagnation point and lies in the middle of the testing section and lies in the top of the Pitot tube where the fluid stagnates after entering the pitot tube, see figure 4.3a. This point assists in getting the velocity of air exiting the mesh and frame assembly.

Following is an example of the data collected from these experiments for a wire mesh of wire diameter 1.6 mm and an open area of 67% is tabulated in table 4.1. The table shows the pressure differences between different points and the corresponding velocity calculated for each reading for a single mesh as well as for two layers of mesh at different spacing that varies from zero to 21mm for the case presented.

Table 4.1 shows the data collected for woven wire mesh of wire diameter 1.6mm and an open area of 67%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_2 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$h_{B'} - h_B$ (mm)	$V_{air}$ (m/s)	$h_{B'} - h_A$ (mm)
<i>For single mesh</i>					
42.5	12.0	32.5	54.0	30.33	10.5
36.0	9.5	28.5	45.0	27.69	9.0
23.5	6.0	18.5	29.0	22.23	5.0
16.0	4.0	12.5	19.5	18.23	3.5
11.5	3.0	9.0	14.0	15.45	2.5
8.0	2.0	6.0	10.0	13.05	2.0
6.0	1.5	4.5	7.5	11.31	1.0
5.0	1.0	4.0	6.0	10.11	1.0
3.0	0.5	2.5	3.5	7.72	0.5
2.0	0.5	1.5	2.5	6.53	0.5
<i>For zero spacing</i>					
58.5	12.0	48.5	50.0	29.19	9.0
50.5	9.5	43.0	43.0	27.07	7.5
33.5	6.0	28.5	29.0	22.23	5.0
23.0	4.0	19.5	19.5	18.23	4.0
16.0	3.0	13.5	13.0	14.88	3.0
11.5	2.0	9.5	9.5	12.72	2.5
9.0	1.5	7.5	7.0	10.92	2.0
7.0	1.0	6.0	5.5	9.68	1.5
4.0	0.5	3.5	3.5	7.72	1.0
3.0	0.5	2.5	2.5	6.53	0.5
<i>For 5mm spacing</i>					
60.5	12.0	50.5	49.0	28.90	11.5



**Table 4.1** continued

52.0	9.5	44.5	42.5	26.91	10.0
35.0	6.0	30.0	28.0	21.84	7.0
23.5	4.0	20.0	19.0	17.99	5.0
16.5	3.0	14.0	13.0	14.88	4.0
12.0	2.0	10.0	9.5	12.72	3.0
9.0	1.5	7.5	7.0	10.92	2.0
7.0	1.0	6.0	5.5	9.68	2.0
4.0	0.5	3.5	3.0	7.15	1.0
3.0	0.5	2.5	2.5	6.53	1.0
<i>For 8mm spacing</i>					
60.0	12.0	50.0	48.5	28.75	11.5
52.0	9.5	44.5	42.5	26.91	10.0
35.0	6.0	30.0	28.5	22.04	6.5
24.0	4.0	20.5	19.5	18.23	4.5
16.5	3.0	14.0	13.5	15.17	3.5
12.0	2.0	10.0	9.5	12.72	2.5
9.0	1.5	7.5	7.0	10.92	2.0
7.0	1.0	6.0	5.5	9.68	2.0
4.0	0.5	3.5	3.0	7.15	1.0
3.0	0.5	2.5	2.0	5.84	1.0
<i>For 12mm spacing</i>					
59.0	12.0	49.0	45.0	27.69	7.5
51.5	9.5	44.0	39.5	25.94	6.5
34.5	6.0	29.5	26.5	21.25	4.5
23.5	4.0	20.0	18.0	17.51	3.0
16.0	3.0	13.5	12.5	14.59	2.0
11.5	2.0	9.5	9.0	12.38	1.5
8.5	1.5	7.0	6.5	10.52	1.5

**Table 4.1** continued

7.0	1.0	6.0	5.0	9.23	1.0
4.0	0.5	3.5	3.0	7.15	0.5
3.0	0.5	2.5	2.0	5.84	0.5
<i>For 15mm spacing</i>					
59.5	12.0	49.5	46.0	28.00	14.0
52.5	9.5	45.0	40.0	26.11	12.5
35.0	6.0	30.0	27.0	21.45	8.5
24.0	4.0	20.5	18.0	17.51	6.0
16.5	3.0	14.0	12.5	14.59	4.5
12.0	2.0	10.0	9.0	12.38	3.0
9.0	1.5	7.5	6.5	10.52	2.5
7.0	1.0	6.0	5.0	9.23	2.0
4.0	0.5	3.5	3.0	7.15	1.0
3.0	0.5	2.5	2.0	5.84	1.0
<i>For 18mm spacing</i>					
59.0	12.0	49.0	44.0	27.38	15.0
52.0	9.5	44.5	39.0	25.78	13.0
35.0	6.0	30.0	26.0	21.05	9.0
23.5	4.0	20.0	18.0	17.51	6.0
16.5	3.0	14.0	12.5	14.59	4.5
12.0	2.0	10.0	9.0	12.38	3.0
9.0	1.5	7.5	6.5	10.52	2.5
7.0	1.0	6.0	5.0	9.23	2.0
4.0	0.5	3.5	3.0	7.15	1.0
3.0	0.5	2.5	2.0	5.84	1.0
<i>For 21mm spacing</i>					
58.5	12.0	48.5	44.0	27.38	15.0
51.5	9.5	44.5	39.0	25.78	13.0

**Table 4.1** continued

34.5	6.0	29.5	26.0	21.05	8.5
23.5	4.0	20.0	17.5	17.27	6.0
16.5	3.0	14.0	12.0	14.30	4.0
11.5	2.0	9.5	9.0	12.38	3.0
9.0	1.5	7.5	6.5	10.52	2.5
7.0	1.0	6.0	5.0	9.23	2.0
4.0	0.5	3.5	3.0	7.15	1.0
3.0	0.5	2.5	2.0	5.84	1.0

The pattern shown above is followed for all the meshes involved in the present work. The table shows the only the raw data that needed further treatment to get the desired output which is presented in the next section. Rest of the data along with few corrections is presented in appendix A.

#### ***4.4 GENERAL SOURCES OF ERROR***

There are some general sources of error associated with these experiments that have the potential to alter the outcome excluding errors associated with the measurements of data which would be discussed in the next chapter. These sources are discussed hereunder

##### **PITOT TUBE NOT PARALLEL TO THE BASE**

The measuring knob (a pipe of very small diameter) of the Pitot tube shown in figure 3.5a should be aligned parallel to the base of the testing section as it stagnates the air that enters and registers a pressure reading when attached with the manometer. If it is kept at an angle to the base then the flow streamlines would not impinge straight onto the Pitot tube and a different pressure reading would be obtained. So care should be taken while installing the frame and

mesh assembly into the testing section and the measuring knob must be aligned in case it is not, before closing the lid of testing section.

### LOOSE TUBE FITTINGS

The pipes connecting points A, B, B' are connected to the manometer though the pipes are the connections are made and broken quite frequently. While doing so care must be taken to switch off the wind tunnel as the fluid inside the manometer may come out or sucked into the testing section depending on the pressure difference. Moreover the pipes should fit over the manometer tightly as failure to do would bleed the valuable and the readings would not be accurate.

### CURL IN THE MESH

A curl in the mesh especially during the experiments is likely to appear if the layers of mesh were not held stretched and clamped together tightly while mounting on to the frame. This would disturb the meshes in tandem of the meshes and the spacing between the meshes. Thus the readings obtained would not be accurate and the outcome of the present would deviate.

### MESHES NOT IN TANDEM

The present work is based on the meshes in tandem see figure 1.2 and 1.3 for chapter 1. Meshes can lose their in tandem alignment while mounting on to the frame, so care must be taken while clamping.

#### ***4.5 CHAPTER SUMMARY***

This chapters covers the experimental procedure followed through the experiments and the raw data collected is explained with the help of figures to help reader understand the points between which the reading are taken. General sources of error are discussed in this chapter as well.

## Chapter 5

# **DATA CONVERSION AND ERROR ANALYSIS**

### ***5.1 CHAPTER OVERVIEW***

This chapter discusses how the data obtained from the experiments is further processed to get to the form required for the analysis using several equations and formulae. Since all the measuring instruments can measure to a certain degree of accuracy hence various errors involved in the measurement of the experimental data are also detailed in the form of percentage errors. The least count of a device is the smallest division on its measuring scale that an instrument can measure. A typical processed data is also shown in this section, also see Appendix A for other processed data and Appendix C for MATLAB scripts.

### ***5.2 DATA PROCESSING***

Raw data collected from the experiments as discussed in chapter 4, table 4.1 needs further work to convert it into more useful information to reach a conclusion. We need coefficient of drag  $C_d$  from these experiments as to see how that varies with porosity of meshes and with the spacing between the meshes and to get  $C_d$  we need velocity which is obtained using some equations and is shown in table 4.1 and 5.1 as  $V_{\text{air}}$  measured in units of m/s. We also need Reynolds number (Re) to see how  $C_d$  varies with it, which in turn is calculated from velocity. Since the pressure drop due to assembly and mesh alone occur at different Reynolds number they cannot be subtracted to get  $\Delta h$  straightaway as shown in table 4.1 and thus  $\Delta h_{\text{CR}}$  (corrected) is calculated using interpolation through MATLAB, see appendix C or scripts. The detailed analysis is shown next.

**Table 5.1 shows the corrected data collected for woven wire mesh of wire diameter 1.6mm and an open area of 67%.**

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_2 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_{B'} - h_B$ (mm)	$V_{air}$ (m/s)	$h_{B'} - h_A$ (mm)
<i>For single mesh</i>						
42.5	12.0	32.5	22.74	54.0	30.33	10.5
36.0	9.5	28.5	19.48	45.0	27.69	9.0
23.5	6.0	18.5	12.76	29.0	22.23	5.0
16.0	4.0	12.5	8.72	19.5	18.23	3.5
11.5	3.0	9.0	6.23	14.0	15.45	2.5
8.0	2.0	6.0	4.22	10.0	13.05	2.0
6.0	1.5	4.5	3.15	7.5	11.31	1.0
5.0	1.0	4.0	2.71	6.0	10.11	1.0
3.0	0.5	2.5	1.67	3.5	7.72	0.5
2.0	0.5	1.5	1.05	2.5	6.53	0.5
<i>For zero spacing</i>						
58.5	12.0	48.5	40.17	50.0	29.19	9.0
50.5	9.5	43.0	34.69	43.0	27.07	7.5
33.5	6.0	28.5	22.76	29.0	22.23	5.0
23.0	4.0	19.5	15.72	19.5	18.23	4.0
16.0	3.0	13.5	11.11	13.0	14.88	3.0
11.5	2.0	9.5	7.90	9.5	12.72	2.5
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	1.5
4.0	0.5	3.5	2.67	3.5	7.72	1.0
3.0	0.5	2.5	2.05	2.5	6.53	0.5
<i>For 5mm spacing</i>						
60.5	12.0	50.5	42.53	49.0	28.90	11.5

**Table 5.1** continued

52.0	9.5	44.5	36.38	42.5	26.91	10.0
35.0	6.0	30.0	24.63	28.0	21.84	7.0
23.5	4.0	20.0	16.40	19.0	17.99	5.0
16.5	3.0	14.0	11.61	13.0	14.88	4.0
12.0	2.0	10.0	8.40	9.5	12.72	3.0
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.05	2.5	6.53	1.0
<i>For 8mm spacing</i>						
60.0	12.0	50.0	42.21	48.5	28.75	11.5
52.0	9.5	44.5	36.38	42.5	26.91	10.0
35.0	6.0	30.0	24.44	28.5	22.04	6.5
24.0	4.0	20.5	16.72	19.5	18.23	4.5
16.5	3.0	14.0	11.42	13.5	15.17	3.5
12.0	2.0	10.0	8.40	9.5	12.72	2.5
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 12mm spacing</i>						
59.0	12.0	49.0	42.48	45.0	27.69	7.5
51.5	9.5	44.0	36.96	39.5	25.94	6.5
34.5	6.0	29.5	24.67	26.5	21.25	4.5
23.5	4.0	20.0	16.77	18.0	17.51	3.0
16.0	3.0	13.5	11.29	12.5	14.59	2.0
11.5	2.0	9.5	8.09	9.0	12.38	1.5
8.5	1.5	7.0	6.03	6.5	10.52	1.5



**Table 5.1** continued

7.0	1.0	6.0	5.09	5.0	9.23	1.0
4.0	0.5	3.5	2.86	3.0	7.15	0.5
3.0	0.5	2.5	2.25	2.0	5.84	0.5
<i>For 15mm spacing</i>						
59.5	12.0	49.5	42.61	46.0	28.00	14.0
52.5	9.5	45.0	37.78	40.0	26.11	12.5
35.0	6.0	30.0	24.99	27.0	21.45	8.5
24.0	4.0	20.5	17.27	18.0	17.51	6.0
16.5	3.0	14.0	11.79	12.5	14.59	4.5
12.0	2.0	10.0	8.59	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 18mm spacing</i>						
59.0	12.0	49.0	42.84	44.0	27.38	15.0
52.0	9.5	44.5	37.64	39.0	25.78	13.0
35.0	6.0	30.0	25.35	26.0	21.05	9.0
23.5	4.0	20.0	16.77	18.0	17.51	6.0
16.5	3.0	14.0	11.79	12.5	14.59	4.5
12.0	2.0	10.0	8.59	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 21mm spacing</i>						
58.5	12.0	48.5	42.34	44.0	27.38	15.0
51.5	9.5	44.5	37.14	39.0	25.78	13.0

**Table 5.1** continued

34.5	6.0	29.5	24.85	26.0	21.05	8.5
23.5	4.0	20.0	16.95	17.5	17.27	6.0
16.5	3.0	14.0	11.97	12.0	14.30	4.0
11.5	2.0	9.5	8.09	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0

### 5.2.1 PRESSURE DROP DUE TO MESH ONLY ( $\Delta h_{CR}$ )

The pressure drop  $\Delta h$  because of frame only, as shown table 4.1 cannot be use for further calculations as  $\Delta h_2$  and  $\Delta h_1$  occur at different air velocities and hence at different Reynolds number. So there is a need to to have them at the same velocity which is accomplished by interpolating  $\Delta h_1$  at the the velocity  $V_{air}$  shown in table 4.1 that correspond to  $\Delta h_2$ . A program is written in MATLAB for each mesh to interpolate these values correctly. A quadratic fit is observed (see figure 5.1) for the data of  $\Delta h_1$  and  $V_{air}$  through MATLAB using both graphical fit and the the values obtained for squares of the residuals  $J$ , sum of squares of deviation  $S$  and coefficient of determination  $r^2$ , see bestfit.m file in Appendix C.

Once the value of  $\Delta h_1$  at the velocity of air  $V_{air}$  for  $\Delta h_2$  is found the corrected value of pressure drop due to mesh alone  $\Delta h_{CR}$  is then calculated as  $\Delta h_{CR} = \Delta h_2 - \Delta h_1$  in units of mm of water, see table 5.1. For example for velocity of air  $V_{air} = 18\text{m/s}$ , using the coefficients obtained from MATLAB (see bestfit.m)

$$0.0206\Delta h_1^2 + 0.0323\Delta h_1 - 0.1480 = 18$$

for the quadratic fit the value of  $\Delta h_1$  can be calculated by solving the equation above.

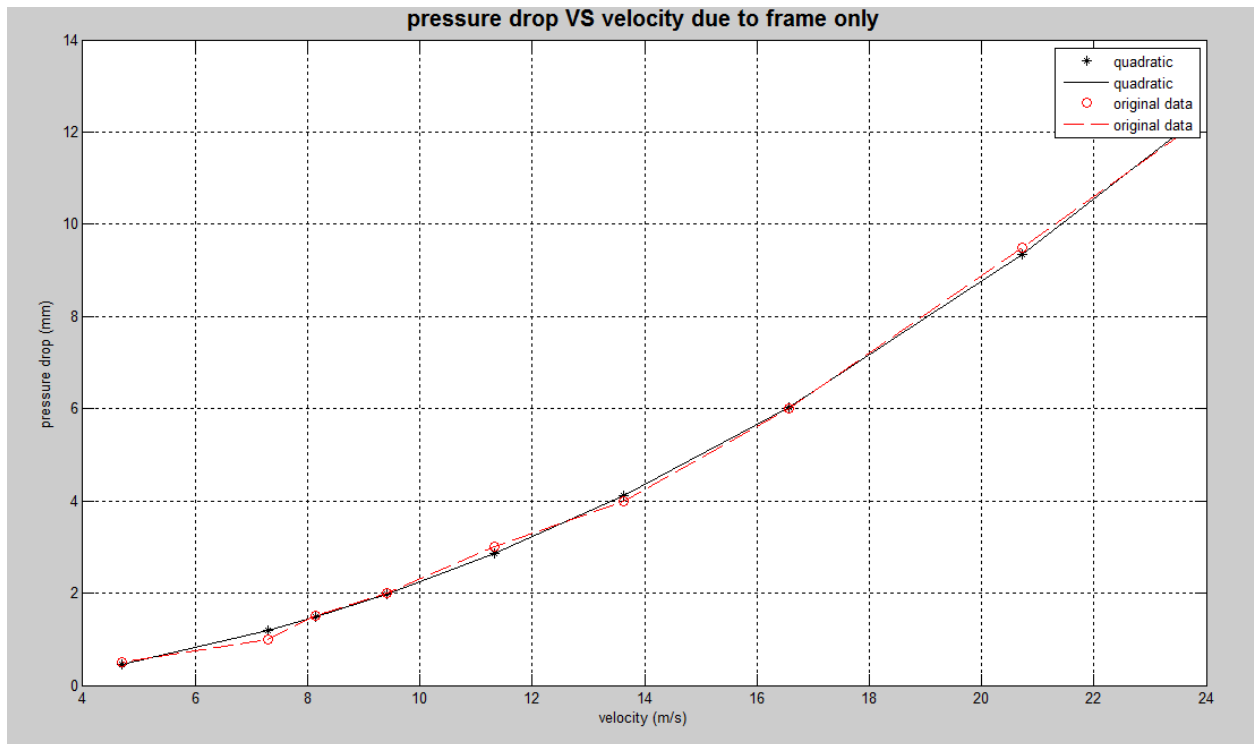


Figure 5.1 quadratic fit data of  $\Delta h_1$  and  $V_{air}$  both measured for single mesh.

### 5.2.2 MEASUREMENT OF DENSITY OF AIR

During the experimentation, the value of atmospheric pressure using barometer in units of kpa and temperature of air at the test facility using thermometer in units of °C are measured before every set of mesh is placed in the testing section and an average of the these values for each mesh is taken to calculate data further. The density of air is given by equation 2.8 (Anthony Esposito, pp.41)

$$\rho_{air} = \frac{P_{atm} \times 1000}{R \times T_{air}}$$

Where  $\rho_{air}$  is the density of air in units of kg/m<sup>3</sup>,  $P_{atm}$  is the atmospheric pressure in units of pa (Pascals),  $T_{air}$  is the temperature of air in units of K (Kelvin) and R is the gas constant whose value is 287 N.m/kg.k For example for atmospheric pressure  $P_{atm} = 94$  kpa, at air temperature of 14°C, the density of air

$$\rho_{air} = \frac{94 \times 1000}{287 \times (14 + 273)} = 1.412 \text{ kg/m}^3$$

### 5.2.3 CALCULATION OF AIR VELOCITY

The velocity of air exiting the mesh can be found using the Bernoulli's equation 5.19 (Anthony Esposito, pp.219) between points B' and B (see figure 4.3a, 4.3b, 4.3c) in the form

$$V_{air} = \sqrt{\frac{(h_{B'} - h_B) \times \gamma_{water} \times 2 \times 10^{-3}}{\rho_{air}}}$$

Where  $(h_{B'} - h_B)$  is the pressure difference between the stagnation and static point respectively behind the frame installation point measured in units of mm of water,  $V_{air}$  is the velocity of air

exiting the mesh measured in units of m/s,  $\gamma_{water}$  is the specific weight of water whose value is 9790 N/m<sup>3</sup> for the purpose of these calculations and  $\rho_{air}$  is the density of air in units of kg/m<sup>3</sup> which is calculated during the during the experiments based on the average temperature for each set of mesh.

For example: - If wire diameter of 1.6mm with 67% open area have  $(h_{B'} - h_B) = 54$  for a single mesh at an air density  $\rho_{air} = 1.149$  kg/m<sup>3</sup>. Then the velocity of air would be

$$V_{air} = \sqrt{\frac{(54) \times 9790 \times 2 \times 10^{-3}}{1.149}} = 30.33 \text{ m/s}$$

#### 5.2.4 CALCULATION OF REYNOLDS NUMBER (Re)

Reynolds number have been caculated by the following equation 7.3 (Anthony Esposito, pp.309)

$$Re = \frac{\rho_{air} \times V_{air} \times D_{wire}}{\mu_{air}}$$

Where  $D_{wire}$  is the diameter of wire used in units of meters,  $\rho_{air}$  is the density of air,  $V_{air}$  is the velocity of air and  $\mu_{air}$  is the absolute viscosity in units of N.s/m<sup>2</sup>.

For example:- for wire diameter of 1.6mm with 67% open area having  $V_{air} = 30.33$  m/s for a single mesh at an air density  $\rho_{air} = 1.149$  kg/m<sup>3</sup> with absolute viscosity  $\mu = 1.88 \times 10^{-5}$  N.s/m<sup>2</sup>.

$$Re = \frac{\rho_{air} \times V_{air} \times D_{wire}}{\mu_{air}} = \frac{1.149 \times 30.33 \times 1.6 \times 10^{-3}}{1.88 \times 10^{-5}} = 2966$$

### 5.2.5 CALCULATION OF PRESSURE RATIO

One of plots of the results obtained from these experiments has pressure ratio on the vertical axis whereas Reynolds number on the horizontal axis. Pressure ratio is obtained by dividing the pressure drop  $\Delta h_{CR}$  because of two layers of mesh with the pressure drop  $\Delta h$  because of single mesh in place both calculated at the same Reynolds number. Hence the values obtained for  $\Delta h$  from data collected off the experiments needs to be interpolated at the velocities corresponding to  $\Delta h_{CR}$ , which is achieved using MATLAB program (see appendix C) for each mesh involved.

For example, for air velocity of 18m/s, using the coefficients obtained for the following quadratic equation from MATLAB, the value of  $\Delta h_{single}$  can be obtained.

$$0.2292 \Delta h_{single}^2 - 0.2289 \Delta h_{single} + 3.3838 = 18$$

Such values are calculated at each spacing for every mesh. The pressure ratio was then obtained by dividing  $\Delta h_{CR}$  with the corresponding value of pressure drop because of single mesh  $\Delta h_{single}$

$$Pressure\ ratio = \frac{\Delta h_{CR}}{\Delta h_{Single}}$$

For example:- for wire diameter of 1.6mm with 67% open area having  $\Delta h_{CR} = 48.5$  mm at zero spacing, the value of pressure ratio can be obtained as follows:

$$pressure\ ratio = \frac{\Delta h_{CR}}{\Delta h_{Single}} = \frac{48.5}{32.5}$$

### 5.2.6 CALCULATION OF COEFFICIENT OF DRAG

Another set of plots of the results obtained from these experiments is plotted as coefficient of drag ( $C_d$ ) VS Reynolds (Re) number. The coefficient of drag has been obtained by using the following equation 13.5 (Anthony Esposito, pp.587)

$$C_d = \frac{\Delta h_{CR} \times 10^3 \times \gamma_{water}}{\frac{1}{2} \rho_{air} V_{air}^2}$$

Where,  $\Delta h_{CR}$  is the pressure drop that occurs because of mesh in place (mm)

$V_{air}$  = Velocity of air (m/s)

$\rho_{air}$  = Density of air (kg/m<sup>3</sup>)

$\gamma_{water}$  = 9790 N/m<sup>3</sup> (Specific weight of water)

For example: - for wire diameter of 1.6mm with 67% open area having  $V_{air}$  = 30.33 m/s for a single mesh at an air density  $\rho_{air}$  = 1.149 kg/m<sup>3</sup> with  $\Delta h_{CR}$  = 32.5mm for a single mesh

$$C_d = \frac{\Delta h_{CR} \times 10^3 \times \gamma_{water}}{\frac{1}{2} \rho_{air} V_{air}^2} = \frac{32.5 \times 10^3 \times 9790}{\frac{1}{2} \times 1.149 \times 30.33^2} = 0.602$$

### 5.3 **ERROR ANALYSIS**

The instrument used for taking the pressure readings is a manometer whose scale has a least count of 1mm, but the readings could be measured with accuracy close to 0.5mm with the naked eye. Hence for the purpose of these experimental readings an accuracy of 0.5mm has been

assumed. A typical error analysis is also shown in the tabulated form and the remaining error analysis can be referred to in Appendix B. The method used to calculate these errors has been illustrated below:-

### 5.3.1 ERROR ASSOCIATED WITH THE MEASUREMENT OF DENSITY OF AIR ( $\rho_{air}$ ):

The density of air for these experiments has been calculated using the ideal gas equation 2.8 (Anthony Esposito, pp.41) of the form

$$\rho_{air} = \frac{P_{atm}}{R \times T_{air}}$$

Where,  $P_{atm}$  is the atmospheric pressure measured for each experiment in units of Pascal (Pa), R is the gas constant of air (287 N.m/kg.k) and T is the temperature of air in units of Kelvin (K).

The error associated with the measurement of density has two components in it that is the error involved in the measurement of atmospheric pressure ( $P_{atm}$ ) and the temperature of air ( $T_{air}$ ).

#### ***Error associated with the measurement of $P_{atm}$ , R and $T_{air}$ :-***

The atmospheric pressure is measured using manometer with least count of 0.01, so as an example the error associated with the measurement of a 100 kpa pressure is 0.01%. Gas constant R does not constitute any error to the measurement of density. The temperature has been measured using a thermometer with a least count of 1°C and as an example, to measure a temperature of 290K the associated error is  $1/290 = 0.34\%$ . Since these errors do not cause considerable error in the measurement of density, therefore is assumed constant for the present work.



### ***Variation of air density because of humidity:-***

The temperature range used for these experiments is from 12°C to 18°C. We can calculate the variation in air density by considering the density at 0% humidity to 100% humidity at an approximate temperature of 15°C using “Airah Psychrometric chart “at STP.

At 0% humidity air density,  $\rho_{\text{air}} = 1/0.816 = 1.225 \text{ kg/m}^3$ .

At 100% humidity air density,  $\rho_{\text{air}} = 1/0.830 = 1.205 \text{ kg/m}^3$ .

Therefore percentage change in density as humidity varies from 0% to 100% =  $(1.225 - 1.205)/1.225 = 1.6\%$  .But during the experiments the humidity was never 100%, so the variation would still be less and hence can be ignored.

### **5.3.2 ERROR ASSOCIATED WITH THE MESUREMENT OF PRESSURE DROP ( $h_{\text{CR}}$ ):**

The pressure in units of Pascal (Pa) is given by the relation (Anthony Esposito, pp.203)

$$P_{\text{air}} = \rho_{\text{air}} \times g \times \Delta h_{\text{CR}}$$

It can be visualised that only  $\Delta h_{\text{CR}}$  (the difference in the water level in a manometer) causes error in the measurement of pressure as the error associated with the measurement of  $\rho_{\text{air}}$  has been ignored and  $g$  (acceleration due to gravity) is a constant.

Since  $\Delta h_{\text{CR}} = \Delta h_2 - \Delta h_1$

Therefore equation 3 [52], can be used to calculate the error associated with  $\Delta h$ .

$$\Delta(\Delta h) = \sqrt{(\Delta(\Delta h_2))^2 + (\Delta(\Delta h_1))^2}$$

Where  $\Delta(\Delta h)$  is the error associated with the measurement of pressure drop because of only mesh in terms of millimeteres of water,  $\Delta(\Delta h_2)$  is the error associated with the measurement of pressure drop because of mesh and frame in units of millimeters of water and  $\Delta(\Delta h_1)$  is the error

in pressure drop measurement because of frame in units of millimeters of water.

Taking an accuracy of 0.5mm for the measured data for pressure drops, the equation gives

$$\Delta(\Delta h) = \sqrt{(0.5)^2 + (0.5)^2} = \sqrt{0.5}$$

This in fractional form is

$$\frac{\Delta(\Delta h)}{\Delta h} = \frac{\sqrt{0.5}}{\Delta h}$$

### 5.3.3 ERROR ASSOCIATED WITH THE MEASUREMENT OF VELOCITY OF AIR ( $V_{air}$ ):

The velocity is given by the relation 5.19(Anthony Esposito, pp.219)

$$V_{air} = \sqrt{\frac{(h_{B'} - h_B) \times \gamma_{water} \times 2 \times 10^{-3}}{\rho_{air}}}$$

Where (  $h_{B'} - h_B$  )is the difference in water level in the manometer between points B' and B respectively in units of millimeters. Since all other quantities are constant on the right hand side of the equation except (  $h_{B'} - h_B$  ), hence the error in the measured value of  $V_{air}$  occurs only because of this.

Therefore equation 5 (Petz, M & Shott, 1998) can be used to calculate the error associated with  $V_{air}$ .

$$\frac{(\Delta V_{air})}{V_{air}} = \frac{1}{2} \times \frac{0.5}{(h_{B'} - h_B)}$$

Where ( $\Delta V_{air}$ ) is the error in the measurements of velocity. The error for the measurement of (  $h_{B'} - h_B$  ) has been taken as 0.5mm.The formula gives the fractional error for velocity.

#### 5.3.4 ERROR ASSOCIATED WITH THE MEASUREMENT OF COEFFICIENT OF DRAG

(C<sub>d</sub>):

The coefficient of drag has been calculated using the equation 13.5 (Anthony Esposito, pp.587)

$$C_d = \frac{\Delta h}{\frac{1}{2} \rho_{air} V_{air}^2}$$

The sources of error in the formula for C<sub>d</sub> are Δh and V<sub>air</sub> as the density of air ρ<sub>air</sub> is assumed constant. Therefore

$$\frac{\Delta C_d}{C_d} = \sqrt{\left(\frac{\Delta(\Delta h)}{\Delta h}\right)^2 + \left(2 \times \frac{\Delta V_{air}}{V_{air}}\right)^2}$$

Where ΔC<sub>d</sub> is the error associated with the measurement of coefficient of drag and the formula gives the fractional error for C<sub>d</sub>. The percentage error for C<sub>d</sub> can be found by multiplying right side of the equation above with 100.

$$\frac{\Delta C_d}{C_d} = \sqrt{\left(\frac{\sqrt{0.5}}{\Delta h}\right)^2 + \left(\frac{0.5}{h_{B'} - h_B}\right)^2} \times 100$$

This equation gives the percentage error associated with the measurement of coefficient of drag.

**EXAMPLE**:- For wire diameter of 0.45mm and open area of 34% for zero spacing we have, Δh=106.45mm; h<sub>B'</sub> - h<sub>B</sub>= 20mm; V<sub>air</sub>= 18.58m/s, the errors are as follows:-

Pressure error

$$\frac{\Delta(\Delta h)}{\Delta h} = \frac{\sqrt{0.5}}{106.45} = 0.0066$$

This is equal to 0.66% in percentage form.

#### Velocity error

$$\frac{(\Delta V_{air})}{V_{air}} = \frac{1}{2} \times \frac{0.5}{20} = 0.0125$$

This is equal to 1.25% in the percentage form.

#### Coefficient of drag error

$$\frac{\Delta C_d}{C_d} = \sqrt{(0.0066)^2 + (2 \times 0.0125)^2} = 0.0259$$

This is equal to 2.59% in the percentage form.

### **5.4 CHAPTER SUMMARY**

This chapter covers data conversion from the raw data gathered during the experiments to convert to more useful form for analysis using some formulas. A detailed error analysis is carried out in this chapter covering every single reading taken during the experiments with an example for a typical mesh.

## Chapter 6

# **RESULTS AND DISCUSSION**

### ***6.1 CHAPTER OVERVIEW***

This section of the present work discusses the outcome of the project. All the plots of the results have been explained and the trend in these plots is suitably commented. Any discrepancies associated with the difference in the results obtained and the results expected are also discussed in this section. All the plotting work presented here is done using software called MATLAB and the scripts written to obtain the required results are attached in Appendix C.

### ***6.2 RESULTS***

The data collected from all the meshes is analyzed here individually and the outcome of these results would be discussed in the next section. One program written for the analyses outputs three different plots that is

- Pressure drop due to mesh ( $\Delta h_{CR}$ ) VS velocity of air ( $V_{air}$ )
- Pressure ratio (two layers / single layer) VS Reynolds number ( $Re$ ).
- Coefficient of drag ( $C_d$ ) VS Reynolds number ( $Re$ ).

whereas the other program give a plot for coefficient of drag ( $C_d$ ) VS porosity of the meshes. These results are discussed hereunder

#### **6.2.1 FOR WIRE DIAMETER OF 0.45MM AND OPEN AREA OF 34%**

Figure 6.1 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

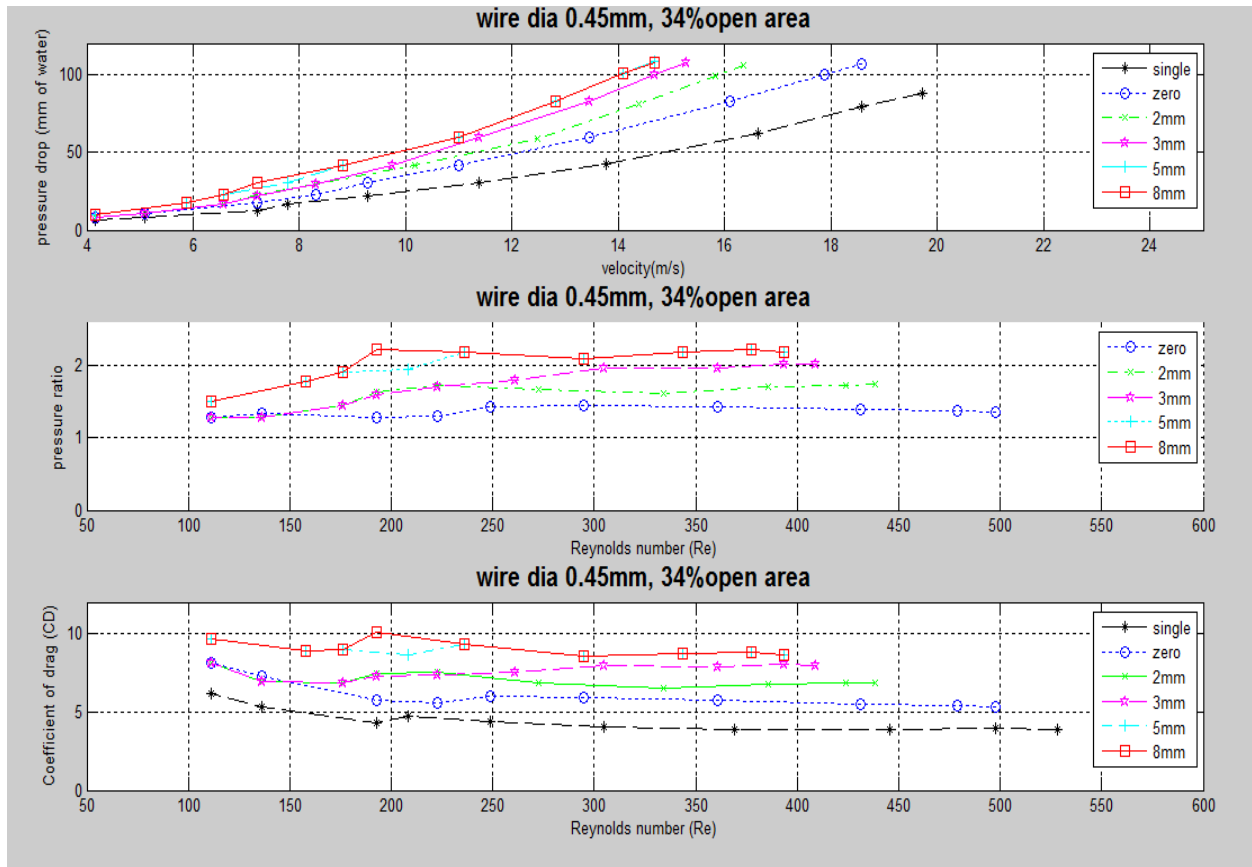


Figure 6.1 results for wire diameter of 0.45mm and open area of 34%.

*Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 5mm, the pressure drop gets more and more and if we increase the distance further than 5mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as per equation 5.16 (Anthony Esposito, pp. 217)

$$h = \frac{V^2}{2 \times g}$$

where  $v$  is the velocity of air and  $h$  is the pressure drop in units of meters (m). The quality of tandemness cannot be guaranteed in this case due to small cell size.

*Pressure ratio VS Reynolds number(Re):*

Almost following the same pattern as pressure drop, the pressure ratio increases as we increase the distance between two layers of mesh. At zero spacing the pressure ratio increases from 1.25 to 1.4 over  $110 \leq Re \leq 250$  and thereafter stays around 1.4, however the pressure drop ratios are almost same for a spacing of 5mm or more and vary between 1.5 and 2.2. As a contrast the pressure ratio for zero spacing and 3mm spacing are same (1.25) between Reynolds number 110 and 175.

*Coefficient of drag  $C_d$  VS Reynolds number (Re):*

For single mesh,  $C_d \cong 4$  for Reynolds number  $Re > 300$  and it varies from 6 to 4 for  $Re < 300$ . The same pattern is followed for zero spacing and  $C_d$  drops from 8 to 6 for  $Re < 250$  which stays around 6 with further increase in Reynolds number.

In all two layered cases except for 8mm spacing at  $Re = 200$ , the  $C_d$  drops sharply for  $110 \leq Re \leq 200$  but the fluctuation decreases as we increase the Reynolds number. The  $C_d$  for two layers at all stages is less than twice of the  $C_d$  due to single mesh that is

$$2 \times C_{d_{single}} > C_{d_{double}}$$

$C_d \cong 8.5$  for 5mm spacing and  $C_d \cong 8$  for 3mm spacing for  $Re \geq 300$ .

### 6.2.2 FOR WIRE DIAMETER OF 0.40MM AND OPEN AREA OF 47%

Figure 6.2 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

#### *Pressure drop VS Velocity:*

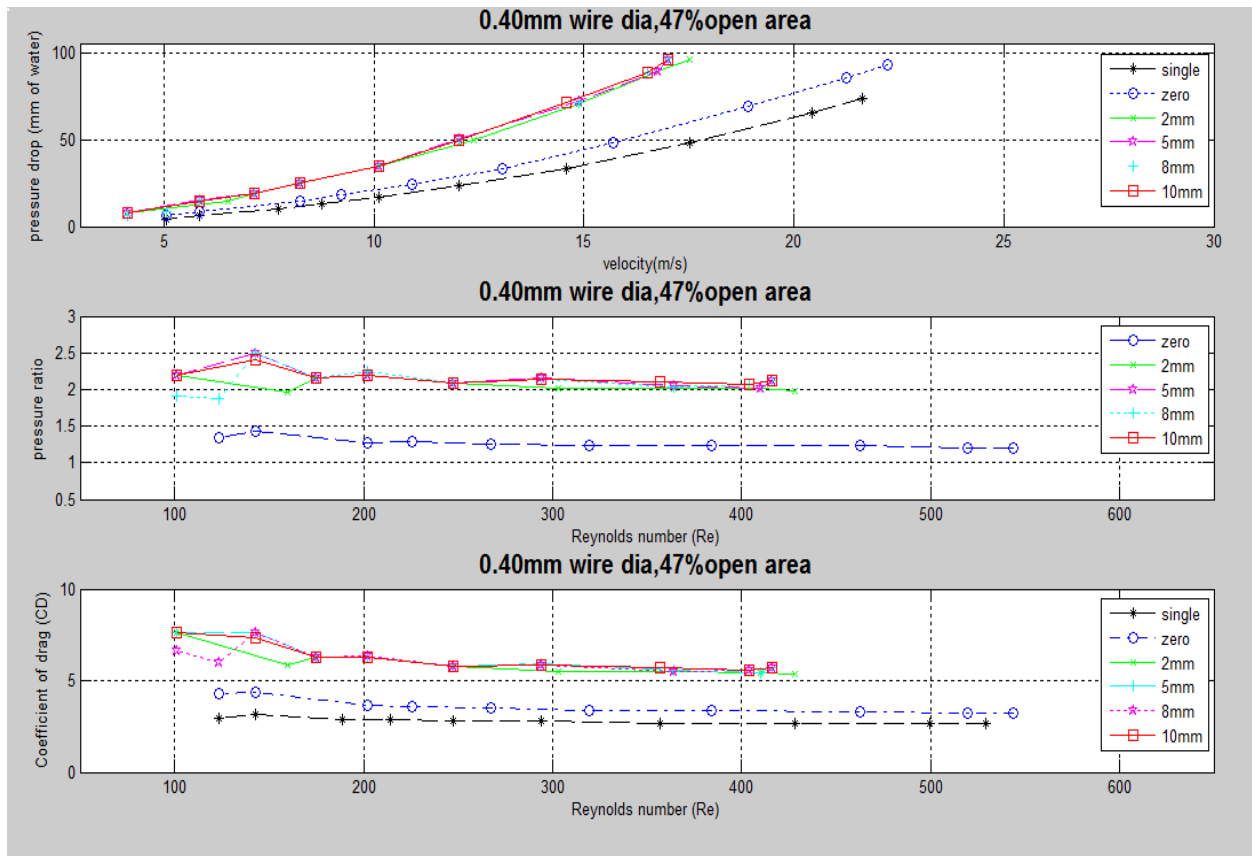
The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 5mm, the pressure drop gets more and more, if we increase the distance further than 5mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for section 6.2.1. The quality of tandemness cannot be guaranteed due to small cell size.

#### *Pressure ratio VS Reynolds number (Re):*

Almost following the same pattern as pressure drop, the pressure ratio increases as we increase the distance between two layers of mesh. At zero spacing the pressure ratio increases from 1.4 to 1.25 over C and thereafter stays around 1.25, however the pressure drop ratios for two layers of mesh fluctuates between 1.8 to 2.5 for  $100 \leq Re \leq 175$  and then tends to stabilize at a pressure ratio of 2 for  $Re \geq 250$ .





**Figure 6.2 results for wire diameter of 0.40mm and open area of 47%.**

*Coefficient of drag  $C_d$  VS Reynolds number (Re):*

For single mesh,  $C_d \cong 3$  for Reynolds number  $Re < 250$  and it becomes almost constant for  $Re > 300$ . The same pattern is followed for zero spacing and  $C_d$  drops from 4.3 to 3.2 for  $Re < 250$  which stays around 6 with further increase in Reynolds number.

In all two layered cases except for 8mm spacing at  $Re = 200$ , the  $C_d$  drops sharply for  $110 \leq Re \leq 500$  and thereafter tends to stabilize as we further increase the Reynolds number. For a spacing of 2mm to 10 mm the  $C_d$  fluctuates between 7.6 and 6 for  $100 \leq Re \leq 200$ , but the fluctuation decreases as we increase the Reynolds number beyond 200 and they tend to stabilize around 5.5 mark. To summarise,

$C_d \cong 3$  for single mesh

$C_d \cong 4.3$  to  $3.2$  for zero spacing

$C_d \cong 7.6$  to  $5.5$  for 10 mm spacing

### 6.2.3 FOR WIRE DIAMETER OF 1.6 MM AND OPEN AREA OF 57%

Figure 6.3 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

#### *Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 10mm, the pressure drop gets more and more, if we increase the distance further than 10mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for other cases.

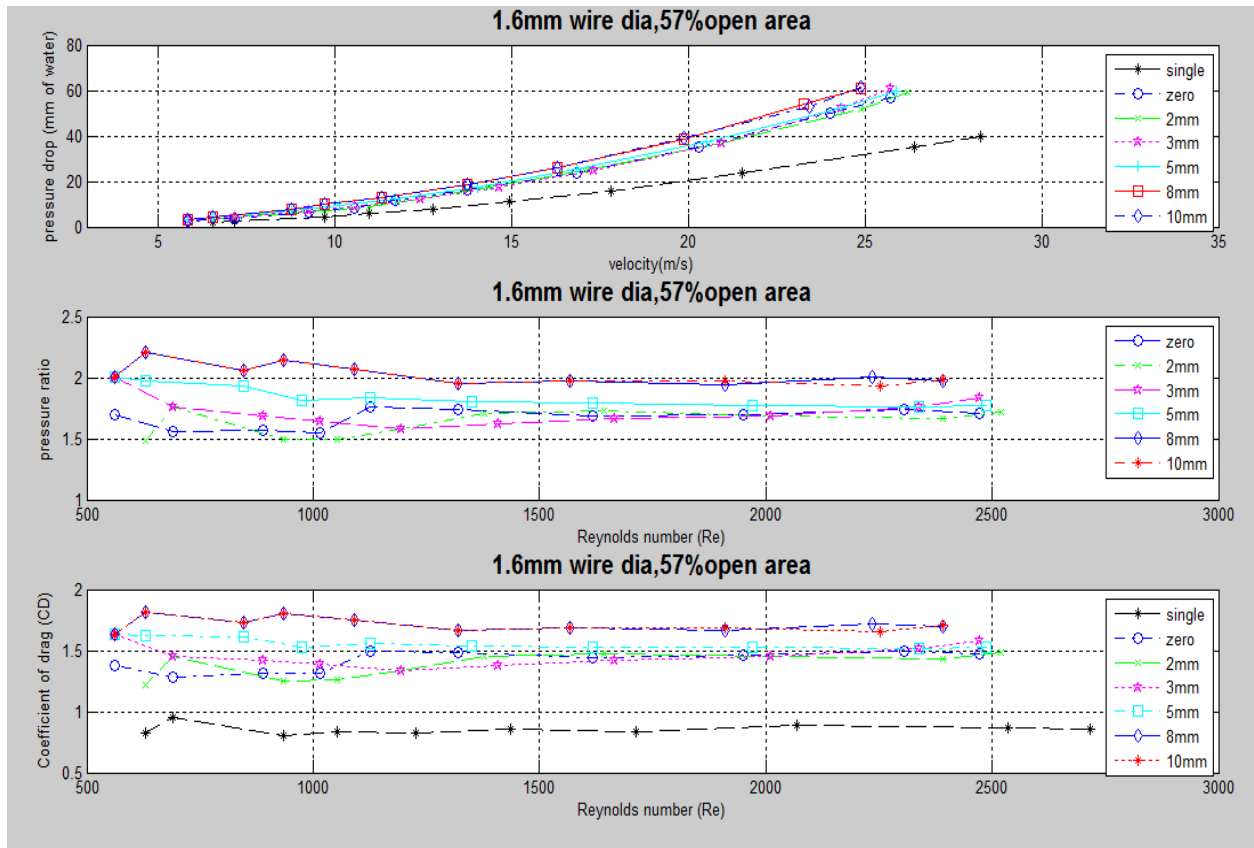


Figure 6.3 results for wire diameter of 1.6 mm and open area of 57%.

*Pressure ratio VS Reynolds number (Re):*

In this case, for spacing from zero to 3mm unlike first two cases explained above, the pressure ratio for 2mm spacing is less than for zero spacing at  $900 \leq Re \leq 1400$  and at  $2000 \leq Re \leq 2500$  and for 3mm spacing it is less than the value for zero spacing at  $1100 \leq Re \leq 2300$ . The pressure ratio fluctuates for at every spacing for Reynolds number  $500 \leq Re \leq 1500$  and the fluctuation decreases if Reynolds number is increased further. Pressure ratio is almost same for 8 mm and 10 mm spacing for  $Re \leq 1500$ . The quality of tandemness is average in this case.

*Coefficient of drag  $C_d$  VS Reynolds number ( $Re$ ):*

The general trend in this case is that as we increase the spacing between the two layers  $C_d$  increases with it. However it is interesting to note that for 2 mm spacing the value of  $C_d$  is less than that of zero spacing for  $900 \leq Re \leq 1400$  and at  $2000 \leq Re \leq 2500$ . In case of 3mm spacing it is lower than that of zero spacing for number  $1100 \leq Re \leq 2300$ . To summarise,

$$C_d \cong 0.8 \text{ for single mesh}$$

$$C_d \cong 1.2 \text{ to } 1.8 \text{ for other spacing}$$

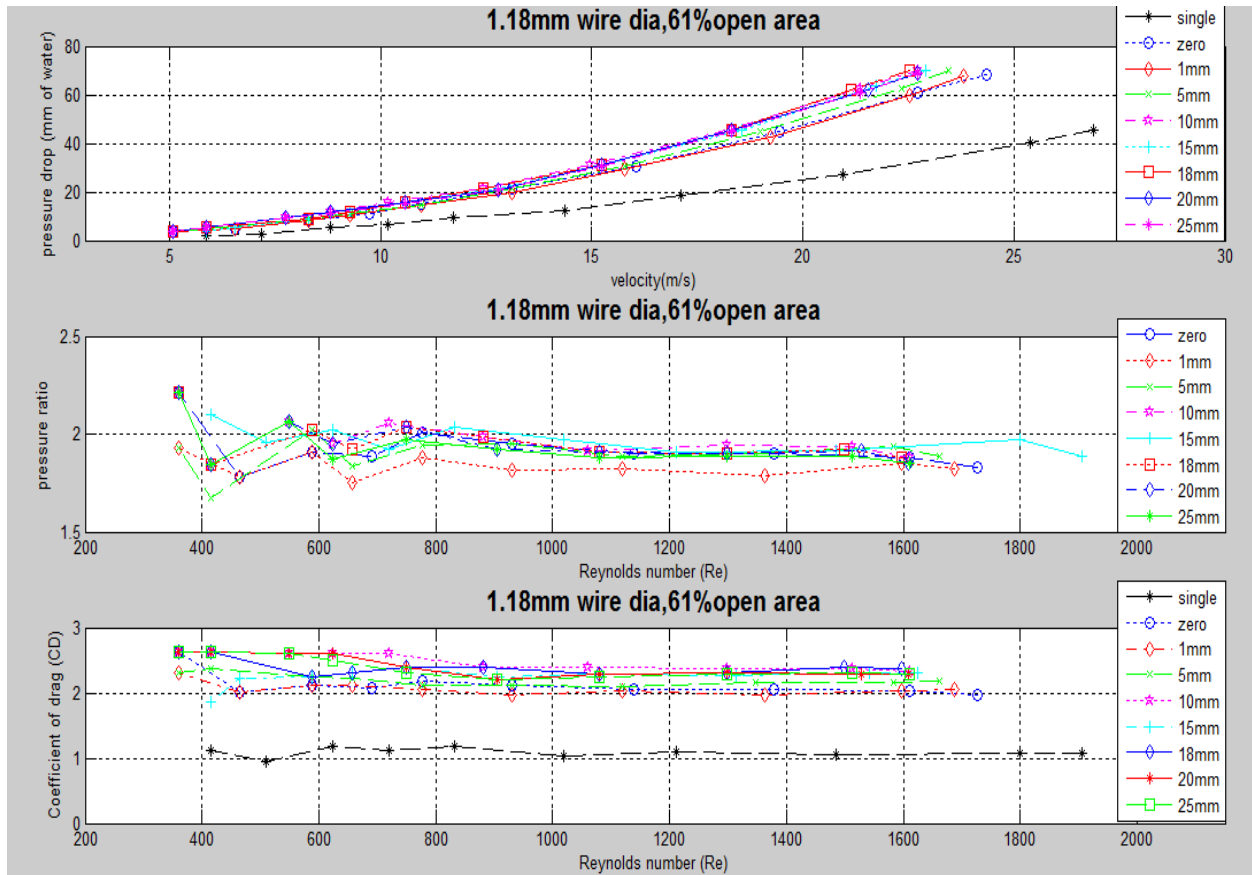
#### 6.2.4 FOR WIRE DIAMETER OF 1.18 MM AND OPEN AREA OF 61%

Figure 6.4 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

*Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 25 mm, the pressure drop gets more and more, if we increase the distance further than 25 mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for other cases. The quality of tandemness is good in this case.



**Figure 6.4 results for wire diameter of 1.18 mm and open area of 61%.**

*Pressure ratio VS Reynolds number (Re):*

In this case, the pressure ratio for 1mm spacing is less than that of zero spacing for the range of Reynolds number considered. The pressure ratio for all every spacing fluctuates over  $400 \leq Re \leq 1000$  that overall varies from 1.8 to 2.1. The pressure ratio for 10 mm spacing is the highest among all spacings over the range of Reynolds number considered. The pressure ratio results are quite in contrast to the other cases and point towards some error. The overall data except 1mm spacing fluctuates a little around 1.9 for  $Re \geq 1000$ . The quality of tandemness is good in this case.

*Coefficient of drag  $C_d$  VS Reynolds number ( $Re$ ):*

A general trend in this case is hard to establish as the value of  $C_d$  for zero spacing is twice that of single mesh which in turn is greater than that of 1 mm spacing. The coefficient of drag stabilizes for  $Re \geq 1000$  after which the individual values attained by each spacing do not vary much. To summarise,

$$C_d \cong 1 \quad \text{for single mesh}$$

$$C_d \cong 2.3 \quad \text{for other spacings}$$

$$C_d \cong 2 \quad \text{for zero and 10 mm spacing}$$

The results seem inconclusive in this case.

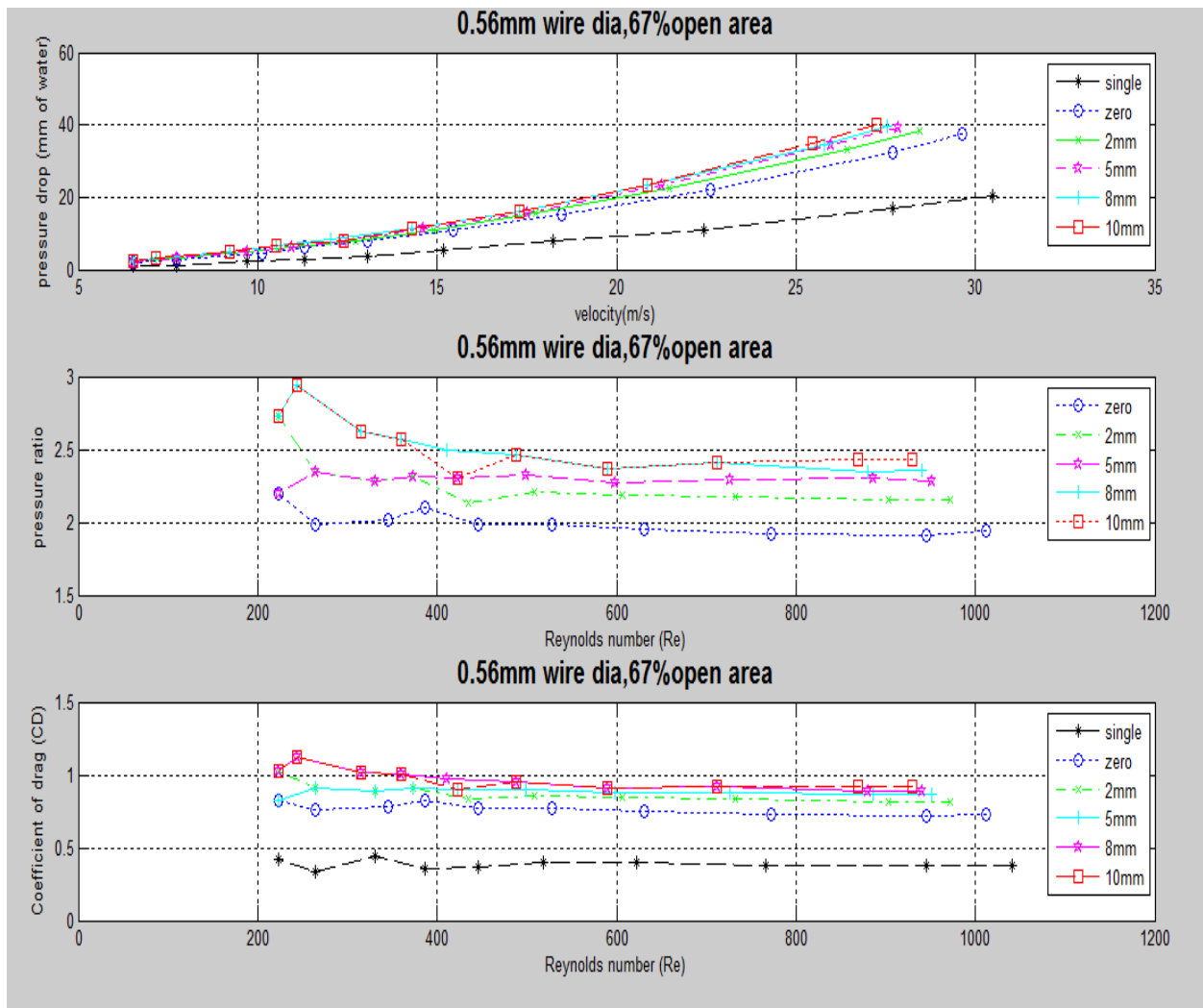
#### 6.2.5 FOR WIRE DIAMETER OF 0.56 MM AND OPEN AREA OF 67%

Figure 6.5 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

*Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 10 mm, the pressure drop gets more and more, if we increase the distance further than 10 mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for other cases. The quality of tandemness is good in this case.



**Figure 6.5 results for wire diameter of 0.56 mm and open area of 67%.**

*Pressure ratio VS Reynolds number (Re):*

Almost following the same pattern as pressure drop, the pressure ratio increases as we increase the distance between two layers of mesh. At zero spacing the pressure ratio is nearly twice that of single mesh drops from 2.2 to 1.9 at  $200 \leq Re \leq 800$ . The pressure ratio at spacings other than zero seems to stabilize at  $Re > 600$ . The wire meshes with 8 mm and 10 mm have almost same

pressure ratio that varies from 3 to 2.4 times the single mesh. The quality of tandemness is good in this case.

*Coefficient of drag  $C_d$  VS Reynolds number ( $Re$ ):*

A general trend in this case is that the coefficient of drag  $C_d$  increases as we increase the spacing between two layers with  $C_d$  being minimum for zero spacing among all different spacings. The value of  $C_d$  for all the individual spacings becomes constant after  $Re > 600$ . To summarise,

$$C_d \cong 0.4 \text{ for single mesh}$$

$$C_d \cong 0.72 \text{ for zero spacing}$$

$$C_d \cong 0.92 \text{ for zero and 10 mm spacing}$$

#### 6.2.6 FOR WIRE DIAMETER OF 1.6 MM AND OPEN AREA OF 67%

Figure 6.6 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

*Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 21 mm, the pressure drop gets more and more, if we increase the distance further than 21mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for other cases. The quality of tandemness is good in



this case.

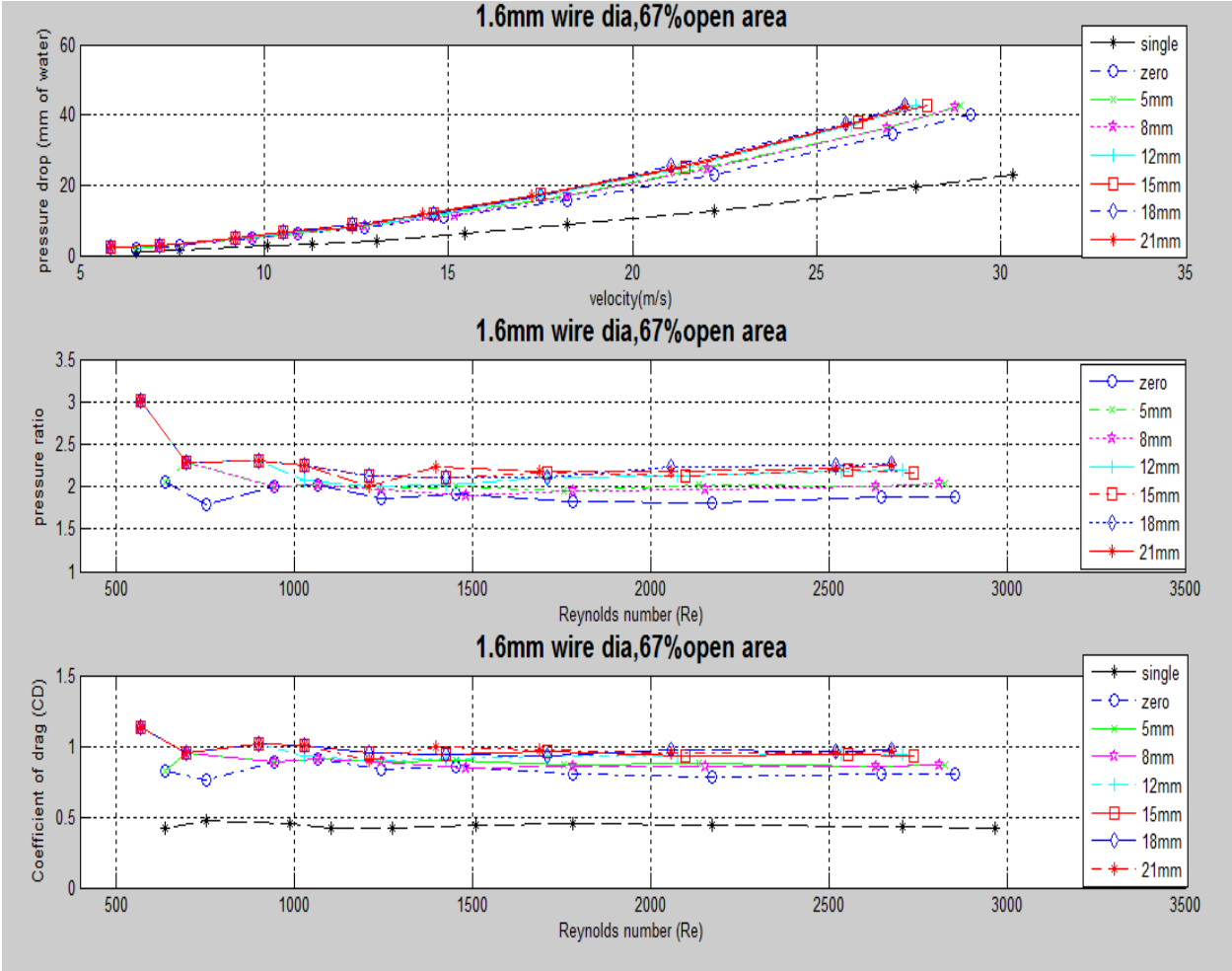


Figure 6.6 results for wire diameter of 1.6 mm and open area of 67%.

*Pressure ratio VS Reynolds number (Re):*

The pressure ratio seems to stabilize to a constant value for the individual spacings when  $Re > 2000$ . At zero spacing the pressure ratio is approximately 1.8 times than that of a single mesh. In contrast the pressure ratio for 8 mm spacing is less than that of 5 mm. It seems that at lower

Reynolds the pressure ratio can increase. The quality of tandemness is good in this case.

*Coefficient of drag  $C_d$  VS Reynolds number ( $Re$ ):*

A general trend in this case is that the coefficient of drag  $C_d$  increases as we increase the spacing between two layers with  $C_d$  being minimum for zero spacing among all different spacings. The value of  $C_d$  for all the individual spacings becomes almost constant after  $Re > 600$ . To summarise,

$$C_d \cong 0.4 \text{ to } 0.5 \text{ for single mesh}$$

$$C_d \cong 0.8 \text{ for zero spacing}$$

$$C_d \cong 0.8 \text{ to } 1.1 \text{ for all other spacings}$$

#### 6.2.7 FOR WIRE DIAMETER OF 1.6 MM AND OPEN AREA OF 67%

Figure 6.7 shows the output of the program in a single figure. Following can be inferred from the individual plots:-

*Pressure drop VS Velocity:*

The pressure drop because of mesh  $\Delta h_{CR}$  increases as we increase the spacing between the two layers of mesh, with single mesh having the minimum pressure drop as expected. As we increase the distance from zero to 25 mm, the pressure drop gets more and more, if we increase the distance further than 25mm the pressure drop essentially stays constant.

The pressure drop seems to obey the relationship that the pressure drop  $\Delta h_{CR}$  is proportional to the square of air velocity that is  $V_{air}^2$  as for other cases. The quality of tandemness is good in this case.

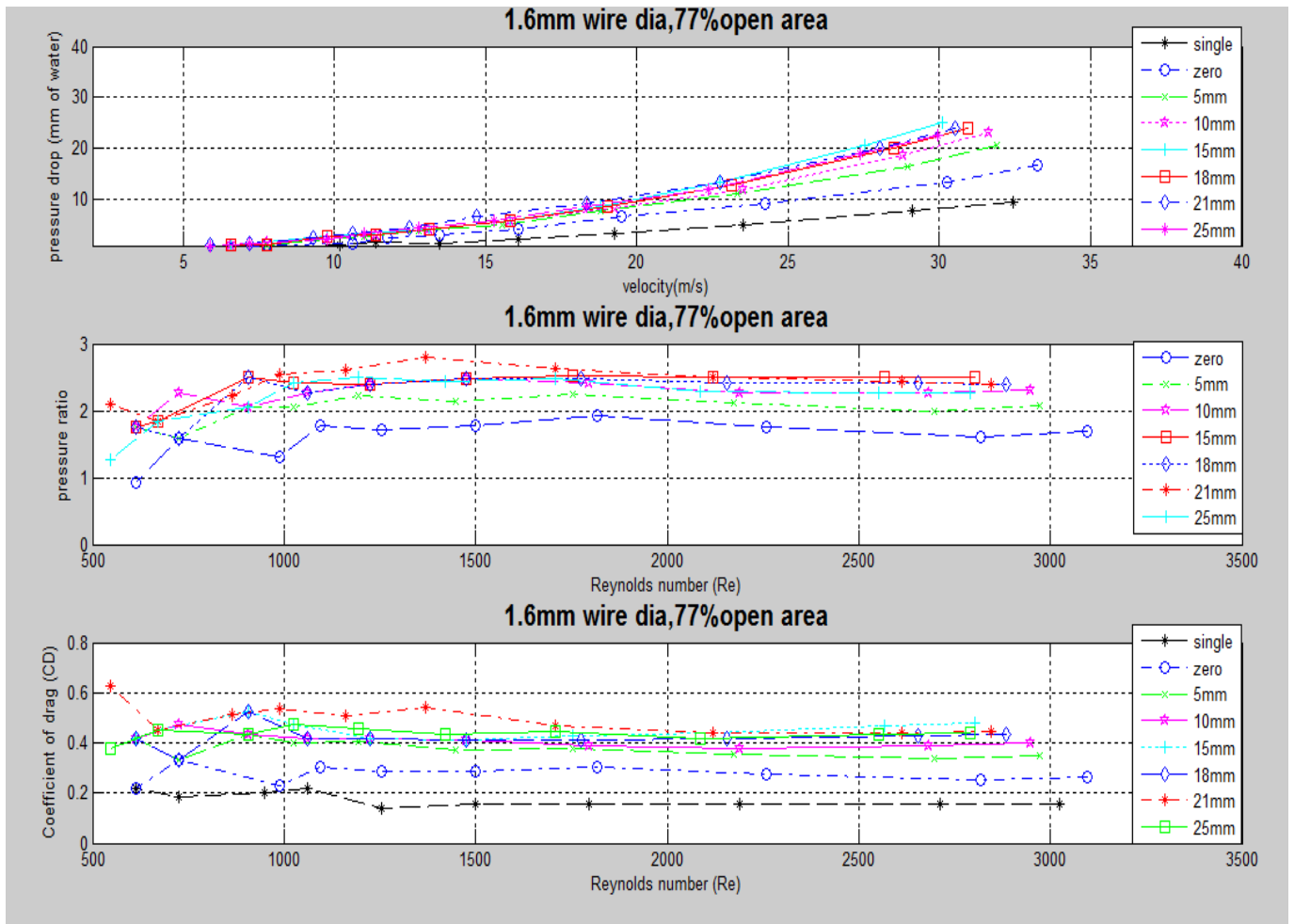


Figure 6.7 results for wire diameter of 1.6 mm and open area of 77%.

*Pressure ratio VS Reynolds number (Re):*

The pressure ratio seems to stabilize to a constant value for the individual spacings when  $Re > 2000$ . At zero spacing the pressure ratio is approximately 1.8 times than that of a single mesh. The pressure ratio for zero spacing is approximately 1.8 times than that of single mesh, while for all other spacings it varies from 2.0 to 2.5 times that of a single mesh. It can be inferred that at low Reynolds number the pressure ratio is lower and it increases with increasing Reynolds number. The quality of tandemness is good in this case.

*Coefficient of drag  $C_d$  VS Reynolds number ( $Re$ ):*

A general trend in this case is that the coefficient of drag  $C_d$  increases as we increase the spacing between two layers with  $C_d$  being minimum for zero spacing among all different spacings. The value of  $C_d$  for all the individual spacings becomes almost constant after  $Re > 2500$ . The value of  $C_d$  is maximum for a spacing of 21 mm over most of the Reynolds number range considered here. To summarise,

$$C_d \cong 0.2 \quad \text{for single mesh}$$

$$C_d \cong 0.3 \quad \text{for zero spacing}$$

$$C_d \cong 0.35 \text{ to } 0.47 \quad \text{for all other spacings}$$

#### 6.2.8 COEFFICIENT OF DRAG VS POROSITY

Figure 6.8 shows the output of the program for coefficient of drag verses porosity at common Reynolds number. Since they follow the same trend, hence only one typical plot for 5 mm spacing is explained hereunder:-

The plot for coefficient of drag verses porosity (see figure 6.8) shows that at lower Reynolds number ( $Re$ ), the effect of porosity is stronger than at higher Reynolds number ( $Re$ ) for particular spacing. As an example at  $Re = 300$ , the coefficient of drag  $C_d$  is 8.5 but at higher Reynolds number the value of  $C_d$  is never greater than 2. It can be inferred from the plot that as the porosity increases the coefficient of drag  $C_d$  decreases which is similar to single mesh. The same trend is observed at other spacings.



Figure 6.8 drag coefficient VS porosity at 5mm spacing

### 6.3 DISCUSSION

The results obtained from the experimental data were explained in the last section of this chapter. All due care is given to keep the tendemness of the wire meshes but for the meshes with finer cell sizes especially with the 34% open are and 47% area the tandemness cannot be guaranteed.

After careful investigation, the general trend found is that as we increase the spacing between the two layers of mesh in tandem the coefficient of drag associated with the flow through mesh increases.

The other trend noticed in the experimental work presented is that the pressure drop  $\Delta h_{CR}$  due to two layers of mesh as air flows through them is proportional to the velocity of air  $V_{air}$  being considered which supports the current theory that describes the relationship as

$$h = \frac{v^2}{2 \times g}$$

where  $v$  is the velocity of air in units of  $m/s$ ,  $g$  is the acceleration due to gravity in units  $m/s^2$  and  $h$  is the pressure drop in units of meters (m).

In the absence of any data for the flow through two layers of mesh, only single layer behavior is compared with the work of other researchers. Figure 6.9 compares the results obtained from the current work and the work done by previous researchers.

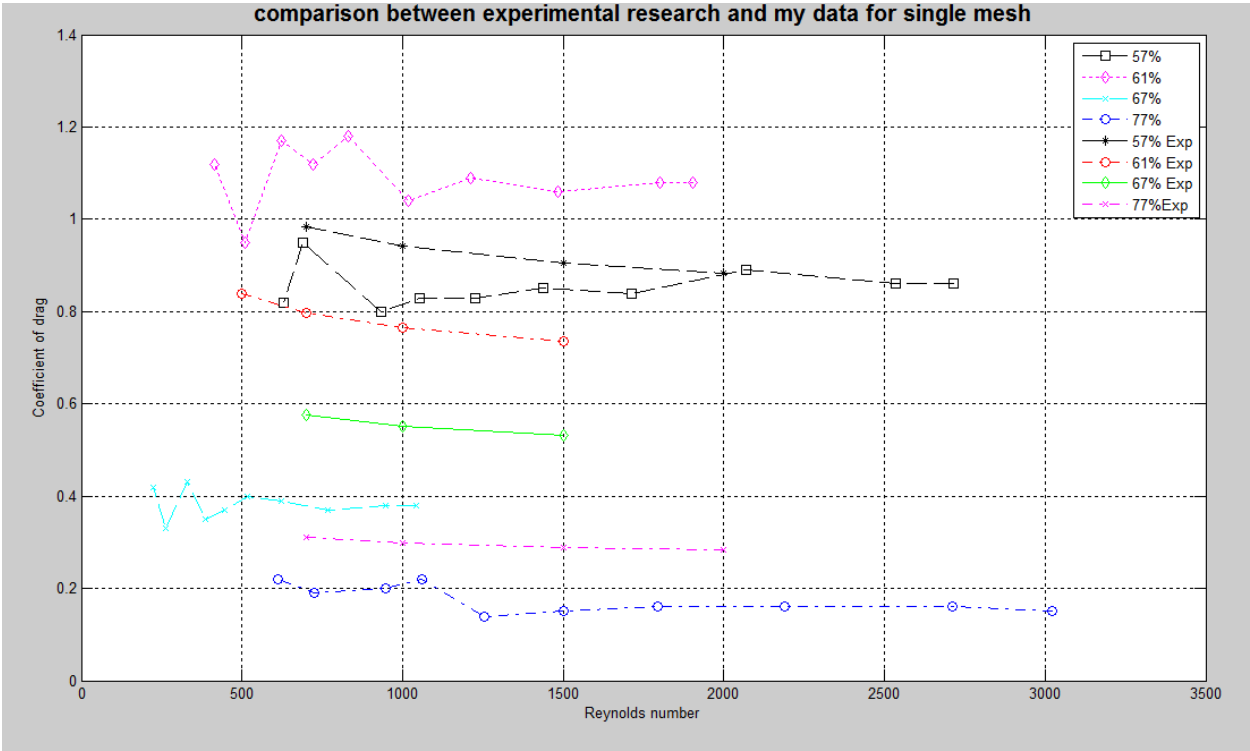


Figure 6.9 compares between current work and experimental research of others.

Equation 6 (A. Sharifian and David R. Buttsworth, 2007) relates porosity and Reynolds number to coefficient of drag as shown below:

$$C_{dc} = -0.491 + \frac{0.47}{P^{1.773}} - \frac{7.49}{Re^{0.661}} + \frac{6.475}{P^{2.244} Re^{0.661}}$$

For the range of  $10 \leq Re \leq 1000$  and  $0.27 \leq P \leq 0.82$ , where P is the porosity of the mesh. The equation mentioned here has a maximum error of about 6.5% with respect to the simulation results.

Figure 6.9 shows that the error obtained for the present work with respect to equation shown above is 16.8% for wire mesh of porosity 0.57 (57%), 10% to 28% for the mesh of porosity 0.61, 17% for porosity of 0.67 for wire diameter of 0.56 mm and 15% for porosity of 77%. Hence the results seem justified.

Wire meshes of 0.34 porosity and 0.47 porosity have been excluded from as the comparison due to their small range Reynolds number, the trend those graphs follow cannot be established. The program used to plot figure 6.9 can be found in Appendix C (under the file comparework.m).

Figure 6.10 is shown below for a vague comparison for two layered mesh using the same equation for single mesh as above where blue line are stacked as shown in the legend box that is for 34% porosity to 77% porosity at the bottom. It is evident from the figure that for porosity of 0.77 the equation can describe the two layered problem with an error of only 10% and with an error of 20% for mesh of porosity 0.67. But for porosity this equation gives an error of 140% and for 57% the error is about 70%. Hence for lower coefficient of drag values associated with the flow this equation can fairly explain the phenomenon for two layered meshes as well.

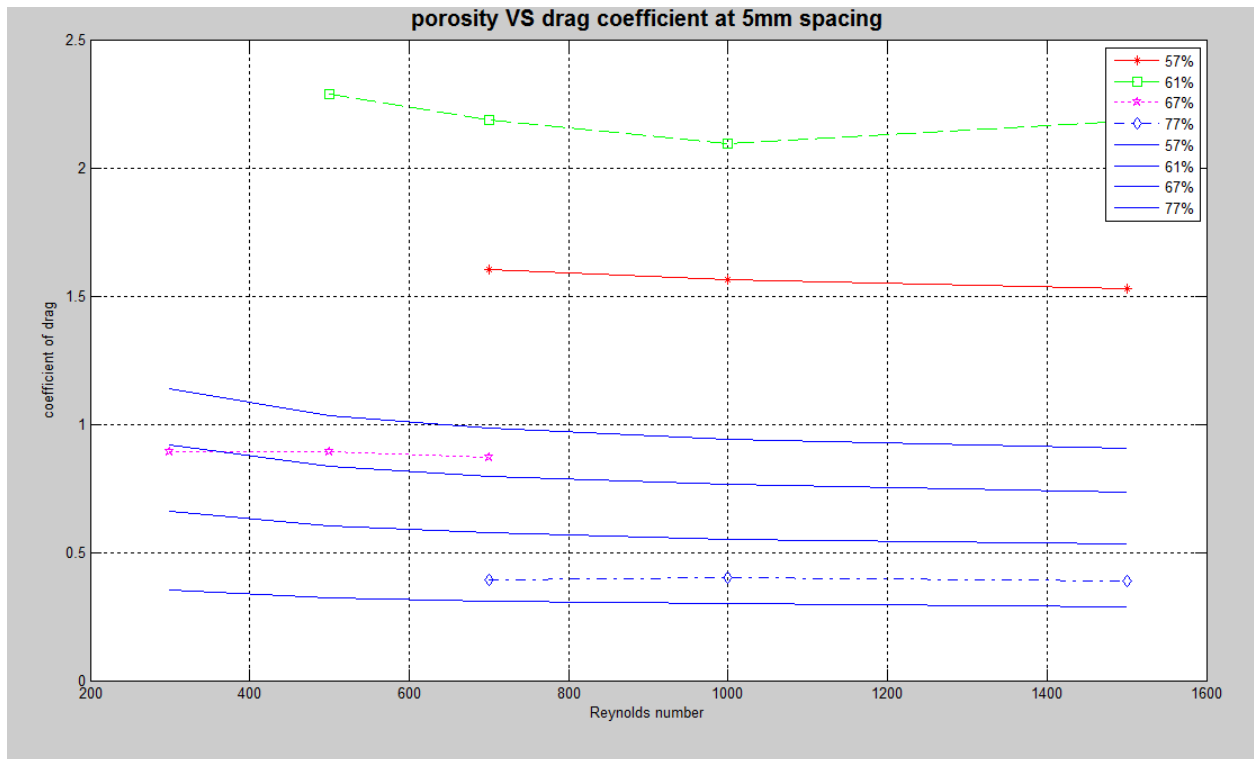


Figure 6.10 compares two layered mesh using the equation developed for single mesh by earlier researchers.

Some differences in the variations were observed for coefficient of drag with respect to Reynolds number which could probably be because of the fact that Reynolds number depends upon porosity. Because if we refer to figures 6.5 and 6.6 which differ only in diameter but have the same open area, for both of these meshes coefficient of drag is around 0.4 for single mesh and around 0.8 for zero spacing which is twice that of single mesh. Moreover the variations above zero spacing are almost same for both these meshes. The quality of tandemness is good for this case.

*AS A POTENTIAL APPLICATION TOWARDS FIRE FIGHTING*

The flow in the wind tunnel is restricted to move through the mesh which is a very ideal condition for mesh installed in bush area to prevent fire because wind can move around the mesh and can change the direction suddenly when face an obstruction. However these analyses



are important to study the behavior of mesh under extreme conditions and to derive relations and conclusions can be applied in the general sense. Therefore in the real life scenario a mesh is expected to face a much less drag force than it does in the wind tunnel.

In some cases observed in this chapter it has been found that coefficient of drag sometimes exceed twice that of two individual meshes which does not guarantee that the drag force on wire mesh will be twice as well because the flows could be at different velocities and hence at different Reynolds number.

#### ***6.4 CHAPTER SUMMARY***

This chapter covers the results obtained from the experimental data. Every plot obtained from MATLAB programs is explained here individually followed by general discussion of the outcome of the project. Variation of porosity with Reynolds number is also discussed in this chapter.

## Chapter 7

### **CONCLUSION AND FURTHER WORK**

#### *7.1 CONCLUSION*

Based in the results and discussion in the last chapter in can be inferred from the experiments that as the distance between the two layers of mesh is increased the coefficient of drag also increases to a certain value and the pressure drop due to mesh proves the theory that pressure drop due to mesh is directly proportional to the square of velocity of air.

The coefficient of drag is same for same porosity meshes irrespective of their diameters which indicate that the Reynolds number could be a function of porosity in this case. However there is no experimental data available for two layers of mesh to compare the outcome of the present work for two layers of mesh. But single layer data available from the previous researchers is used to prove the validity of these experiments. It is found that the error associated is within the bounds of the experimental studies.

The equation for single layer of mesh used to compare the present work and work done by other researchers in the case of two layers of mesh and it is found that at lower values of coefficient of drag the results obtained from using two layers of mesh are within 10% to 20% as depicted by the equation for single mesh. However they deviate a lot for higher values of drag coefficients. The experimental data suggests that the drag force on two layers of mesh is less than the sum of drag force of two individual meshes.

The testing environment is extreme for the mesh which is supposed to be installed in a bush area and the drag force obtained from the experimental results would be greater than what the mesh would face in open environment as air would move around the mesh. However the experimental data can be analysed to study the behavior of mesh during high velocity winds. But before the installation of such a mesh into the bush area it must be made sure that the base of the meshes

should be free of any debris that is there should not be any direct contact of fuel such as grass across the two layers of mesh otherwise the effectiveness of these meshes to prevent a fire from spread could be doubted. That is why it is recommended that these meshes should be installed at the banks of the surfaced roads.

## **7.2 FURTHER WORK**

Before the project goes to the stage of recommending the use of wire mesh as a fire suppressant, further study is required in the field of flow through two layers of mesh to establish the results presented here or to sort any discrepancies. Following points may assist in further studies in this field:-

- Make sure that the mesh holding mechanism has some means to assist in tandemness of meshes and must have the ability to keep the meshes stretched at all times during the experiments.
- All the equipments used must be calibrated for accurate readings.
- Pipe fittings must not be loose that connect manometer to the points where the measurements are taken.
- Pitot tube's L-shape must turn into the flow at right angle to the base of the testing section.

# References

- Standards Australia international,” construction of buildings in bushfire-prone areas, AS 3959-1999”, Standards Australia (1999), Sydney, Australia.
- Grantham, C 1984, ‘From miner’s lamp to bushfire protection: The flame arrester’, Journal of Electrical and Electronics Engineering Australia, vol. 4, no. 4, pp. 346-347.
- Australian surveying and land information group, Department of Industry, Science and resource 2001, ‘Planning for bushfire protection, A guide for Councils, Planners, Fire authorities, developers and home owners’, NSW rural fire service, Canberra, Australia.
- New South Wales Government 2006, ‘Planning for bush fire protection- appendix 3’ , NSW Rural Fire Service, Homebush Bay NSW, Australia, viewed Feb. 2008.
- [http://www.bopp.ch/default.aspx?navigation\\_id=2&sprachcode=en&gclid=CPLaicu8m5YCFQ0xawodm3917A](http://www.bopp.ch/default.aspx?navigation_id=2&sprachcode=en&gclid=CPLaicu8m5YCFQ0xawodm3917A)
- Anthony Esposito, Fluid Mechanics with Applications, Department of Manufacturing Engineering, Miami University, Oxford, Ohio.
- A. Sharifian and David R. Buttsworth, Computational Simulation of the Wind-Force on metal meshes, Faculty of Engineering and Surveying, University of Southern Queensland, Australia.
- E. M. Laws and J. L. Livesey, Department of aeronautical engineering, University of Salford, Salford M5 4WT, England)

Davis, G. de Vahl. 1957. The flow of air through wire screens. PhD. Thesis, Cambridge University, England.

Elder, J.W. 1959. Steady flow through non-uniform gauges of arbitrary shape. J. Fluid Mech, 5: 355-63

Baines, W. D., Peterson, E. G. 1951. An investigation of flow through screens. Trans. ASME 73: 467-80.

Cowdrey, C.F. 1968. Some observations on the flow through a single row of parallel closely spaced cylinders. Natl. Phys. Lab. Aeronaut. Note 1064.

White, F.M., Viscous fluid flow, 1974, McGraw-Hill, USA.

Engineering laboratory design inc. 2451 Louisiana Avenue North, Minneapolis, Minnesota 55427 (for wind tunnel reference).

Air flow developments limited, Lancaster road, Buckingham Shire HP123QP, ENGLAND.

Airah Psychometric Chart, Australian Institute of Refrigeration, Air Conditioning & Heating, Inc. Barometer Pressure 101.325 kpa.

Petz, M&Shott, M 1998,'Errors', in F Aprahamian (ed.),Handling experimental data, open University Press, Milton Keynes.

University of Southern Queensland  
FACULTY OF ENGINEERING AND SURVEYING

**ENG 4111/4112 Research Project**  
**PROJECT SPECIFICATION**

FOR: **RANJIT SINGH PADDA**

TOPIC: FORCE ON DOUBLE LAYERED SCREEN AT DIFFERENT POROSITIES  
AND SPACINGS

SUPERVISOR: Dr. Ahmad Sharifian

PROJECT AIM: This project seeks to investigate the drag force as air flow through the double layered screen at different porosities and varying spacing between two layers

PROGRAMME: Issue A, 20<sup>th</sup> march 2008

- 1). Research the background of air flow through screens (mesh).
- 2). Design the fixture to hold meshes at their designated places while conducting experiments through wind tunnel.
- 3). Conduct some preliminary experiments using single mesh to study how instruments work.
- 4). Conduct experiments in USQ lab to have the readings of drag force.
- 5). Research the theory behind the experimental results and discovering the discrepancies.

AGREED \_\_\_\_\_ (Student)  
(Supervisor)

Date / /2008

Date / /2008

Examiner/Co-examiner:

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# Appendix A

## Corrected data for experiments

Included in this Appendix is the corrected data for the woven wire meshes of following specifications:-

A.1. Wire diameter of 0.45 mm and open area of 34%

A.2. Wire diameter of 0.40 mm and open area of 47%

A.3. Wire diameter of 1.6 mm and open area of 57%

A.4. Wire diameter of 1.18 mm and open area of 61%

A.5. Wire diameter of 0.56 mm and open area of 67%

A.6. Wire diameter of 1.6 mm and open area of 67%

A.7. Wire diameter of 1.6 mm and open area of 77%

Table A.1 shows the data collected for woven wire mesh of wire diameter 0.45mm and an open area of 34%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
96.0	12.0	86.0	87.51	22.5	19.71	73.0
87.0	9.5	79.5	79.44	20.0	18.58	66.0
68.5	6.0	63.5	62.42	16.0	16.62	52.0
47.0	4.0	43.5	42.79	11.0	13.78	36.0
33.0	3.0	30.5	30.11	7.5	11.38	25.5
24.0	2.0	22.0	22.07	5.0	9.29	18.5
18.0	1.5	16.5	16.65	3.5	7.77	14.0
14.0	1.0	13.0	12.84	3.0	7.20	11.5
8.5	0.5	8.0	7.95	1.5	5.09	7.0
6.5	0.5	6.0	6.15	1.0	4.16	5.5
<i>For zero spacing</i>						
114.0	12.0	104.00	106.44	20.0	18.58	93.5
106.5	9.5	99.00	99.50	18.5	17.87	88.5
88.0	6.0	83.00	82.30	15.0	16.09	72.0
64.0	4.0	60.50	59.98	10.5	13.46	53.0
44.0	3.0	41.50	41.30	7.0	10.99	37.0
32.0	2.0	30.00	30.07	5.0	9.29	27.0
24.0	1.5	22.50	22.45	4.0	8.31	20.0
18.5	1.0	17.50	17.34	3.0	7.20	15.5
11.5	0.5	11.00	10.95	1.5	5.09	10.0
8.5	0.5	8.00	8.15	1.0	4.16	7.5
<i>For 2mm spacing</i>						



**Table A.1** continued

112.0	12.0	102.0	106.11	15.5	16.36	96.5
104.5	9.5	97.0	98.98	14.5	15.82	90.0
85.5	6.0	80.5	80.92	12.0	14.39	73.5
62.0	4.0	58.5	58.54	9.0	12.47	53.5
43.5	3.0	41.0	41.18	6.0	10.18	37.5
31.5	2.0	29.5	29.95	4.0	8.31	27.0
23.5	1.5	22.0	22.34	3.0	7.20	20.0
18.0	1.0	17.0	17.04	2.5	6.57	16.0
11.0	0.5	10.5	10.45	1.5	5.09	10.0
8.5.0	0.5	8.0	8.15	1.0	4.16	7.5
<i>For 3mm spacing</i>						
112.5	12.0	102.5	107.35	13.5	15.27	98.5
105.0	9.5	97.5	100.23	12.5	14.69	92.0
86.5	6.0	81.5	82.48	10.5	13.46	75.0
62.5	4.0	59.0	59.61	7.5	11.38	54.5
43.5	3.0	41.0	41.38	5.5	9.74	38.0
31.0	2.0	29.0	29.45	4.0	8.31	27.5
23.0	1.5	21.5	21.84	3.0	7.20	20.5
18.0	1.0	17.0	17.04	2.5	6.57	16.0
11.0	0.5	10.5	10.45	1.5	5.09	10.0
8.5	0.5	8.0	8.15	1.0	4.16	7.5
<i>For 5mm spacing</i>						
113.0	12.0	103.0	108.23	12.5	14.69	100.5
105.5	9.5	98.0	101.10	11.5	14.09	93.5
86.5	6.0	81.5	82.85	9.5	12.81	77.0
62.5	4.0	59.0	59.80	7.0	10.99	55.5
43.5	3.0	41.0	41.76	4.5	8.81	39.0
31.5	2.0	29.5	30.15	3.5	7.77	28.5

**Table A.1** continued

23.5	1.5	22.0	22.54	2.5	6.57	21.0
18.5	1.0	17.5	17.74	2.0	5.88	16.5
11.5	0.5	11.0	9.65	1.0	4.16	10.0
8.5	0.5	8.0	9.65	1.0	4.16	7.5
<i>For 8mm spacing</i>						
112.5	12.0	102.5	107.73	12.5	14.69	99.5
105.5	9.5	98.0	101.10	11.5	14.09	93.5
86.5	6.0	81.5	82.85	9.5	12.81	76.5
62.5	4.0	59.0	59.80	7.0	10.99	55.5
43.5	3.0	41.0	41.76	4.5	8.81	39.0
31.5	2.0	29.5	30.34	3.0	7.20	28.5
23.5	1.5	22.0	22.54	2.5	6.57	21.0
18.5	1.0	17.5	17.74	2.0	5.88	16.5
11.0	0.5	10.5	9.65	1.0	4.16	10.5
8.5	0.5	8.0	9.65	1.0	4.16	8.0

Table A.2 shows the data collected for woven wire mesh of wire diameter 0.40mm and an open area of 47%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
84.0	12.0	74.0	73.81	27.5	21.64	53.0
74.5	9.5	67.0	65.41	24.5	20.42	47.0
55.0	6.0	50.0	48.27	18.0	17.51	33.0
38.0	4.0	34.5	33.29	12.5	14.59	23.0
27.0	3.0	24.5	23.78	8.5	12.03	17.0
19.0	2.0	17.0	16.71	6.0	10.11	12.5
14.5	1.5	13.0	12.79	4.5	8.75	9.0
11.5	1.0	10.5	10.17	3.5	7.72	7.5
7.0	0.5	6.5	6.25	2.0	5.84	4.5
5.0	0.5	4.5	4.46	1.5	5.05	3.5
<i>For zero spacing</i>						
104.0	12.0	94.0	93.27	29.0	22.22	72.5
95.5	9.5	88.0	85.68	26.5	21.24	67.0
77.0	6.0	72.0	69.18	21.0	18.91	54.0
55.4	4.0	50.5	48.56	14.5	15.71	38.0
37.5	3.0	35.0	33.72	10.0	13.05	27.0
27.0	2.0	25.0	24.34	7.0	10.92	19.5
20.0	1.5	18.5	18.09	5.0	9.23	15.0
16.0	1.0	15.0	14.48	4.0	8.25	11.5
9.5	0.5	9.0	8.75	2.0	5.84	7.0
7.0	0.5	6.5	6.46	1.5	5.05	5.5
<i>For 2mm spacing</i>						

**Table A.2** continued

103.0	12.0	93.0	96.27	18.0	17.51	83.0
95.5	9.5	88.0	89.32	16.5	16.76	76.5
76.0	6.0	71.0	71.11	13.0	14.88	59.0
53.0	4.0	49.5	49.59	9.0	12.38	41.5
37.0	3.0	34.5	34.71	6.0	10.11	29.5
26.5	2.0	24.5	24.98	4.0	8.25	21.5
20.0	1.5	18.5	18.86	3.0	7.15	16.0
15.5	1.0	14.5	14.56	2.5	6.52	13.0
9.0	0.5	8.5	7.66	1.0	4.13	7.0
7.0	0.5	6.5	7.6637	1.0	4.13	5.5
<i>For 5mm spacing</i>						
103.0	12.0	93.0	96.64	17.0	17.01	83.5
95.5	9.5	88.0	89.32	16.5	16.76	77.5
77.0	6.0	72.0	72.11	13.0	14.88	61.5
53.5	4.0	50.0	50.28	8.5	12.03	43.0
37.0	3.0	34.5	34.71	6.0	10.11	31.0
26.5	2.0	24.5	24.98	4.0	8.25	22.5
20.0	1.5	18.5	18.86	3.0	7.15	16.5
16.0	1.0	15.0	15.25	2.0	5.84	13.5
9.5	0.5	9.0	7.66	1.0	4.13	7.5
7.0	0.5	6.5	7.66	1.0	4.13	6.0
<i>For 8mm spacing</i>						
103.5	12.0	93.5	97.14	17.0	17.01	85.0
95.0	9.5	87.5	89.00	16.0	16.51	78.0
76.5	6.0	71.5	71.61	13.0	14.88	63.0
53.0	4.0	49.5	49.78	8.5	12.03	43.5
37.0	3.0	34.5	34.71	6.0	10.11	31.0
27.0	2.0	25.0	25.48	4.0	8.25	22.0

**Table A.2** continued

20.0	1.5	18.5	18.86	3.0	7.15	17.0
16.0	1.0	15.0	15.25	2.0	5.84	13.0
9.5	0.5	9.0	8.96	1.5	5.05	8.0
7.0	0.5	6.5	6.66	1.0	4.13	6.0
<i>For 10mm spacing</i>						
103.0	12.0	93.0	96.64	17.0	17.01	85.0
95.0	9.5	87.5	89.00	16.0	16.51	79.0
76.0	6.0	71.0	71.29	12.5	14.59	62.5
53.0	4.0	49.5	49.78	8.5	12.03	44.0
37.0	3.0	34.5	34.71	6.0	10.11	30.5
26.5	2.0	24.5	24.98	4.0	8.25	22.0
20.0	1.5	18.5	18.86	3.0	7.15	16.0
15.5	1.0	14.5	14.75	2.0	5.84	13.0
9.0	0.5	8.5	7.66	1.0	4.13	8.0
7.0	0.5	6.5	7.66	1.0	4.13	6.0

Table A.3 shows the data collected for woven wire mesh of wire diameter 1.6mm and an open area of 57%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
57.0	12.0	47.0	39.79	46.5	28.27	7.0
50.0	9.5	42.5	34.96	40.5	26.39	6.0
34.0	6.0	29.0	23.90	27.0	21.54	4.5
22.5	4.0	19.0	15.53	18.5	17.83	3.0
16.0	3.0	13.5	11.06	13.0	14.95	2.0
11.5	2.0	9.5	7.87	9.5	12.78	1.5
8.5	1.5	7.0	5.81	7.0	10.97	1.0
6.5	1.0	5.5	4.39	5.5	9.72	1.0
4.0	0.5	3.5	2.85	3.0	7.18	0.5
3.0	0.5	2.5	2.05	2.5	6.56	0.5
<i>For zero spacing</i>						
71.0	12.0	61.0	56.69	38.5	25.73	28.5
62.5	9.5	55.0	50.02	33.5	24.00	25.5
44.0	6.0	39.0	35.00	24.0	20.31	18.0
30.0	4.0	26.5	23.77	16.5	16.84	12.5
20.5	3.0	18.0	16.31	11.0	13.75	8.5
15.0	2.0	13.0	11.93	8.0	11.73	6.0
11.0	1.5	9.5	8.50	6.5	10.57	4.5
8.5	1.0	7.5	6.58	5.0	9.27	3.5
5.0	0.5	4.5	3.85	3.0	7.18	2.0
3.5	0.5	3.0	2.75	2.0	5.86	1.5
<i>For 2mm spacing</i>						

**Table A.3** continued

74.0	12.0	64.0	59.15	40.0	26.22	30.5
65.0	9.5	57.5	51.61	36.0	24.88	27.0
46.5	6.0	41.5	36.95	25.5	20.94	19.0
31.5	4.0	28.0	25.08	17.0	17.09	13.0
22.0	3.0	19.5	17.44	12.0	14.36	8.5
15.5	2.0	13.5	12.06	9.0	12.44	6.0
11.5	1.5	10.0	8.81	7.0	10.97	4.5
9.0	1.0	8.0	6.89	5.5	9.72	3.5
5.5	0.5	5.0	4.35	3.0	7.18	2.0
4.0	0.5	3.5	3.05	2.5	6.56	1.5
<i>For 3mm spacing</i>						
75.0	12.0	65.0	60.69	38.5	25.73	28.5
65.0	9.5	57.5	52.16	34.5	24.35	25.5
46.5	6.0	41.5	36.95	25.5	20.94	18.0
31.5	4.0	28.0	24.90	17.5	17.34	12.0
22.0	3.0	19.5	17.25	12.5	14.66	8.0
15.5	2.0	13.5	12.06	9.0	12.44	5.5
11.5	1.5	10.0	9.00	6.5	10.57	4.0
9.0	1.0	8.0	7.08	5.0	9.27	3.5
5.5	0.5	5.0	4.35	3.0	7.18	2.0
4.0	0.5	3.5	3.25	2.0	5.86	1.5
<i>For 5mm spacing</i>						
74.0	12.0	64.0	59.52	39.0	25.89	31.0
65.0	9.5	57.5	52.16	34.5	24.35	28.0
46.5	6.0	41.5	37.32	24.5	20.52	20.0
31.5	4.0	28.0	25.27	16.5	16.84	14.0
22.0	3.0	19.5	17.62	11.5	14.06	9.5
15.5	2.0	13.5	12.43	8.0	11.73	7.0

**Table A.3** continued

11.5	1.5	10.0	9.19	6.0	10.16	5.0
9.0	1.0	8.0	7.27	4.5	8.80	4.0
5.5	0.5	4.5	4.05	2.5	6.56	2.5
4.0	0.5	3.5	3.25	2.0	5.86	2.0
<i>For 8mm spacing</i>						
74.5	12.0	64.5	61.11	36.0	24.88	35.5
66.0	9.5	58.5	54.25	31.5	23.27	32.5
47.0	6.0	42.0	38.37	23.0	19.88	22.5
32.0	4.0	28.5	26.14	15.5	16.32	15.5
22.5	3.0	20.0	18.31	11.0	13.75	11.0
16.0	2.0	14.0	13.13	7.5	11.35	8.0
12.0	1.5	10.5	9.89	5.5	9.72	6.5
9.5	1.0	8.5	7.77	4.5	8.80	4.5
5.5	0.5	5.0	4.55	2.5	6.56	3.0
4.0	0.5	3.5	3.25	2.0	5.86	2.0
<i>For 10mm spacing</i>						
75.0	12.0	65.0	61.61	36.0	24.88	35.5
66.0	9.5	58.5	53.07	32.0	23.45	31.5
47.5	6.0	42.5	38.87	23.0	19.88	23.0
32.0	4.0	28.5	26.14	15.5	16.32	15.5
22.5	3.0	20.0	18.31	11.0	13.75	10.5
16.0	2.0	14.0	13.13	7.5	11.35	7.5
12.0	1.5	10.5	9.89	5.5	9.72	5.0
9.5	1.0	8.5	7.77	4.5	8.80	4.5
5.5	0.5	5.0	4.55	2.5	6.56	2.5
4.0	0.5	3.5	3.25	2.0	5.86	2.0



Table A.4 shows the data collected for woven wire mesh of wire diameter 1.18mm and an open area of 61%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
61.0	12.0	51.0	45.41	42.0	26.88	18.5
54.5	9.5	47.0	40.55	37.5	25.40	16.5
36.5	6.0	31.5	26.94	25.5	20.95	11.5
25.0	4.0	21.5	18.58	17.0	17.10	7.5
17.0	3.0	14.5	12.43	12.0	14.37	5.5
12.5	2.0	10.5	9.43	8.0	11.73	4.0
9.0	1.5	7.5	6.69	6.0	10.16	3.0
7.0	1.0	6.0	5.27	4.5	8.80	2.5
4.0	0.5	3.5	2.85	3.0	7.18	1.5
3.0	0.5	2.5	2.24	2.0	5.87	1.5
<i>For zero spacing</i>						
81.0	12.0	71.0	68.15	34.5	24.36	47.0
72.0	9.5	64.5	60.79	30.0	22.72	42.0
53.5	6.0	48.3	45.03	22.0	19.45	31.0
36.5	4.0	33.0	30.82	15.0	16.06	21.5
25.0	3.0	22.5	21.18	10.0	13.12	15.0
18.0	2.0	16.0	15.31	7.0	10.97	10.5
13.5	1.5	12.0	11.38	5.5	9.73	8.0
10.0	1.0	9.0	8.46	4.0	8.30	6.5
6.0	0.5	5.5	5.05	2.5	6.56	4.0
4.5	0.5	4.0	3.95	1.5	5.08	3.0
<i>For 1mm spacing</i>						

**Table A.4** continued

80.0	12.0	70.0	67.70	33.0	23.82	44.0
71.0	9.5	63.5	59.97	29.5	22.53	39.5
50.5	6.0	45.5	42.41	21.5	19.23	28.5
35.0	4.0	31.5	29.50	14.5	15.79	20.0
23.5	3.0	21.0	19.68	10.0	13.12	13.5
17.0	2.0	15.0	14.31	7.0	10.97	10.0
12.5	1.5	11.0	10.57	5.0	9.28	7.5
10.0	1.0	9.0	8.46	4.0	8.30	6.0
6.0	0.5	5.5	5.05	2.5	6.56	3.5
4.0	0.5	3.5	3.45	1.5	5.08	2.5
<i>For 5mm spacing</i>						
82.0	12.0	72.0	70.06	32	23.46	47.5
73.5	9.5	66.0	62.65	29.0	22.34	42.5
53.0	6.0	48.0	45.10	21.0	19.00	31.0
36.0	4.0	32.5	30.50	14.5	15.79	21.5
25.0	3.0	22.5	21.18	10.0	13.12	14.5
17.5	2.0	15.5	14.81	7.0	10.97	10.5
13.0	1.5	11.5	11.07	5.0	9.28	8.0
10.5	1.0	9.5	8.96	4.0	8.30	6.5
5.5	0.5	5.0	4.74	2.0	5.87	3.5
4.0	0.5	3.5	3.45	1.5	5.08	2.5
<i>For 10mm spacing</i>						
81.0	12.0	71.0	69.79	30.0	22.72	49.5
72.5	9.5	65.0	62.58	26.5	21.35	44.5
53.5	6.0	48.5	46.15	19.5	18.32	32.5
36.0	4.0	30.0	31.06	13.0	14.96	22.5
25.0	3.0	22.5	21.56	9.0	12.44	16.0
18.0	2.0	16.0	15.69	6.0	10.16	11.5

**Table A.4** continued

13.5	1.5	12.0	11.77	4.5	8.80	8.5
10.5	1.0	9.5	9.15	3.5	7.76	7.0
6.0	0.5	5.5	5.24	2.0	5.87	4.0
4.5	0.5	4.0	3.95	1.5	5.08	3.0
<i>For 15mm spacing</i>						
81.5	12.0	71.5	70.11	30.5	22.91	52.0
74.0	9.5	66.5	63.71	27.5	21.75	45.5
53.0	6.0	48.0	45.47	19.5	18.55	34.0
36.0	4.0	32.5	30.87	13.5	15.24	23.0
25.0	3.0	22.5	21.37	9.0	12.78	15.5
18.0	2.0	16.00	15.50	6.5	10.58	11.5
13.5	1.5	12.0	11.57	5.0	9.28	8.5
10.5	1.0	9.5	8.96	4.0	8.30	7.0
6.5	0.5	6.0	5.55	2.0	6.55	4.0
4.5	0.5	4.0	3.74	1.5	5.87	3.0
<i>For 18mm spacing</i>						
81.0	12.0	71.0	69.97	29.5	22.53	50.5
72.0	9.5	64.5	62.26	26.0	21.15	45.0
52.5	6.0	47.5	45.15	19.5	18.32	33.0
36.0	4.0	32.5	30.87	13.5	15.24	22.5
25.0	3.0	22.5	21.56	9.0	12.44	15.5
18.0	2.0	16.0	15.50	6.5	10.58	11.5
13.5	1.5	12.0	11.57	5.0	9.28	8.5
10.5	1.0	9.5	8.96	4.0	8.30	7.0
6.0	0.5	5.5	5.24	2.0	5.87	4.0
4.5	0.5	4.0	3.95	1.5	5.08	3.0
<i>For 20mm spacing</i>						
80.0	12.0	70.0	68.80	30	22.71	48.0

**Table A.4** continued

72.0	9.5	64.5	61.893	27.0	21.55	44.5
52.5	6.0	47.5	45.15	19.5	18.32	33.0
36.0	4.0	32.5	30.87	13.5	15.24	22.5
24.5	3.0	22.0	20.87	9.5	12.78	15.5
18.0	2.0	16.0	15.50	6.5	10.58	11.5
13.5	1.5	12.0	11.77	4.5	8.80	8.5
10.5	1.0	9.5	9.15	3.5	7.76	7.0
6.0	0.5	5.5	5.24	2.0	5.87	4.0
4.5	0.5	4.0	3.95	1.5	5.08	3.0
<i>For 25mm spacing</i>						
80.0	12.0	70.0	68.79	30	22.72	49.0
71.0	9.5	63.5	61.08	26.5	21.35	43.5
52.0	6.0	47.0	44.657	19.5	18.31	32.0
35.5	4.0	32.0	30.37	13.5	15.24	22.0
24.5	3.0	22.0	20.87	9.5	12.78	15.5
17.5	2.0	15.5	15.00	6.5	10.58	11.0
13.0	1.5	11.5	11.27	4.5	8.80	8.5
10.5	1.0	9.5	9.15	3.5	7.76	7.0
6.0	0.5	5.5	5.24	2.0	5.87	4.0
4.5	0.5	4.0	3.95	1.5	5.08	3.0

Table A.5 shows the data collected for woven wire mesh of wire diameter 0.56mm and an open area of 67%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
40.5	12.0	30.5	20.53	54.5	30.49	14.0
33.5	9.5	26.0	16.96	45.0	27.70	11.5
22.0	6.0	17.0	11.07	9.5	22.43	8.0
15.0	4.0	11.5	7.71	19.5	18.24	5.0
10.5	3.0	8.0	5.42	13.5	15.17	3.0
7.5	2.0	5.5	3.71	10.0	13.06	2.0
5.5	1.5	4.0	2.65	7.5	11.31	1.5
4.5	1.0	3.5	2.40	5.5	9.69	1.5
2.5	0.5	2.0	1.16	3.5	7.73	1.0
2.0	0.5	1.5	1.05	2.5	6.53	0.5
<i>For zero spacing</i>						
56.5	12.0	46.5	37.61	51.5	29.64	2.5
49.0	9.5	41.5	32.46	45.0	27.70	2.5
33.0	6.0	28.0	21.89	30.0	22.62	2.0
22.5	4.0	19.0	15.03	20.0	18.47	2.0
16.0	3.0	13.5	10.73	14.0	15.45	1.5
11.5	2.0	9.5	7.71	10.0	13.06	1.0
9.0	1.5	7.5	6.15	7.5	11.31	1.0
7.0	1.0	6.0	4.71	6.0	10.12	1.0
4.0	0.5	3.5	2.66	3.5	7.73	0.5
3.0	0.5	2.5	2.05	2.5	6.53	0.5
<i>For 2mm spacing</i>						

**Table A.5** continued

56.0	12.0	46.0	38.56	47.5	28.46	5.0
48.5	9.5	41.0	33.41	41.0	26.44	4.5
32.5	6.0	27.5	22.48	27.0	21.46	3.5
22.5	4.0	19.0	15.58	18.5	17.76	3.0
16.0	3.0	13.5	11.10	13.0	14.89	2.5
11.5	2.0	9.5	7.90	9.5	12.73	2.0
9.0	1.5	7.5	6.33	7.0	10.93	2.0
7.0	1.0	6.0	4.90	5.5	9.69	1.5
4.5	0.5	4.0	3.16	3.5	7.73	1.5
3.5	0.5	3.0	2.55	2.5	6.53	1.5
<i>For 5mm spacing</i>						
56.0	12.0	46.0	39.28	45.5	27.86	7.5
49.0	9.5	41.5	34.44	39.5	25.96	6.5
33.0	6.0	28.0	23.16	26.5	21.26	4.5
22.5	4.0	19.0	15.76	18.0	17.52	3.5
16.0	3.0	13.5	11.29	12.5	14.60	2.5
11.5	2.0	9.5	8.08	9.0	12.39	2.5
9.0	1.5	7.5	6.33	7.0	10.93	2.0
7.0	1.0	6.0	4.90	5.5	9.69	1.5
4.5	0.5	4.0	3.16	3.5	7.73	1.0
3.0	0.5	2.5	2.05	2.5	6.53	1.0
<i>For 8mm spacing</i>						
56.0	12.0	46.0	39.64	44.5	27.55	9.0
49.0	9.5	41.5	34.63	39.0	25.79	8.0
33.0	6.0	28.0	23.53	25.5	20.85	6.0
22.5	4.0	19.0	15.94	17.5	17.28	4.5
16.0	3.0	13.5	11.47	12.0	14.31	3.5
11.5	2.0	9.5	8.27	8.5	12.04	3.0

**Table A.5** continued

9.0	1.5	7.5	6.52	6.5	10.53	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.5	0.5	4.0	3.36	3.0	7.10	1.5
3.5	0.5	3.0	2.55	2.5	6.53	1.0
<i>For 10mm spacing</i>						
56.0	12.0	46.0	40.00	43.5	27.24	10.0
49.0	9.5	41.5	34.99	38.0	25.46	8.5
33.0	6.0	28.0	23.53	25.5	20.85	7.0
22.5	4.0	19.0	15.94	17.5	17.28	5.0
16.0	3.0	13.5	11.47	12.0	14.31	3.5
11.5	2.0	9.5	8.08	9.0	12.39	3.0
9.0	1.5	7.5	6.52	6.5	10.53	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.5	0.5	4.0	3.36	3.0	7.15	1.5
3.5	0.5	3.0	2.55	2.5	6.53	1.0

Table A.6 shows the data collected for woven wire mesh of wire diameter 1.6mm and an open area of 67%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
42.5	12.0	32.5	22.74	54.0	30.33	10.5
36.0	9.5	28.5	19.48	45.0	27.69	9.0
23.5	6.0	18.5	12.76	29.0	22.23	5.0
16.0	4.0	12.5	8.72	19.5	18.23	3.5
11.5	3.0	9.0	6.23	14.0	15.45	2.5
8.0	2.0	6.0	4.22	10.0	13.05	2.0
6.0	1.5	4.5	3.15	7.5	11.31	1.0
5.0	1.0	4.0	2.71	6.0	10.11	1.0
3.0	0.5	2.5	1.67	3.5	7.72	0.5
2.0	0.5	1.5	1.05	2.5	6.53	0.5
<i>For zero spacing</i>						
58.5	12.0	48.5	40.17	50.0	29.19	9.0
50.5	9.5	43.0	34.69	43.0	27.07	7.5
33.5	6.0	28.5	22.76	29.0	22.23	5.0
23.0	4.0	19.5	15.72	19.5	18.23	4.0
16.0	3.0	13.5	11.11	13.0	14.88	3.0
11.5	2.0	9.5	7.90	9.5	12.72	2.5
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	1.5
4.0	0.5	3.5	2.67	3.5	7.72	1.0
3.0	0.5	2.5	2.05	2.5	6.53	0.5
<i>For 5mm spacing</i>						



**Table A.6** continued

60.5	12.0	50.5	42.53	49.0	28.90	11.5
52.0	9.5	44.5	36.38	42.5	26.91	10.0
35.0	6.0	30.0	24.63	28.0	21.84	7.0
23.5	4.0	20.0	16.40	19.0	17.99	5.0
16.5	3.0	14.0	11.61	13.0	14.88	4.0
12.0	2.0	10.0	8.40	9.5	12.72	3.0
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.05	2.5	6.53	1.0
<i>For 8mm spacing</i>						
60.0	12.0	50.0	42.21	48.5	28.75	11.5
52.0	9.5	44.5	36.38	42.5	26.91	10.0
35.0	6.0	30.0	24.44	28.5	22.04	6.5
24.0	4.0	20.5	16.72	19.5	18.23	4.5
16.5	3.0	14.0	11.42	13.5	15.17	3.5
12.0	2.0	10.0	8.40	9.5	12.72	2.5
9.0	1.5	7.5	6.34	7.0	10.92	2.0
7.0	1.0	6.0	4.90	5.5	9.68	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 12mm spacing</i>						
59.0	12.0	49.0	42.48	45.0	27.69	7.5
51.5	9.5	44.0	36.96	39.5	25.94	6.5
34.5	6.0	29.5	24.67	26.5	21.25	4.5
23.5	4.0	20.0	16.77	18.0	17.51	3.0
16.0	3.0	13.5	11.29	12.5	14.59	2.0
11.5	2.0	9.5	8.09	9.0	12.38	1.5

**Table A.6** continued

8.5	1.5	7.0	6.03	6.5	10.52	1.5
7.0	1.0	6.0	5.09	5.0	9.23	1.0
4.0	0.5	3.5	2.86	3.0	7.15	0.5
3.0	0.5	2.5	2.25	2.0	5.84	0.5
<i>For 15mm spacing</i>						
59.5	12.0	49.5	42.61	46.0	28.00	14.0
52.5	9.5	45.0	37.78	40.0	26.11	12.5
35.0	6.0	30.0	24.99	27.0	21.45	8.5
24.0	4.0	20.5	17.27	18.0	17.51	6.0
16.5	3.0	14.0	11.79	12.5	14.59	4.5
12.0	2.0	10.0	8.59	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 18mm spacing</i>						
59.0	12.0	49.0	42.84	44.0	27.38	15.0
52.0	9.5	44.5	37.64	39.0	25.78	13.0
35.0	6.0	30.0	25.35	26.0	21.05	9.0
23.5	4.0	20.0	16.77	18.0	17.51	6.0
16.5	3.0	14.0	11.79	12.5	14.59	4.5
12.0	2.0	10.0	8.59	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0
<i>For 21mm spacing</i>						
58.5	12.0	48.5	42.34	44.0	27.38	15.0

**Table A.6** continued

51.5	9.5	44.5	37.14	39.0	25.78	13.0
34.5	6.0	29.5	24.85	26.0	21.05	8.5
23.5	4.0	20.0	16.95	17.5	17.27	6.0
16.5	3.0	14.0	11.97	12.0	14.30	4.0
11.5	2.0	9.5	8.09	9.0	12.38	3.0
9.0	1.5	7.5	6.53	6.5	10.52	2.5
7.0	1.0	6.0	5.09	5.0	9.23	2.0
4.0	0.5	3.5	2.86	3.0	7.15	1.0
3.0	0.5	2.5	2.25	2.0	5.84	1.0

Table A.7 shows the data collected for woven wire mesh of wire diameter 1.6mm and an open area of 77%.

$\Delta h_2 = \Delta h_A - \Delta h_B$ (Assembly) (mm)	$\Delta h_1 = \Delta h_A - \Delta h_B$ (Frame) (mm)	$\Delta h = \Delta h_2 - \Delta h_1$ (Mesh) (mm)	$\Delta h_{CR}$ (corrected) (mm)	$h_B' - h_B$ (mm)	$V_{air}$ (m/s)	$h_B' - h_A$ (mm)
<i>For single mesh</i>						
32.0	12.0	22.0	9.45	61.0	32.44	29.0
26.0	9.5	18.5	7.78	49.0	29.10	24.0
17.0	6.0	12.0	5.02	32.0	23.50	15.5
11.5	4.0	8.0	3.39	21.5	19.26	10.0
8.0	3.0	5.5	2.30	15.0	16.09	7.0
5.5	2.0	3.5	1.48	10.5	13.46	4.5
4.5	1.5	3.0	1.62	7.5	11.37	3.5
3.5	1.0	2.5	1.19	6.0	10.17	2.5
2.0	0.5	1.5	0.65	3.5	7.77	1.5
1.5	0.5	1.0	0.54	2.5	6.57	1.0
<i>For zero spacing</i>						
40.5	12.0	30.5	16.85	64.0	33.23	24.0
33.0	9.5	25.5	13.35	53.0	30.24	19.5
22.0	6.0	17.0	9.29	34.0	24.22	12.0
15.0	4.0	11.5	6.71	22.0	19.48	7.5
10.0	3.0	7.5	4.30	15.0	16.09	4.5
7.0	2.0	5.0	2.98	10.5	13.46	3.5
5.5	1.5	4.0	2.42	8.0	11.75	2.5
4.0	1.0	3.0	1.49	6.5	10.59	2.0
2.5	0.5	2.0	1.15	3.5	7.77	1.0
1.5	0.5	1.0	0.54	2.5	6.57	0.5

**Table A.7** continued

<i>For 5mm spacing</i>						
42.5	12.0	32.5	20.68	59.0	31.90	17.0
34.5	9.5	27.0	16.49	48.5	28.93	14.0
23.5	6.0	18.0	11.21	31.5	23.31	9.0
15.5	4.0	12.0	7.76	20.5	18.81	5.5
10.5	3.0	8.0	5.17	14.0	15.54	3.0
7.5	2.0	5.5	3.86	9.5	12.80	2.0
5.5	1.5	4.0	2.80	7.0	10.99	1.5
4.5	1.0	3.5	2.38	5.5	9.74	1.5
2.5	0.5	2.0	1.15	3.5	7.77	1.0
2.0	0.5	1.5	1.04	2.5	6.57	0.5
<i>For 10mm spacing</i>						
44.5	12.0	34.5	23.04	58.0	31.63	14.0
36.5	9.5	29.0	18.67	48.0	28.78	12.0
24.0	6.0	19.0	12.02	32.0	23.50	8.0
16.5	4.0	13.0	8.39	21.5	19.26	5.0
11.5	3.0	9.0	5.98	14.5	15.82	3.0
8.0	2.0	6.0	4.17	10.0	13.13	2.0
6.0	1.5	4.5	3.12	7.5	11.37	1.5
4.5	1.0	3.5	2.38	5.5	9.74	1.0
3.0	0.5	2.5	1.65	3.5	7.77	0.5
2.0	0.5	1.5	1.04	2.5	6.57	0.5
<i>For 15mm spacing</i>						
44.5	12.0	34.5	25.05	52.5	30.09	8.0
37.0	9.5	29.5	20.64	44.0	27.55	7.5
24.5	6.0	19.5	13.26	30.0	22.75	5.5
16.5	4.0	13.0	8.76	20.5	18.80	4.5
11.5	3.0	9.0	5.98	14.5	15.82	3.0

**Table A.7** continued

8.0	2.0	6.0	4.17	10.0	13.13	2.0
6.0	1.5	4.5	3.30	7.0	10.99	1.0
5.0	1.0	4.0	2.88	5.5	9.74	1.0
2.5	0.5	2.0	1.35	3.0	7.19	0.5
2.0	0.5	1.5	1.04	2.5	6.57	0.5
<i>For 18mm spacing</i>						
44.5	12.0	34.5	23.95	55.5	30.94	11.5
37.5	9.5	30.0	20.05	47.0	28.47	10.0
24.5	6.0	19.5	12.89	31.0	23.13	6.5
16.5	4.0	13.0	8.58	21.0	19.03	4.5
11.5	3.0	9.0	5.98	14.5	15.82	3.0
8.0	2.0	6.0	4.17	10.0	13.13	3.0
6.0	1.5	4.5	3.12	7.5	11.37	1.5
5.0	1.0	4.0	2.88	5.5	9.74	1.0
2.5	0.5	2.0	1.15	3.5	7.77	0.5
2.0	0.5	1.5	1.04	2.5	6.57	0.5
<i>For 21mm spacing</i>						
44.0	12.0	34.0	24.00	54.0	30.52	9.5
37.0	9.5	29.5	20.09	45.5	28.02	8.5
24.5	6.0	19.5	13.26	30.0	22.75	5.5
16.5	4.0	13.0	9.13	19.5	18.34	3.0
11.5	3.0	9.0	6.74	12.5	14.68	1.5
8.0	2.0	6.0	4.55	9.0	12.46	0.5
6.0	1.5	4.5	3.49	6.5	10.59	0.5
4.5	1.0	3.5	2.57	5.0	9.29	0.5
2.5	0.5	2.0	1.35	3.0	7.19	0.5
2.0	0.5	1.5	1.24	2.0	5.87	0.5
<i>For 25mm spacing</i>						

**Table A.7** continued

42.0	12.0	32.0	22.72	52.0	29.95	10.0
35.0	9.5	27.5	18.83	43.5	27.39	9.0
23.0	6.0	18.0	12.13	29.0	22.37	6.0
16.0	4.0	12.5	8.63	19.5	18.34	4.0
11.0	3.0	8.5	5.86	13.5	15.26	2.5
8.0	2.0	6.0	4.36	9.5	12.80	2.0
6.0	1.5	4.5	3.30	7.0	10.99	1.0
4.5	1.0	3.5	2.38	5.5	9.74	1.0
2.5	0.5	2.0	1.35	3.0	7.19	0.5
1.5	0.5	1.0	0.74	2.0	5.87	0.5

## **Appendix B**

### **Error analysis for the experimental data**

Included in this Appendix is the error analysis data for the woven wire meshes of following specifications:-

B.1. Wire diameter of 0.45 mm and open area of 34%

B.2. Wire diameter of 0.40 mm and open area of 47%

B.3. Wire diameter of 1.6 mm and open area of 57%

B.4. Wire diameter of 1.18 mm and open area of 61%

B.5. Wire diameter of 0.56 mm and open area of 67%

B.6. Wire diameter of 1.6 mm and open area of 67%

B.7. Wire diameter of 1.6 mm and open area of 77%



**Table B.1** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 0.45mm and open area of 34%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved by using single layer of mesh.</i>					
87.51	0.80	19.71	1.11	3.88	2.36
79.44	0.89	18.58	1.25	3.97	2.65
62.42	1.13	16.62	1.56	3.90	3.32
42.79	1.65	13.78	2.27	3.89	4.83
30.11	2.34	11.38	3.33	4.01	7.06
22.07	3.20	9.29	5.00	4.41	10.51
16.65	4.24	7.77	7.14	4.76	14.90
12.84	5.50	7.20	8.33	4.27	17.55
7.95	8.89	5.09	16.67	5.29	34.49
6.15	11.48	4.16	25.00	6.14	51.30
<i>Following are the percentage errors involved by using two layers of mesh at zero spacing.</i>					
106.44	0.66	18.58	1.25	5.32	2.58
99.50	0.71	17.87	1.35	5.38	2.79
82.30	0.85	16.09	1.67	5.48	3.44
59.98	1.17	13.46	2.38	5.71	4.90
41.30	1.71	10.99	3.57	5.90	7.34
30.07	2.35	9.29	5.00	6.01	10.23
22.45	3.14	8.31	6.25	5.61	12.89
17.34	4.07	7.20	8.33	5.77	17.15
10.95	6.45	5.09	16.67	7.29	33.95
8.15	8.66	4.16	25.00	8.13	50.74
<i>Following are the percentage errors involved by using two layers of mesh at 2mm spacing.</i>					

**Table B.1** continued

106.11	0.66	16.36	1.61	6.84	3.29
98.98	0.71	15.82	1.72	6.82	3.52
80.92	0.87	14.39	2.08	6.74	4.25
58.54	1.20	12.47	2.78	6.50	5.68
41.18	1.71	10.18	4.17	6.86	8.50
29.95	2.36	8.31	6.25	7.49	12.73
22.34	3.16	7.20	8.33	7.44	16.96
17.04	4.14	6.57	10.00	6.81	20.42
10.45	6.76	5.09	16.67	6.96	34.01
8.15	8.66	4.16	25.00	8.13	50.74
<i>Following are the percentage errors involved by using two layers of mesh at 3mm spacing.</i>					
107.35	0.65	15.27	1.85	7.94	3.76
100.23	0.70	14.69	2.00	8.02	4.06
82.48	0.85	13.46	2.38	7.86	4.83
59.61	1.18	11.38	3.33	7.94	6.77
41.38	1.70	9.74	4.54	7.53	9.25
29.45	2.40	8.31	6.25	7.36	12.74
21.84	3.23	7.20	8.33	7.27	16.97
17.04	4.14	6.57	10.00	6.81	20.42
10.45	6.76	5.09	16.67	6.96	34.01
8.15	8.66	4.16	25.00	8.13	50.74
<i>Following are the percentage errors involved by using two layers of mesh at 5mm spacing.</i>					
108.23	0.65	14.69	2.00	8.66	4.05
101.10	0.69	14.09	2.17	8.79	4.40
82.85	0.85	12.81	2.63	8.71	5.33
59.80	1.18	10.99	3.57	8.55	7.24
41.76	1.69	8.81	5.56	9.29	11.24
30.15	2.34	7.77	7.14	8.62	14.47

**Table B.1** continued

22.54	3.13	6.57	10.00	9.01	20.24
17.74	3.98	5.88	12.50	8.86	25.31
9.65	7.32	4.16	25.00	9.63	50.53
9.65	7.32	4.16	25.00	9.63	50.53
<i>Following are the percentage errors involved by using two layers of mesh at 8mm spacing.</i>					
107.73	0.65	14.69	2.00	8.62	4.05
101.10	0.69	14.09	2.17	8.79	4.40
82.85	0.85	12.81	2.63	8.71	5.33
59.80	1.18	10.99	3.57	8.55	7.24
41.76	1.69	8.81	5.56	9.29	11.24
30.34	2.32	7.20	8.33	10.11	16.82
22.54	3.13	6.57	10.00	9.01	20.24
17.74	3.98	5.88	12.50	8.86	25.31
9.65	7.32	4.16	25.00	9.63	50.53
9.65	7.32	4.16	25.00	9.63	50.53

**Table B.2** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 0.40mm and open area of 47%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved for using single mesh</i>					
73.81	0.95	21.64	0.91	2.68	2.05
65.41	1.08	20.42	1.02	2.67	2.30
48.27	1.46	17.51	1.39	2.68	3.14
33.29	2.12	14.59	2.00	2.66	4.52
23.78	2.97	12.03	2.94	2.79	6.59
16.71	4.22	10.11	4.17	2.78	9.34
12.79	5.52	8.75	5.56	2.84	12.41
10.17	6.95	7.72	7.14	2.90	15.88
6.25	11.29	5.84	12.50	3.12	27.43
4.46	15.85	5.05	16.67	2.97	36.91
<i>Following are the percentage errors involved for using two layers of mesh at zero spacing.</i>					
93.27	0.75	22.22	0.86	3.21	1.88
85.68	0.82	21.24	0.94	3.23	2.05
69.18	1.02	18.91	1.19	3.29	2.59
48.56	1.45	15.71	1.72	3.35	3.74
33.72	2.09	13.05	2.50	3.37	5.42
24.34	2.90	10.92	3.57	3.47	7.71
18.09	3.90	9.23	5.00	3.61	10.73
14.48	4.88	8.25	6.25	3.62	13.41
8.75	8.07	5.84	12.50	4.37	26.27
6.46	10.94	5.05	16.67	4.31	35.08
<i>Following are the percentage errors involved for using two layers of mesh at 2mm spacing.</i>					
96.27	0.73	17.51	1.39	5.34	2.87

**Table B.2** continued

89.32	0.79	16.76	1.52	5.41	3.13
71.11	0.99	14.88	1.92	5.46	3.97
49.59	1.42	12.38	2.78	5.50	5.73
34.71	2.03	10.11	4.17	5.78	8.57
24.98	2.83	8.25	6.25	6.24	12.82
18.86	3.74	7.15	8.33	6.28	17.08
14.56	4.85	6.52	10.00	5.83	20.58
7.66	9.22	4.13	25.00	7.64	50.84
7.6637	9.2267	4.13	25.00	7.6498	50.8442
<i>Following are the percentage errors involved for using two layers of mesh at 5mm spacing.</i>					
96.64	0.73	17.01	1.47	5.68	3.03
89.32	0.79	16.76	1.52	5.41	3.13
72.11	0.98	14.88	1.92	5.54	3.96
50.28	1.40	12.03	2.94	5.91	6.04
34.71	2.03	10.11	4.17	5.78	8.57
24.98	2.83	8.25	6.25	6.24	12.81
18.86	3.74	7.15	8.33	6.28	17.08
15.25	4.63	5.84	12.50	7.61	25.42
7.66	9.22	4.13	25.00	7.64	50.84
7.66	9.22	4.13	25.00	7.64	50.84
<i>Following are the percentage errors involved for using two layers of mesh at 8mm spacing.</i>					
97.14	0.72	17.01	1.47	5.71	3.02
89.00	0.79	16.51	1.56	5.55	3.22
71.61	0.98	14.88	1.92	5.50	3.97
49.78	1.42	12.03	2.94	5.85	6.05
34.71	2.03	10.11	4.16	5.78	8.57
25.48	2.77	8.25	6.25	6.37	12.80
18.86	3.74	7.15	8.33	6.28	17.08

**Table B.2** continued

15.25	4.63	5.84	12.50	7.61	25.42
8.96	7.89	5.05	16.67	5.98	34.25
6.66	10.61	4.13	25.00	6.65	51.11
<i>Following are the percentage errors involved for using two layers of mesh at 10mm spacing.</i>					
96.64	0.73	17.01	1.47	5.68	3.03
89.00	0.79	16.51	1.56	5.55	3.22
71.29	0.99	14.59	2.00	5.70	4.12
49.78	1.42	12.03	2.94	5.85	6.05
34.71	2.03	10.11	4.17	5.78	8.57
24.98	2.83	8.25	6.25	6.24	12.81
18.86	3.74	7.15	8.33	6.28	17.08
14.75	4.79	5.84	12.50	7.36	25.45
7.66	9.22	4.13	25.00	7.64	50.84
7.66	9.22	4.13	25.00	7.64	50.84

**Table B.3** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 1.6mm and open area of 57%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved for using single mesh</i>					
39.79	1.77	28.27	0.54	0.85	2.07
34.96	2.02	26.39	0.61	0.86	2.36
23.90	2.95	21.54	0.93	0.88	3.48
15.53	4.55	17.83	1.35	0.83	5.29
11.06	6.38	14.95	1.92	0.85	7.45
7.87	8.97	12.78	2.63	0.82	10.41
5.81	12.15	10.97	3.57	0.83	14.09
4.39	16.10	9.72	4.54	0.79	18.49
2.85	24.76	7.18	8.33	0.95	29.84
2.05	34.47	6.56	10.00	0.81	39.86
<i>Following are the percentage errors involved by using two layers of mesh with zero spacing</i>					
56.69	1.24	25.73	0.64	1.47	1.80
50.02	1.41	24.00	0.74	1.49	2.05
35.00	2.01	20.31	1.04	1.45	2.90
23.77	2.97	16.84	1.51	1.44	4.24
16.31	4.33	13.75	2.27	1.48	6.28
11.93	5.92	11.73	3.12	1.49	8.61
8.50	8.31	10.57	3.84	1.30	11.32
6.58	10.74	9.27	5.00	1.31	14.67
3.85	18.34	7.18	8.33	1.28	24.78
2.75	25.69	5.86	12.50	1.37	35.84
<i>Following are the percentage errors involved by using two layers of mesh with 2mm spacing</i>					
59.15	1.19	26.22	0.62	1.47	1.72

**Table B.3** continued

51.61	1.37	24.88	0.69	1.43	1.95
36.95	1.91	20.94	0.98	1.44	2.73
25.08	2.81	17.09	1.47	1.47	4.07
17.44	4.05	14.36	2.08	1.45	5.81
12.06	5.86	12.44	2.78	1.34	8.07
8.81	8.01	10.97	3.57	1.25	10.73
6.89	10.26	9.72	4.54	1.25	13.70
4.35	16.23	7.18	8.33	1.45	23.26
3.05	23.17	6.56	10.00	1.21	30.61
<i>Following are the percentage errors involved by using two layers of mesh with 3mm spacing</i>					
60.69	1.16	25.73	0.65	1.57	1.74
52.16	1.35	24.35	0.72	1.51	1.98
36.95	1.91	20.94	0.98	1.44	2.73
24.90	2.83	17.34	1.43	1.42	4.02
17.25	4.09	14.66	2.00	1.38	5.72
12.06	5.86	12.44	2.78	1.34	8.07
9.00	7.84	10.57	3.84	1.38	10.99
7.08	9.98	9.27	5.00	1.41	14.13
4.35	16.24	7.18	8.33	1.45	23.26
3.25	21.74	5.86	12.50	1.62	33.13
<i>Following are the percentage errors involved by using two layers of mesh with 5mm spacing</i>					
59.52	1.18	25.89	0.64	1.52	1.74
52.16	1.35	24.35	0.72	1.51	1.98
37.32	1.89	20.52	1.02	1.52	2.78
25.27	2.79	16.84	1.51	1.53	4.12
17.62	4.01	14.06	2.17	1.53	5.91
12.43	5.68	11.73	3.12	1.55	8.44
9.19	7.68	10.16	4.16	1.53	11.34



**Table B.3** continued

7.27	9.72	8.80	5.55	1.61	14.76
4.05	17.45	6.56	10.00	1.61	26.54
3.25	21.74	5.86	12.50	1.62	33.13
<i>Following are the percentage errors involved by using two layers of mesh with 8mm spacing</i>					
61.11	1.15	24.88	0.69	1.69	1.80
54.25	1.30	23.27	0.79	1.72	2.05
38.37	1.84	19.88	1.08	1.66	2.84
26.14	2.70	16.32	1.61	1.68	4.20
18.31	3.86	13.75	2.27	1.66	5.96
13.13	5.38	11.35	3.33	1.75	8.56
9.89	7.14	9.72	4.54	1.79	11.56
7.77	9.09	8.80	5.55	1.72	14.36
4.55	15.53	6.56	10.00	1.81	25.32
3.25	21.74	5.86	12.50	1.62	33.13
<i>Following are the percentage errors involved by using two layers of mesh with 10mm spacing</i>					
61.61	1.14	24.88	0.69	1.71	1.80
53.07	1.33	23.45	0.78	1.65	2.05
38.87	1.81	19.88	1.09	1.69	2.83
26.14	2.70	16.32	1.61	1.68	4.20
18.31	3.86	13.75	2.27	1.66	5.96
13.13	5.38	11.35	3.33	1.75	8.56
9.89	7.14	9.72	4.54	1.79	11.56
7.77	9.09	8.80	5.55	1.72	14.36
4.55	15.53	6.56	10.00	1.81	25.32
3.25	21.74	5.86	12.50	1.62	33.13

**Table B.4** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 1.18mm and open area of 61%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved by using single layer of mesh.</i>					
45.41	1.55	26.88	0.59	1.08	1.95
40.55	1.74	25.40	0.67	1.08	2.19
26.94	2.62	20.95	0.98	1.05	3.27
18.58	3.80	17.10	1.47	1.09	4.80
12.43	5.68	14.37	2.08	1.03	7.04
9.43	7.49	11.73	3.12	1.18	9.75
6.69	10.55	10.16	4.17	1.11	13.45
5.27	13.41	8.80	5.56	1.17	17.41
2.85	24.76	7.18	8.33	0.95	29.84
2.24	31.43	5.87	12.50	1.12	40.16
<i>Following are the percentage errors involved by using two layers of mesh with zero spacing</i>					
68.15	1.03	24.36	0.53	1.97	1.48
60.79	1.16	22.72	0.59	2.02	1.66
45.03	1.57	19.45	0.81	2.04	2.25
30.82	2.29	16.06	1.16	2.05	3.26
21.18	3.33	13.12	1.67	2.11	4.71
15.31	4.61	10.97	2.38	2.19	6.63
11.38	6.21	9.73	3.12	2.06	8.81
8.46	8.35	8.30	3.85	2.11	11.35
5.05	13.99	6.56	6.25	2.01	18.76
3.95	17.88	5.08	8.33	2.63	24.44
<i>Following are the percentage errors involved by using two layers of mesh with 1mm spacing</i>					
67.70	1.04	23.82	0.76	2.05	1.84

**Table B.4** continued

59.97	1.17	22.53	0.85	2.03	2.06
42.41	1.66	19.23	1.16	1.97	2.86
29.50	2.39	15.79	1.72	2.03	4.19
19.68	3.59	13.12	2.50	1.96	6.15
14.31	4.93	10.97	3.57	2.04	8.68
10.57	6.68	9.28	5.00	2.11	12.02
8.46	8.35	8.30	6.25	2.11	15.03
5.05	13.99	6.56	10.00	2.01	24.41
3.45	20.47	5.08	16.67	2.30	39.12
<i>Following are the percentage errors involved by using two layers of mesh with 5mm spacing</i>					
70.06	1.00	23.46	0.78	2.19	1.86
62.65	1.12	22.34	0.86	2.16	2.06
45.10	1.56	19.00	1.19	2.14	2.85
30.50	2.31	15.79	1.72	2.10	4.158
21.18	3.33	13.12	2.50	2.11	6.01
14.81	4.77	10.97	3.57	2.11	8.59
11.07	6.38	9.28	5.00	2.21	11.86
8.96	7.88	8.30	6.25	2.23	14.78
4.74	14.89	5.87	12.50	2.37	29.09
3.45	20.47	5.08	16.67	2.30	39.12
<i>Following are the percentage errors involved by using two layers of mesh with 10mm spacing</i>					
69.79	1.01	22.72	0.83	2.32	1.95
62.58	1.12	21.35	0.94	2.36	2.19
46.15	1.53	18.32	1.28	2.36	2.98
31.06	2.27	14.96	1.92	2.38	4.46
21.56	3.27	12.44	2.77	2.39	6.45
15.69	4.50	10.16	4.16	2.61	9.47
11.77	6.00	8.80	5.55	2.61	12.63

**Table B.4** continued

9.15	7.72	7.76	7.14	2.61	16.23
5.24	13.42	5.87	12.50	2.62	28.39
3.95	17.88	5.08	16.67	2.63	37.82
<i>Following are the percentage errors involved by using two layers of mesh with 15mm spacing</i>					
70.11	1.00	22.91	0.82	2.29	1.92
63.71	1.10	21.75	0.91	2.31	2.13
45.47	1.55	18.55	1.28	2.27	2.99
30.87	2.29	15.24	1.85	2.28	4.35
21.37	3.30	12.78	2.78	2.25	6.46
15.50	4.56	10.58	3.84	2.38	8.94
11.57	6.10	9.28	5.00	2.31	11.71
8.96	7.88	8.30	6.25	2.23	14.78
5.55	12.73	6.55	12.50	2.22	28.05
3.74	18.85	5.87	16.67	1.87	38.29
<i>Following are the percentage errors involved by using two layers of mesh with 18mm spacing</i>					
69.97	1.01	22.53	0.85	2.37	1.97
62.26	1.13	21.15	0.96	2.39	2.23
45.15	1.56	18.32	1.28	2.31	3.00
30.87	2.29	15.24	1.85	2.28	4.35
21.56	3.27	12.44	2.78	2.39	6.452
15.50	4.56	10.58	3.85	2.38	8.94
11.57	6.10	9.28	5.00	2.31	11.78
8.96	7.88	8.30	6.25	2.23	14.78
5.24	13.47	5.87	12.50	2.62	28.39
3.95	17.88	5.08	16.67	2.63	37.82
<i>Following are the percentage errors involved by using two layers of mesh with 20mm spacing</i>					
68.80	1.02	22.71	0.83	2.29	1.95
61.893	1.14	21.55	0.93	2.29	2.17

**Table B.4** continued

45.15	1.56	18.32	1.28	2.31	3.00
30.87	2.29	15.24	1.85	2.28	4.35
20.87	3.38	12.78	2.78	2.19	6.50
15.50	4.56	10.58	3.84	2.38	8.94
11.77	6.00	8.80	5.55	2.61	12.62
9.15	7.72	7.76	7.14	2.61	16.23
5.24	13.46	5.87	12.50	2.62	28.39
3.95	17.88	5.08	16.67	2.63	37.82
<i>Following are the percentage errors involved by using two layers of mesh with 25mm spacing</i>					
68.79	1.02	22.72	0.83	2.29	1.95
61.08	1.15	21.35	0.94	2.30	2.21
44.657	1.58	18.31	1.28	2.29	3.01
30.37	2.32	15.24	1.85	2.25	4.37
20.87	3.38	12.78	2.63	2.19	6.25
15.00	4.71	10.58	3.84	2.30	9.02
11.27	6.27	8.80	5.55	2.50	12.76
9.15	7.72	7.76	7.14	2.61	16.23
5.24	13.46	5.87	12.50	2.62	28.39
3.95	17.88	5.08	16.67	2.635	37.82

**Table B.5** shows the errors associated with the experimental readings corresponding to the values of quantities measured for wire diameter 0.56mm and open area of 67%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved by using single layer of mesh.</i>					
20.53	3.44	30.49	0.46	0.378	3.56
16.96	4.16	27.70	0.56	0.37	4.31
11.07	6.38	22.43	0.85	0.37	6.60
7.71	9.16	18.24	1.28	0.39	9.51
5.42	13.03	15.17	1.85	0.40	13.53
3.71	19.02	13.06	2.50	0.37	19.66
2.65	26.67	11.31	3.33	0.35	27.49
2.40	29.42	9.69	4.55	0.43	30.79
1.16	60.48	7.73	7.14	0.33	62.14
1.05	66.71	6.53	10.00	0.42	69.65
<i>Following are the percentage errors involved by using two layers of mesh with zero spacing</i>					
37.61	1.87	29.64	0.48	0.73	2.11
32.46	2.17	27.70	0.56	0.72	2.44
21.89	3.23	22.62	0.83	0.72	3.63
15.03	4.70	18.47	1.25	0.75	5.32
10.73	6.58	15.45	1.79	0.76	7.49
7.71	9.16	13.06	2.50	0.77	10.43
6.15	11.49	11.31	3.33	0.82	13.28
4.71	14.99	10.12	4.17	0.78	17.15
2.66	26.49	7.73	7.14	0.76	30.09
2.05	34.32	6.53	10.00	0.82	39.72
<i>Following are the percentage errors involved by using two layers of mesh with 2mm spacing</i>					
38.56	1.83	28.46	0.53	0.81	2.11

**Table B.5** continued

33.41	2.11	26.44	0.61	0.81	2.44
22.48	3.14	21.46	0.93	0.83	3.65
15.58	4.53	17.76	1.35	0.84	5.28
11.10	6.36	14.89	1.92	0.85	7.43
7.90	8.94	12.73	2.63	0.83	10.38
6.33	11.15	10.93	3.57	0.90	13.24
4.90	14.42	9.69	4.55	0.89	17.04
3.16	22.31	7.73	7.14	0.90	26.49
2.55	27.62	6.53	10.00	1.02	34.10
<i>Following are the percentage errors involved by using two layers of mesh with 5mm spacing</i>					
39.28	1.80	27.86	0.55	0.86	2.10
34.44	2.05	25.96	0.63	0.87	2.41
23.16	3.05	21.26	0.94	0.87	3.58
15.76	4.48	17.52	1.39	0.87	5.27
11.29	6.26	14.60	2.00	0.90	7.43
8.08	8.74	12.39	2.78	0.89	10.35
6.33	11.15	10.93	3.57	0.90	13.24
4.90	14.42	9.69	4.55	0.89	17.04
3.16	22.31	7.73	7.14	0.90	26.49
2.05	34.32	6.53	10.00	0.82	39.72
<i>Following are the percentage errors involved by using two layers of mesh with 8mm spacing</i>					
39.64	1.78	27.55	0.56	0.89	2.10
34.63	2.04	25.79	0.64	0.88	2.41
23.53	3.00	20.85	0.98	0.92	3.58
15.94	4.43	17.28	1.43	0.91	5.27
11.47	6.16	14.31	2.08	0.95	7.43
8.27	8.54	12.04	2.94	0.97	10.37
6.52	10.83	10.53	3.85	1.00	13.28

**Table B.5** continued

5.09	13.87	9.23	5.00	1.02	17.10
3.36	21.01	7.10	8.33	1.12	26.81
2.55	27.62	6.53	10.00	1.02	34.10
<i>Following are the percentage errors involved by using two layers of mesh with 10mm spacing</i>					
40.00	1.76	27.24	0.57	0.91	2.10
34.99	2.02	25.46	0.65	0.92	2.41
23.53	3.00	20.85	0.98	0.92	3.58
15.94	4.43	17.28	1.42	0.91	5.27
11.47	6.16	14.31	2.08	0.95	7.43
8.08	8.74	12.39	2.77	0.89	10.35
6.52	10.83	10.53	3.84	1.00	13.28
5.09	13.87	9.23	5.00	1.02	17.10
3.36	21.01	7.15	8.33	1.12	26.81
2.55	27.62	6.53	10.00	1.02	34.10



**Table B.6** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 1.6mm and open area of 67%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved by using single mesh of mesh.</i>					
22.74	3.10	30.33	0.46	0.42	3.24
19.48	3.62	27.69	0.56	0.43	3.79
12.76	5.53	22.23	0.86	0.44	5.80
8.72	8.10	18.23	1.28	0.44	8.50
6.23	11.33	15.45	1.79	0.44	11.88
4.22	16.74	13.05	2.50	0.42	17.47
3.15	22.43	11.31	3.33	0.41	23.40
2.71	26.00	10.11	4.16	0.45	27.312
1.67	42.27	7.72	7.14	0.47	44.62
1.05	66.71	6.53	10.00	0.42	69.65
<i>Following are the percentage errors involved by using two layers of mesh with zero spacing</i>					
40.17	1.76	29.19	0.50	0.80	2.02
34.69	2.03	27.07	0.58	0.80	2.34
22.76	3.10	22.23	0.86	0.78	3.55
15.72	4.49	18.23	1.28	0.80	5.17
11.11	6.36	14.88	1.92	0.85	7.43
7.90	8.94	12.72	2.63	0.83	10.37
6.34	11.14	10.92	3.57	0.90	13.24
4.90	14.40	9.68	4.54	0.89	17.03
2.67	26.45	7.72	7.14	0.76	30.06
2.05	34.32	6.53	10.00	0.82	39.72
<i>Following are the percentage errors involved by using two layers of mesh with 5mm spacing</i>					
42.53	1.66	28.90	0.51	0.86	1.95

**Table B.6** continued

36.38	1.94	26.91	0.58	0.85	2.27
24.63	2.87	21.84	0.89	0.87	3.38
16.40	4.30	17.99	1.31	0.86	5.04
11.61	6.08	14.88	1.92	0.89	7.20
8.40	8.40	12.72	2.63	0.88	9.92
6.34	11.14	10.92	3.57	0.90	13.22
4.90	14.40	9.68	4.54	0.89	17.03
2.86	24.67	7.15	8.33	0.95	29.77
2.05	34.32	6.53	10.0	0.82	39.72
<i>Following are the percentage errors involved by using two layers of mesh with 8mm spacing</i>					
42.21	1.67	28.75	0.51	0.87	1.96
36.38	1.94	26.91	0.59	0.85	2.27
24.44	2.89	22.04	0.88	0.85	3.38
16.72	4.22	18.23	1.28	0.85	4.94
11.42	6.18	15.17	1.85	0.84	7.21
8.40	8.40	12.72	2.63	0.88	9.92
6.34	11.14	10.92	3.57	0.90	13.21
4.90	14.40	9.68	4.54	0.89	17.03
2.86	24.67	7.15	8.33	0.95	29.77
2.25	31.31	5.84	12.50	1.12	40.07
<i>Following are the percentage errors involved by using two layers of mesh with 12mm spacing</i>					
42.48	1.66	27.69	0.56	0.94	2.00
36.96	1.91	25.94	0.63	0.93	2.29
24.67	2.86	21.25	0.94	0.93	3.43
16.77	4.21	17.51	1.39	0.93	5.04
11.29	6.25	14.59	2.00	0.90	7.42
8.09	8.73	12.38	2.78	0.90	10.35
6.03	11.72	10.52	3.84	0.92	14.02

**Table B.6** continued

5.09	13.87	9.23	5.00	1.01	17.10
2.86	24.67	7.15	8.33	0.95	29.77
2.25	31.31	5.84	12.50	1.12	40.07
<i>Following are the percentage errors involved by using two layers of mesh with 15mm spacing</i>					
42.61	1.65	28.00	0.54	0.92	1.98
37.78	1.87	26.11	0.62	0.94	2.25
24.99	2.82	21.45	0.93	0.92	3.38
17.27	4.09	17.51	1.39	0.96	4.94
11.79	5.99	14.59	2.00	0.94	7.20
8.59	8.22	12.38	2.78	0.95	9.92
6.53	10.82	10.52	3.84	1.00	13.20
5.09	13.87	9.23	5.00	1.01	17.10
2.86	24.67	7.15	8.33	0.95	29.77
2.25	31.31	5.84	12.50	1.12	40.07
<i>Following are the percentage errors involved by using two layers of mesh with 18mm spacing</i>					
42.84	1.65	27.38	0.56	0.97	2.00
37.64	1.87	25.78	0.64	0.96	2.27
25.35	2.78	21.05	0.96	0.97	3.38
16.77	4.21	17.51	1.39	0.93	5.04
11.79	5.99	14.59	2.00	0.94	7.20
8.59	8.22	12.38	2.78	0.95	9.92
6.53	10.82	10.52	3.84	1.00	13.28
5.09	13.87	9.23	5.00	1.01	17.10
2.86	24.67	7.15	8.33	0.95	29.77
2.25	31.31	5.84	12.50	1.12	40.07
<i>Following are the percentage errors involved by using two layers of mesh with 21mm spacing</i>					
42.34	1.67	27.38	0.56	0.96	2.02
37.14	1.90	25.78	0.64	0.95	2.29

**Table B.6** continued

24.85	2.84	21.05	0.96	0.95	3.43
16.95	4.17	17.27	1.42	0.96	5.05
11.97	5.90	14.30	2.08	0.99	7.22
8.09	8.73	12.38	2.78	0.90	10.35
6.53	10.82	10.52	3.84	1.00	13.28
5.09	13.87	9.23	5.00	1.01	17.10
2.86	24.67	7.15	8.33	0.95	29.77
2.25	31.31	5.84	12.50	1.12	40.07

**Table B.7** shows the percentage error associated with the experimental readings corresponding to the values of the quantities measured for wire diameter 1.6mm and open area of 77%.

Pressure drop $\Delta h_{CR}$ corrected) (mm)	Pressure Error $\Delta(\Delta h_{CR})$	Velocity $V_{air}$ (m/s)	Velocity Error $\Delta V_{air}$	Drag Coff. ( $C_D$ )	Drag Coff. error ( $\Delta C_D$ )
<i>Following are the percentage errors involved by using single layer of mesh.</i>					
9.45	7.48	32.44	0.41	0.15	7.52
7.78	9.07	29.10	0.51	0.15	9.13
5.02	14.06	23.50	0.78	0.15	14.14
3.39	20.82	19.26	1.16	0.15	20.95
2.30	30.71	16.09	1.67	0.15	30.89
1.48	47.57	13.46	2.38	0.14	47.81
1.62	43.61	11.37	3.33	0.21	44.12
1.19	59.33	10.17	4.17	0.19	59.91
0.65	107.95	7.77	7.14	0.18	108.83
0.54	129.08	6.57	10.00	0.21	130.62
<i>Following are the percentage errors involved by using two layers of mesh with zero spacing</i>					
16.85	4.19	33.23	0.39	0.26	4.26
13.35	5.29	30.24	0.47	0.25	5.37
9.29	7.60	24.22	0.73	0.27	7.74
6.71	10.53	19.48	1.13	0.30	10.76
4.30	16.43	16.09	1.66	0.28	16.76
2.98	23.67	13.46	2.38	0.28	24.15
2.42	29.12	11.75	3.12	0.30	29.78
1.49	47.17	10.59	3.84	0.23	47.80
1.15	61.22	7.77	7.14	0.33	62.86
0.54	129.08	6.57	10.00	0.21	130.62
<i>Following are the percentage errors involved by using two layers of mesh with 5mm spacing</i>					
20.68	3.41	31.90	0.42	0.35	3.52

**Table B.7** continued

16.49	4.28	28.93	0.51	0.34	4.40
11.21	6.30	23.31	0.79	0.35	6.50
7.76	9.11	18.81	1.22	0.37	9.43
5.17	13.65	15.54	1.78	0.36	14.11
3.86	18.29	12.80	2.63	0.40	19.04
2.80	25.17	10.99	3.57	0.40	26.17
2.38	29.68	9.74	4.54	0.43	31.04
1.15	61.22	7.77	7.14	0.33	62.86
1.04	67.48	6.57	10.00	0.41	70.38
<i>Following are the percentage errors involved by using two layers of mesh with 10mm spacing</i>					
23.04	3.06	31.63	0.43	0.39	3.18
18.67	3.78	28.78	0.52	0.38	3.92
12.02	5.87	23.50	0.78	0.37	6.08
8.39	8.42	19.26	1.16	0.39	8.73
5.98	11.80	15.82	1.72	0.41	12.30
4.17	16.92	13.13	2.50	0.41	17.65
3.12	22.65	11.37	3.33	0.41	23.61
2.38	29.68	9.74	4.54	0.43	31.04
1.65	42.72	7.77	7.14	0.47	45.05
1.04	67.48	6.57	10.00	0.41	70.38
<i>Following are the percentage errors involved by using two layers of mesh with 15mm spacing</i>					
25.05	2.82	30.09	0.47	0.47	2.97
20.64	3.42	27.55	0.56	0.46	3.60
13.26	5.33	22.75	0.83	0.44	5.58
8.76	8.06	18.80	1.22	0.42	8.42
5.98	11.80	15.82	1.72	0.41	12.30
4.17	16.92	13.13	2.50	0.41	17.65
3.30	21.37	10.99	3.57	0.47	22.53

**Table B.7** continued

2.88	24.53	9.74	4.54	0.52	26.16
1.35	52.29	7.19	8.33	0.45	54.88
1.04	67.48	6.57	10.00	0.41	70.38
<i>Following are the percentage errors involved by using two layers of mesh with 18mm spacing</i>					
23.95	2.95	30.94	0.45	0.43	3.08
20.05	3.52	28.47	0.53	0.42	3.68
12.89	5.48	23.13	0.81	0.41	5.71
8.58	8.23	19.03	1.19	0.40	8.57
5.98	11.80	15.82	1.72	0.41	12.30
4.17	16.92	13.13	2.50	0.41	17.65
3.12	22.65	11.37	3.33	0.41	23.61
2.88	24.53	9.74	4.54	0.52	26.16
1.15	61.22	7.77	7.14	0.33	62.86
1.04	67.48	6.57	10.00	0.41	70.38
<i>Following are the percentage errors involved by using two layers of mesh with 21mm spacing</i>					
24.00	2.94	30.52	0.46	0.44	3.08
20.09	3.51	28.02	0.55	0.44	3.68
13.26	5.33	22.75	0.83	0.44	5.58
9.13	7.73	18.34	1.28	0.46	8.15
6.74	10.49	14.68	2.00	0.53	11.22
4.55	15.53	12.46	2.78	0.50	16.49
3.49	20.20	10.59	3.85	0.53	21.62
2.57	27.48	9.29	5.00	0.51	29.25
1.35	52.29	7.19	8.33	0.45	54.88
1.24	56.58	5.87	12.50	0.62	61.86
<i>Following are the percentage errors involved by using two layers of mesh with 25mm spacing</i>					
22.72	3.11	29.95	0.48	0.43	3.25
18.83	3.75	27.39	0.57	0.43	3.92

**Table B.7** continued

12.13	5.82	22.37	0.86	0.41	6.07
8.63	8.18	18.34	1.28	0.44	8.57
5.86	12.05	15.26	1.85	0.43	12.61
4.36	16.20	12.80	2.63	0.45	17.03
3.30	21.37	10.99	3.57	0.47	22.53
2.38	29.68	9.74	4.54	0.43	31.04
1.35	52.29	7.19	8.33	0.45	54.88
0.74	94.33	5.87	12.50	0.37	97.59



# Appendix C

## MATLAB Programs

Included in this Appendix are the MATLAB programs (scripts) for the woven wire meshes of following specifications:-

1. Wire diameter of 0.45 mm and open area of 34% (dotfouotyfivethirtyfour.m)
2. Wire diameter of 0.40 mm and open area of 47% (dotfourtyfourtyseven.m)
3. Wire diameter of 1.6 mm and open area of 57% (sixteenfiftyseven.m)
4. Wire diameter of 1.18 mm and open area of 61% (eleveneightsixtyone.m)
5. Wire diameter of 0.56 mm and open area of 67% (dotfiftysixsixtyseven.m)
6. Wire diameter of 1.6 mm and open area of 67% (sixteensixtyseven.m)
7. Wire diameter of 1.6 mm and open area of 77% (sixteenseventyseven.m)
8. Porosity plot scripts (porosityplotzero.m, porosityplot5mm.m, porosityplot8mm.m, porosityplot10mm.m)
9. Best fit script (bestfit.m)
10. Work compared with others (comparework.m)

Following is the MATLAB program for wire mesh of diameter 0.45mm and open area of 34%

```

%plots of mesh of wire diameter 0.45mm and open area of 34% at an average
%temperature of 18C and atmospheric pressure of 94.68 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 11/08/2008
% For the project of air flow two layered mesh.

clc,clear
%delta_h is the pressure drop for a single mesh that occurs when the velocity of
%air 'v' is varied.
h2=[96,87,68.5,47,33,24,18,14,8.5,6.5];% pressure drop due to mesh and frame.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.
v=[19.71,18.58,16.62,13.78,11.38,9.29,7.77,7.20,5.09,4.16];% the data for velocity of air for frame and mesh.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*V^2).
C_D= delta_h*9790e-3./(0.5*1.134*v.^2);

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [22.5 20 16 11 7.5 5 3.5 3 1.5 1];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%CDsin = CDerr_C_Dmin'

%'h2_0' is the pressure drop because of mesh and frame for a two layered mesh at zero spacing, when the velocity of
%air 'v_0' is varied.
h2_0=[114,106.5,88,64,44,32,24,18.5,11.5,8.5];
v_0=[18.58,17.87,16.09,13.46,10.99,9.29,8.31,7.20,5.09,4.16];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.134*v_0.^2);
%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [20 18.5 15 10.5 7.5 4 3 1.5 1];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.

```

```

CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min'

%h2_2 is the pressure drop because of mesh and frame at 2mm spacing and v_2 is the corresponding velocity that
h2_2=[112,104.5,85.5,62,43.5,31.5,23.5,18,11,8.5];
v_2=[16.36,15.82,14.39,12.47,10.18,8.31,7.20,6.57,5.09,4.16];%velocity due to frame and mesh together in place.
%vmean_2=(v_2-mean(v_2))./std(v_2);%centering the v data at zero mean and scaling the data to a unit standard
deviation
% for calculation of best fit of the data for v_2 and delta_h2.
newh1_2 = polyval(coeff,v_2);
delta_h2 = h2_2-newh1_2;
C_D2= delta_h2*9790e-3./(0.5*1.134*v_2.^2);
%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_2.
cof_2 = polyfit(v,delta_h,k);
single_2 = polyval(cof_2,v_2);

%error calculation for 2mm spacing.
perr_h_2 = (sqrt(0.50)./delta_h2)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_2 = [15.5 14.5 12 9 6 4 3 2.5 1.5 1];% is the vector of values of pressure used to calculate velocity.
verr_v_2 = (1/2)*(0.50./velpre_2)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_2 = perr_h_2+(2*verr_v_2);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_2min = sqrt((perr_h_2).^2+(2*verr_v_2).^2);
%CD2 = CDerr_C_D_2min'

%h2_3 and v_3 occur at a gap of 3mm.
h2_3=[112.5,105,86.5,62.5,43.5,31,23,18,11,8.5];
v_3=[15.27,14.69,13.46,11.38,9.74,8.31,7.20,6.57,5.09,4.16];%velocity due to frame and mesh together in place.
%vmean_3=(v_3-mean(v_3))./std(v_3);%centering the v_3 data at zero mean and scaling the data to a unit standard
deviation
% for calculation of best fit of the data for v_3 and delta_h3.

% for calculation of best fit of the data for v_3 and delta_h3.
newh1_3 = polyval(coeff,v_3);
delta_h3 = h2_3-newh1_3;
C_D3= delta_h3*9790e-3./(0.5*1.134*v_3.^2);
%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_3.
cof_3 = polyfit(v,delta_h,k);
single_3 = polyval(cof_3,v_3);

%error calculation for 3mm spacing.
perr_h_3 = (sqrt(0.50)./delta_h3)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_3 = [13.5 12.5 10.5 7.5 5.5 4 3 2.5 1.5 1];% is the vector of values of pressure used to calculate velocity.
verr_v_3 = (1/2)*(0.50./velpre_3)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_3 = perr_h_3+(2*verr_v_3);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_3min = sqrt((perr_h_3).^2+(2*verr_v_3).^2);
%CD3 = CDerr_C_D_3min'

%h2_5 and v_5 occur at a gap of 5mm.
h2_5=[113,105.5,86.5,62.5,43.5,31.5,23.5,18.5,10,10];
v_5=[14.69,14.09,12.81,10.99,8.81,7.77,6.57,5.88,4.16,4.16];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_5 and delta_h5.

```

```

newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.134*v_5.^2);
%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [12.5 11.5 9.5 7 4.5 3.5 2.5 2 1 1];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%h2_8 and v_8 occur at a gap of 8mm.
h2_8=[112.5,105.5,86.5,62.5,43.5,31.5,23.5,18.5,10,10];
v_8=[14.69,14.09,12.81,10.99,8.81,7.20,6.57,5.88,4.16,4.16];%velocity due to frame and mesh together in place.
%vmean_8=(v_2-mean(v_8))./std(v_8);%centering the v_8 data at zero mean and scaling the data to a unit standard
deviation
% for calculation of best fit of the data for v_8 and delta_h8.

% for calculation of best fit of the data for v_8 and delta_h8.
newh1_8 = polyval(coeff,v_8);
delta_h8 = h2_8-newh1_8;
C_D8= delta_h8*9790e-3./(0.5*1.134*v_8.^2);
%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_8.
cof_8 = polyfit(v,delta_h,k);
single_8 = polyval(cof_8,v_8);

%error calculation for 8mm spacing.
perr_h_8 = (sqrt(0.50)./delta_h8)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_8 = [12.5 11.5 9.5 7 4.5 3 2.5 2 1 1];% is the vector of values of pressure used to calculate velocity.
verr_v_8 = (1/2)*(0.50./velpre_8)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_8 = perr_h_8+(2*verr_v_8);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_8min = sqrt((perr_h_8).^2+(2*verr_v_8).^2);
%CD8 = CDerr_C_D_8min'

subplot(3,1,1)
%plot for pressure drop(mm)VS velocity (m/s).
%figure(1)
plot(v,delta_h,'-k*'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,':bo'),plot(v_2,delta_h2,'-gx')
plot(v_3,delta_h3,'-mp'),plot(v_5,delta_h5,'--c+')
plot(v_8,delta_h8,'-rs')

title('wire dia 0.45mm, 34%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','3mm','5mm','8mm')
hold off,axis([4 25 0 120])
grid on

```

```

%To non-dimensionalise the values of pressure and velocities into
%(pressure/pressure due to single mesh) and Reynolds number.
delta_h0=delta_h0./single_0; delta_h2=delta_h2./single_2; delta_h3=delta_h3./single_3;
delta_h5=delta_h5./single_5; delta_h8=delta_h8./single_8;
%Reynolds number Re=rho*v*D/meu
xx= 1.134*0.45e-3/1.904e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_2=v_2.*xx; Re_3=v_3.*xx; Re_5=v_5.*xx; Re_8=v_8.*xx;

subplot(3,1,2)
%plot of Reynolds number VS pressure ratio.
%figure(2)
%plot(Re,h,'k*',Re,h,'k--')
hold on
plot(Re_0,delta_h0,':bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
plot(Re_2,delta_h2,'-gx')
plot(Re_3,delta_h3,'--mp'),plot(Re_5,delta_h5,':c+')
plot(Re_8,delta_h8,'-rs')

title('wire dia 0.45mm, 34%open area','FontWeight','Bold','FontSize',15)
legend('zero','2mm','3mm','5mm','8mm')
hold off,axis([50 600 0 2.6])
grid on

subplot(3,1,3)
%plot of coeficient of drag VS reynolds number
%figure(3)

plot(Re,C_D,'--k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,':bo'),plot(Re_2,C_D2,'-gx')
plot(Re_3,C_D3,'--mp'),plot(Re_5,C_D5,':c+')
plot(Re_8,C_D8,'-rs')

title('wire dia 0.45mm, 34%open area','FontWeight','Bold','FontSize',15)

legend('single','zero','2mm','3mm','5mm','8mm')
hold off,axis([50 600 0 12])
grid on

%EOF

```

Following is the MATLAB program for wire mesh of diameter 0.40mm and open area of 47%.

```

%plots of mesh of wire diameter 0.40mm and open area of 47% at an average
%temperature of 13C and atmospheric pressure of 94.39 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 11/08/2008
% For the project of air flow two layered mesh.

clc,clear
h2=[84,74.5,55,38,27,19,14.5,11.5,7,5];%Pressure drop due to mesh and frame.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v=[21.64,20.42,17.51,14.59,12.03,10.11,8.75,7.72,5.84,5.05];%Velocity for mesh and frame together in place.
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);% h1 corresponding to velocity for h2.
delta_h = h2-new_h1;
C_D= delta_h*9790e-3./(0.5*1.15*v.^2);% coefficient of drag C_D=delta_h/((1/2)*rho*V^2).
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of air 'v' is varied.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [27.5 24.5 18 12.5 8.5 6 4.5 3.5 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%CDsin = CDerr_C_Dmin'

%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that occurs when the velocity of
%air 'v_0' is varied
h2_0=[104,95.5,77,54,37.5,27,20,16,9.5,7];%Pressure drop due to mesh and frame.
v_0=[22.22,21.24,18.91,15.71,13.05,10.92,9.23,8.25,5.84,5.05];%Velocity for mesh and frame together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.15*v_0.^2);%coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [29 26.5 21 14.5 10 7 5 4 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);

```

```

%CD0 = CDerr_C_D_0min'

%delta_h2 and v_2 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 2mm.
h2_2=[103,95.5,76,53,37,26.5,20,15.5,8,8];%pressure drop due to mesh and frame together in place.
v_2=[17.51,16.76,14.88,12.38,10.11,8.25,7.15,6.52,4.13,4.13];%Velocity for mesh and frame together in place.

% for calculation of best fit of the data for v_2 and h1_frame.
newh1_2 = polyval(coeff,v_2);
delta_h2 = h2_2-newh1_2;
C_D2= delta_h2*9790e-3./(0.5*1.15*v_2.^2);% coefficient of drag for 2mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_2.
cof_2 = polyfit(v,delta_h,k);
single_2 = polyval(cof_2,v_2);

%error calculation for 2mm spacing.
perr_h_2 = (sqrt(0.50)./delta_h2)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_2 = [18 16.5 13 9 6 4 3 2.5 1 1];% is the vector of values of pressure used to calculate velocity.
verr_v_2 = (1/2)*(0.50./velpre_2)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_2 = perr_h_2+(2*verr_v_2);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_2min = sqrt((perr_h_2).^2+(2*verr_v_2).^2);
%CD2 = CDerr_C_D_2min'

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.
h2_5=[103,95.5,77,53.5,37,26.5,20,16,8,8];%Pressure drop due to mesh and frame in place.
v_5=[17.01,16.76,14.88,12.03,10.11,8.25,7.15,5.84,4.13,4.13];% Velocity due to mesh and frame in place.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.15*v_5.^2);% Coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre_5 = [17 16.5 13 8.5 6 4 3 2 1 1];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%delta_h8 and v_8 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 8mm.
h2_8=[103.5,95,76.5,53,37,27,20,16,9.5,7];%pressure drop due to mesh and frame together in place.
v_8=[17.01,16.51,14.88,12.03,10.11,8.25,7.15,5.84,5.05,4.13];%Velocity for mesh and frame together in place.

% for calculation of best fit of the data for v_8 and h1_frame.

```

```

newh1_8 = polyval(coeff,v_8);
delta_h8 = h2_8-newh1_8;
C_D8= delta_h8*9790e-3./(0.5*1.15*v_8.^2);% coefficient of drag for 8mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_8.
cof_8 = polyfit(v,delta_h,k);
single_8 = polyval(cof_8,v_8);

%error calculation for 8mm spacing.
perr_h_8 = (sqrt(0.50)./delta_h8)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_8 = [17 16 13 8.5 6 4 3 2 1.5 1];% is the vector of values of pressure used to calculate velocity.
verr_v_8 = (1/2)*(0.50./velpre_8)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_8 = perr_h_8+(2*verr_v_8);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_8min = sqrt((perr_h_8).^2+(2*verr_v_8).^2);
%CD8 = CDerr_C_D_8min'

%delta_h10 and v_10 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 10mm.
h2_10=[103,95,76,53,37,26.5,20,15.5,8,8];%Pressure drop due to mesh and frame in place.
v_10=[17.01,16.51,14.59,12.03,10.11,8.25,7.15,5.84,4.13,4.13];% velocity due to mesh and frame in place.

% for calculation of best fit of the data for v_10 and h1_frame.
newh1_10 = polyval(coeff,v_10);
delta_h10 = h2_10-newh1_10;
C_D10= delta_h10*9790e-3./(0.5*1.15*v_10.^2);

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_10.
cof_10 = polyfit(v,delta_h,k);
single_10 = polyval(cof_10,v_10);

%error calculation for 10mm spacing.
perr_h_10 = (sqrt(0.50)./delta_h10)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_10 = [17 16 12.5 8.5 6 4 3 2 1 1];% is the vector of values of pressure used to calculate velocity.
verr_v_10 = (1/2)*(0.50./velpre_10)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_10 = perr_h_10+(2*verr_v_10);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_10min = sqrt((perr_h_10).^2+(2*verr_v_10).^2);
%CD10 = CDerr_C_D_10min'

subplot(3,1,1)
%plot for pressure drop(mm)VS velocity (m/s).
%figure(1)
plot(v,delta_h,'-k*'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,':bo'),plot(v_2,delta_h2,'-gx')
plot(v_5,delta_h5,'--mp'),plot(v_8,delta_h8,'c+')
plot(v_10,delta_h10,'-rs')

title('0.40mm wire dia,47%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','5mm','8mm','10mm')
hold off,axis([3 30 0 105])
grid on

```



```

%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h2=delta_h2./single_2; delta_h5=delta_h5./single_5;
delta_h8=delta_h8./single_8; delta_h10=delta_h10./single_10;
%Reynolds number Re=rho*v*D/meu
xx= 1.15*0.40e-3/1.88e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_2=v_2.*xx; Re_5=v_5.*xx; Re_8=v_8.*xx; Re_10=v_10.*xx;

subplot(3,1,2)
%plot of Reynolds number VS pressure ratio.
%figure(2)
plot(Re_0,delta_h0,'--bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_2,delta_h2,'-gx')
plot(Re_5,delta_h5,'--mp'),plot(Re_8,delta_h8,':c+')
plot(Re_10,delta_h10,'-rs')

title('0.40mm wire dia,47%open area','FontWeight','Bold','FontSize',15)
legend('zero','2mm','5mm','8mm','10mm')
hold off,axis([50 650 0.5 3])
grid on

subplot(3,1,3)
%plot of coeficient of drag VS reynolds number
%figure(3)
plot(Re,C_D,'--k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,'-bo'),plot(Re_2,C_D2,'-gx')
plot(Re_5,C_D5,'--c+'),plot(Re_8,C_D8,':mp')
plot(Re_10,C_D10,'-rs')

title('0.40mm wire dia,47%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','5mm','8mm','10mm')
hold off,axis([50 650 0 10])
grid on

%EOF

```

Following is the MATLAB program for wire mesh of diameter 1.6mm and open area of 57%.

```

%plots of mesh of wire diameter 1.6mm and open area of 57% at an average
%temperature of 15C and atmospheric pressure of 94.18 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 09/08/2008
% For the project of air flow two layered mesh.

clc,clear
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of
%air 'v' is varied.
h2=[57,50,34,22.5,16,11.5,8.5,6.5,4,3];%Pressure drop due to mesh and frame.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v=[28.27,26.39,21.54,17.83,14.95,12.78,10.97,9.72,7.18,6.56];% the velocity of air with frame and mesh in place.
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);% h1 corresponding to velocity for v.
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*v^2).
C_D= delta_h*9790e-3./(0.5*1.139*v.^2);% coefficient of drag for single mesh.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta h when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [46.5 40.5 27 18.5 13 9.5 7 5.5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%Cdsin = CDerr_C_Dmin'

%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that occurs when the velocity of
%air 'v_0' is varied.
h2_0=[71,62.5,44,30,20.5,15,11,8.5,5,3.5];%Pressure drop due to mesh and frame.
v_0=[25.73,24,20.31,16.84,13.75,11.73,10.57,9.27,7.18,5.86];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.139*v_0.^2);% coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [38.5 33.5 24 16.5 11 8 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.

```

```

verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min'

%delta_h2 and v_2 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 2mm.
h2_2=[74,65,46.5,31.5,22,15.5,11.5,9,5.5,4];%Pressure drop due to mesh and frame.
v_2=[26.22,24.88,20.94,17.09,14.36,12.44,10.97,9.72,7.18,6.56];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_2 and h1_frame.
newh1_2 = polyval(coeff,v_2);
delta_h2 = h2_2-newh1_2;
C_D2= delta_h2*9790e-3./(0.5*1.139*v_2.^2);%coefficient of drag for 2mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_2 = polyfit(v,delta_h,k);
single_2 = polyval(cof_2,v_2);

%error calculation for 2mm spacing.
perr_h_2 = (sqrt(0.50)./delta_h2)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_2 = [40 36 25.5 17 12 9 7 5.5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_2 = (1/2)*(0.50./velpre_2)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_2 = perr_h_2+(2*verr_v_2);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_2min = sqrt((perr_h_2).^2+(2*verr_v_2).^2);
%CD2 = CDerr_C_D_2min'

%delta_h3 and v_3 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 3mm.
h2_3=[75,65,46.5,31.5,22,15.5,11.5,9,5.5,4];%Pressure drop due to mesh and frame.
v_3=[25.73,24.35,20.94,17.34,14.66,12.44,10.57,9.27,7.18,5.86];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_3 and h1_frame.
newh1_3 = polyval(coeff,v_3);
delta_h3 = h2_3-newh1_3;
C_D3= delta_h3*9790e-3./(0.5*1.139*v_3.^2);% coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_3.
cof_3 = polyfit(v,delta_h,k);
single_3 = polyval(cof_3,v_3);

%error calculation for 3mm spacing.
perr_h_3 = (sqrt(0.50)./delta_h3)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_3 = [38.5 34.5 25.5 17.5 12.5 9 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_3 = (1/2)*(0.50./velpre_3)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_3 = perr_h_3+(2*verr_v_3);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_3min = sqrt((perr_h_3).^2+(2*verr_v_3).^2);
%CD3 = CDerr_C_D_3min'

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.

```

```

h2_5=[74,65,46.5,31.5,22,15.5,11.5,9.5,4];%Pressure drop due to mesh and frame.
v_5=[25.89,24.35,20.52,16.84,14.06,11.73,10.16,8.80,6.56,5.86];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.139*v_5.^2);% coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [39 34.5 24.5 16.5 11.5 8 6 4.5 2.5 2];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100;% The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%delta_h8 and v_8 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 8mm.
h2_8=[74.5,66,47,32,22.5,16,12,9.5,5.5,4];%Pressure drop due to mesh and frame.
v_8=[24.88,23.27,19.88,16.32,13.75,11.35,9.72,8.80,6.56,5.86];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_8 and h1_frame.
newh1_8 = polyval(coeff,v_8);
delta_h8 = h2_8-newh1_8;
C_D8= delta_h8*9790e-3./(0.5*1.139*v_8.^2);% coefficient of drag for 8mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_8.
cof_8 = polyfit(v,delta_h,k);
single_8 = polyval(cof_8,v_8);

%error calculation for 8mm spacing.
perr_h_8 = (sqrt(0.50)./delta_h8)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_8 = [36 31.5 23 15.5 11 7.5 5.5 4.5 2.5 2];% is the vector of values of pressure used to calculate velocity.
verr_v_8 = (1/2)*(0.50./velpre_8)*100;% The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_8 = perr_h_8+(2*verr_v_8);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_8min = sqrt((perr_h_8).^2+(2*verr_v_8).^2);
%CD8 = CDerr_C_D_8min'

%delta_h10 and v_10 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 10mm.
h2_10=[75,65,47.5,32,22.5,16,12,9.5,5.5,4];%Pressure drop due to mesh and frame.
v_10=[24.88,23.45,19.88,16.32,13.75,11.35,9.72,8.80,6.56,5.86];%velocity due to mesh and frame.

% for calculation of best fit of the data for v_10 and h1_frame.
newh1_10 = polyval(coeff,v_10);
delta_h10 = h2_10-newh1_10;
C_D10= delta_h10*9790e-3./(0.5*1.139*v_10.^2);% coefficient of drag for 10mm spacing.

```

```

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_10.
cof_10 = polyfit(v,delta_h,k);
single_10 = polyval(cof_10,v_10);

%error calculation for 10mm spacing.
perr_h_10 = (sqrt(0.50)./delta_h10)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_10 = [36 32 23 15.5 11 7.5 5.5 4.5 2.5 2];% is the vector of values of pressure used to calculate velocity.
verr_v_10 = (1/2)*(0.50./velpre_10)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_10 = perr_h_10+(2*verr_v_10);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_10min = sqrt((perr_h_10).^2+(2*verr_v_10).^2);
%Cd10 = CDerr_C_D_10min'

subplot(3,1,1)
%plot for pressure drop(mm)VS velocity (m/s).
%figure(1)
plot(v,delta_h,'-k*'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,'-bo'),plot(v_2,delta_h2,'-gx')
plot(v_3,delta_h3,':mp'),plot(v_5,delta_h5,'-c+')
plot(v_8,delta_h8,'-rs'),plot(v_10,delta_h10,'-bd')

title('1.6mm wire dia,57%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','3mm','5mm','8mm','10mm')
hold off,axis([3 35 0 80])
grid on

%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h2=delta_h2./single_2; delta_h3=delta_h3./single_3;
delta_h5=delta_h5./single_5; delta_h8=delta_h8./single_8; delta_h10=delta_h10./single_10;
%Reynolds number Re=rho*v*D/meu
xx= 1.139*1.6e-3/1.897e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_2=v_2.*xx; Re_3=v_3.*xx; Re_5=v_5.*xx; Re_8=v_8.*xx; Re_10=v_10.*xx;

subplot(3,1,2)
%plot for Reynolds number VS pressure ratio.
%figure(2)
plot(Re_0,delta_h0,'-bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_2,delta_h2,'-gx')
plot(Re_3,delta_h3,'-mp'),plot(Re_5,delta_h5,'-cs')
plot(Re_8,delta_h8,'-bd'),plot(Re_10,delta_h10,'-r*')

title('1.6mm wire dia,57%open area','FontWeight','Bold','FontSize',15)
legend('zero','2mm','3mm','5mm','8mm','10mm')
hold off,%axis([0 4000 0 1.7])
grid on

subplot(3,1,3)
%plot of coefficient of drag VS reynolds number
%figure(3)

plot(Re,C_D,'-k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,'-bo'),plot(Re_2,C_D2,'-gx')

```

```
plot(Re_3,C_D3,':mp'),plot(Re_5,C_D5,'-cs')
plot(Re_8,C_D8,'--bd'),plot(Re_10,C_D10,':r*')

title('1.6mm wire dia,57%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','3mm','5mm','8mm','10mm')
hold off,%axis([0 4000 0 2.5])
grid on

%EOF
```

Following is the MATLAB program for wire mesh of diameter 1.18mm and open area of 61%.

```

%plots of mesh of wire diameter 1.18mm and open area of 61% at an average
%temperature of 14.63C and atmospheric pressure of 93.94 kpa

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 13/08/2008
% For the project of air flow two layered mesh.

clc,clear
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of
%air 'v' is varied.
h2=[61,54.5,36.5,25,17,12.5,9,7,4,3];% pressure drop due to mesh and frame.
v=[26.88,25.40,20.95,17.10,14.37,11.73,10.16,8.8,7.18,5.87];%velocity due to frame and mesh together in place.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.
% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*V^2).
C_D= delta_h*9790e-3./(0.5*1.138*v.^2);%coefficient of drag for single mesh.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [42 37.5 25.5 17 12 8 6 4.5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
% CDsin = CDerr_C_Dmin';

%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that
%occurs when the velocity of air 'v_0' is varied.
h2_0=[81,72,53.3,36.5,25,18,13.5,10,6,4.5];% pressure drop due to mesh and frame.
v_0=[24.36,22.72,19.45,16.06,13.12,10.97,9.73,8.3,6.56,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.138*v_0.^2);%coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [47 42 31 21.5 15 10.5 8 6.5 4 3];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.

```

```

CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min';

%delta_h1 is the net pressure drop that occurs through two
%two layers of mesh when set apart by a distance of 1mm.The corresponding
%velocity is v_1.
h2_1=[80,71,50.5,35,23.5,17,12.5,10,6,4];% pressure drop due to mesh and frame.
v_1=[23.82,22.53,19.23,15.79,13.12,10.97,9.28,8.30,6.56,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_1 and h1_frame.
newh1_1 = polyval(coeff,v_1);
delta_h1 = h2_1-newh1_1;
C_D1= delta_h1*9790e-3./(0.5*1.138*v_1.^2);%coefficient of drag for 1mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_1.
cof_1 = polyfit(v,delta_h,k);
single_1 = polyval(cof_1,v_1);

%error calculation for 1mm spacing.
perr_h_1 = (sqrt(0.50)./delta_h1)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_1 = [33 29.5 21.5 14.5 10 7 5 4 2.5 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_1 = (1/2)*(0.50./velpre_1)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_1 = perr_h_1+(2*verr_v_1);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_1min = sqrt((perr_h_1).^2+(2*verr_v_1).^2);
%CD1 = CDerr_C_D_1min';

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.
h2_5=[82,73.5,53,36,25,17.5,13,10.5,5.5,4];% pressure drop due to mesh and frame.
v_5=[23.46,22.34,19.0,15.79,13.12,10.97,9.28,8.30,5.87,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.138*v_5.^2);%coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [32 29 21 14.5 10 7 5 4 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min';

%delta_h10 and v_10 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 10mm.
h2_10=[81,72.5,53.5,36,25,18,13.5,10.5,6,4.5];% pressure drop due to mesh and frame.
v_10=[22.72,21.35,18.32,14.96,12.44,10.16,8.80,7.76,5.87,5.08];%velocity due to frame and mesh together in place.

```



```

% for calculation of best fit of the data for v_10 and h1_frame.
newh1_10 = polyval(coeff,v_10);
delta_h10 = h2_10-newh1_10;
C_D10= delta_h10*9790e-3./(0.5*1.138*v_10.^2);%coefficient of drag for 10mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_10.
cof_10 = polyfit(v,delta_h,k);
single_10 = polyval(cof_10,v_10);

%error calculation for 10mm spacing.
perr_h_10 = (sqrt(0.50)./delta_h10)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_10 = [30 26.5 19.5 13 9 6 4.5 3.5 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_10 = (1/2)*(0.50./velpre_10)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_10 = perr_h_10+(2*verr_v_10);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_10min = sqrt((perr_h_10).^2+(2*verr_v_10).^2);
%CD10 = CDerr_C_D_10min';

%delta_h15 and v_15 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 15mm.
h2_15=[81.5,74,53,36,25,18,13.5,10.5,6.5,4.5];% pressure drop due to mesh and frame.
v_15=[22.91,21.75,18.55,15.24,12.78,10.58,9.28,8.30,6.55,5.87];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_15 and h1_frame.
newh1_15 = polyval(coeff,v_15);
delta_h15 = h2_15-newh1_15;
C_D15= delta_h15*9790e-3./(0.5*1.138*v_15.^2);%coefficient of drag for 15mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_15.
cof_15 = polyfit(v,delta_h,k);
single_15 = polyval(cof_15,v_15);

%error calculation for 15mm spacing.
perr_h_15 = (sqrt(0.50)./delta_h15)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_15 = [30.5 27.5 19.5 13.5 9 6.5 5 4 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_15 = (1/2)*(0.50./velpre_15)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_15 = perr_h_15+(2*verr_v_15);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_15min = sqrt((perr_h_15).^2+(2*verr_v_15).^2);
%CD15 = CDerr_C_D_15min';

%delta_h18 and v_18 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 18mm.
h2_18=[81,72,52.5,36,25,18,13.5,10.5,6,4.5];% pressure drop due to mesh and frame.
v_18=[22.53,21.15,18.32,15.24,12.44,10.58,9.28,8.30,5.87,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_18 and h1_frame.
newh1_18 = polyval(coeff,v_18);
delta_h18 = h2_18-newh1_18;
C_D18= delta_h18*9790e-3./(0.5*1.138*v_18.^2);%coefficient of drag for 18mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_18.

```

```

cof_18 = polyfit(v,delta_h,k);
single_18 = polyval(cof_18,v_18);

%error calculation for 18mm spacing.
perr_h_18 = (sqrt(0.50)/delta_h18)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_18 = [29.5 26 19.5 13.5 9 6.5 5 4 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_18 = (1/2)*(0.50./velpre_18)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_18 = perr_h_18+(2*verr_v_18);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_18min = sqrt((perr_h_18).^2+(2*verr_v_18).^2);
% CD18 = CDerr_C_D_18min';

%delta_h20 and v_20 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 20mm.
h2_20=[80,72,52.5,36,24.5,18,13.5,10.5,6,4.5];% pressure drop due to mesh and frame.
v_20=[22.71,21.55,18.32,15.24,12.78,10.58,8.80,7.76,5.87,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_20 and h1_frame.
newh1_20 = polyval(coeff,v_20);
delta_h20 = h2_20-newh1_20;
C_D20= delta_h20*9790e-3./(0.5*1.138*v_20.^2);%coefficient of drag for 20mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_20.
cof_20 = polyfit(v,delta_h,k);
single_20 = polyval(cof_20,v_20);

%error calculation for 20mm spacing.
perr_h_20 = (sqrt(0.50)/delta_h20)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_20 = [30 27 19.5 13.5 9 6.5 4.5 3.5 2 1.5];% is the vector of values of pressure used to calculate velocity.
verr_v_20 = (1/2)*(0.50./velpre_20)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_20 = perr_h_20+(2*verr_v_20);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_20min = sqrt((perr_h_20).^2+(2*verr_v_20).^2);
%CS20 = CDerr_C_D_20min';

%delta_h25 and v_25 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 25mm.
h2_25=[80,71,52,35.5,24.5,17.5,13,10.5,6,4.5];% pressure drop due to mesh and frame.
v_25=[22.72,21.35,18.31,15.24,12.78,10.58,8.80,7.76,5.87,5.08];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_25 and h1_frame.
newh1_25 = polyval(coeff,v_25);
delta_h25 = h2_25-newh1_25;
C_D25= delta_h25*9790e-3./(0.5*1.138*v_25.^2);%coefficient of drag for 25mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_25.
cof_25 = polyfit(v,delta_h,k);
single_25 = polyval(cof_25,v_25);

%error calculation for 25mm spacing.
perr_h_25 = (sqrt(0.50)/delta_h25)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_25 = [30 26.5 19.5 13.5 9.5 6.5 4.5 3.5 2 1.5];% is the vector of values of pressure used to calculate velocity.

```

```

verr_v_25 = (1/2)*(0.50./velpre_25)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_25 = perr_h_25+(2*verr_v_25);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_25min = sqrt((perr_h_25).^2+(2*verr_v_25).^2);
%CD25 = CDerr_C_D_25min';

subplot(3,1,1)
%Plot for pressure drop VS velocity.
%figure(1)
plot(v,delta_h,'-k*'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,'bo'),plot(v_1,delta_h1,'-rd')
plot(v_5,delta_h5,'-gx'),plot(v_10,delta_h10,'-mp')
plot(v_15,delta_h15,'-c+'),plot(v_18,delta_h18,'-rs')
plot(v_20,delta_h20,'-bd'),plot(v_25,delta_h25,'-m*')

title('1.18mm wire dia,61%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','1mm','5mm','10mm','15mm','18mm','20mm','25mm')
hold off,axis([3 30 0 80])
grid on

%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h1=delta_h1./single_0; delta_h5=delta_h5./single_0; delta_h10=delta_h10./single_0;
delta_h15=delta_h15./single_0; delta_h18=delta_h18./single_0;
delta_h20=delta_h20./single_0; delta_h25=delta_h25./single_0;

%Reynolds number Re=rho*v*D/mu
xx= 1.138*1.18e-3/1.895e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_1=v_1.*xx; Re_5=v_5.*xx; Re_10=v_10.*xx; Re_15=v_15.*xx; Re_18=v_18.*xx;
Re_20=v_20.*xx; Re_25=v_25.*xx;

subplot(3,1,2)
%Plot for pressure drop(mm) VS Reynolds number.
%figure(2)
plot(Re_0,delta_h0,'-bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_1,delta_h1,'-rd')
plot(Re_5,delta_h5,'-gx'),plot(Re_10,delta_h10,'-mp')
plot(Re,delta_h15,'-c+'),plot(Re_18,delta_h18,'-rs')
plot(Re_20,delta_h20,'-bd'),plot(Re_25,delta_h25,'-g*')

title('1.18mm wire dia,61%open area','FontWeight','Bold','FontSize',15)
legend('zero','1mm','5mm','10mm','15mm','18mm','20mm','25mm')
hold off,axis([200 2150 1.5 2.5])
grid on

subplot(3,1,3)
%plot of coefficient of drag VS reynolds number
%figure(3)

plot(Re,C_D,'-k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,'bo'),plot(Re_1,C_D1,'-rd')
plot(Re_5,C_D5,'-gx'),plot(Re_10,C_D10,'-mp')
plot(Re_15,C_D15,'-c+'),plot(Re_18,C_D18,'-bd')
plot(Re_20,C_D20,'-r*'),plot(Re_25,C_D25,'-gs')

```

```
title('1.18mm wire dia,61%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','1mm','5mm','10mm','15mm','18mm','20mm','25mm')
hold off,axis([200 2150 0 3])
grid on
```

```
%EOF
```

Following is the MATLAB program for wire mesh of diameter 0.56mm and open area of 67%.

```

%plots of mesh of wire diameter 0.56mm and open area of 67% at an average
%temperature of 13C and atmospheric pressure of 94.22 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 15/08/2008
% For the project of air flow two layered mesh.

clc,clear
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of
%air 'v' is varied.
h2=[40.5,33.5,22,15,10.5,7.5,5.5,4.5,2.5,2];% pressure drop due to mesh and frame.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.
v=[30.49,27.70,22.43,18.24,15.17,13.06,11.31,9.69,7.73,6.53];%velocity due to frame and mesh together in place.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*v^2).
C_D= delta_h*9790e-3./(0.5*1.148*v.^2);%coefficient of drag for zero spacing.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [54.5 45 29.5 19.5 13.5 10 7.5 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%CDsin = CDerr_C_Dmin'
%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that occurs when the velocity of
%air 'v_0' is varied.
h2_0=[56.5,49,33,22.5,16,11.5,9,7,4,3];% pressure drop due to mesh and frame.
v_0=[29.64,27.70,22.62,18.47,15.45,13.06,11.31,10.12,7.73,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.148*v_0.^2);%coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [51.5 45 30 20 14 10 7.5 6 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.

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```

CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min'

%h_2 and v_2 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 2mm.
h2_2=[56,48.5,32.5,22.5,16,11.5,9,7,4.5,3.5];% pressure drop due to mesh and frame.
v_2=[28.46,26.44,21.46,17.76,14.89,12.73,10.93,9.69,7.73,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_2 and h1_frame.
newh1_2 = polyval(coeff,v_2);
delta_h2 = h2_2-newh1_2;
C_D2= delta_h2*9790e-3./(0.5*1.148*v_2.^2);%coefficient of drag for 2mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_2.
cof_2 = polyfit(v,delta_h,k);
single_2 = polyval(cof_2,v_2);

%error calculation for 2mm spacing.
perr_h_2 = (sqrt(0.50)./delta_h2)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_2 = [47.5 41 27 18.5 13 9.5 7 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_2 = (1/2)*(0.50./velpre_2)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_2 = perr_h_2+(2*verr_v_2);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_2min = sqrt((perr_h_2).^2+(2*verr_v_2).^2);
%CD2 = CDerr_C_D_2min'

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.
h2_5=[56,49,33,22.5,16,11.5,9,7,4.5,3];% pressure drop due to mesh and frame.
v_5=[27.86,25.96,21.26,17.52,14.60,12.39,10.93,9.69,7.73,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.148*v_5.^2);%coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [45.5 39.5 26.5 18 12.5 9 7 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%h_8 and v_8 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 8mm.
h2_8=[56,49,33,22.5,16,11.5,9,7,4.5,3.5];% pressure drop due to mesh and frame.
v_8=[27.55,25.79,20.85,17.28,14.31,12.04,10.53,9.23,7.15,6.53];%velocity due to frame and mesh together in place.

```

```

% for calculation of best fit of the data for v_8 and h1_frame.
newh1_8 = polyval(coeff,v_8);
delta_h8 = h2_8-newh1_8;
C_D8= delta_h8*9790e-3./(0.5*1.148*v_8.^2);%coefficient of drag for 8mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_8.
cof_8 = polyfit(v,delta_h,k);
single_8 = polyval(cof_8,v_8);

%error calculation for 8mm spacing.
perr_h_8 = (sqrt(0.50)./delta_h8)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_8 = [44.5 39 25.5 17.5 12 8.5 6.5 5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_8 = (1/2)*(0.50./velpre_8)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_8 = perr_h_8+(2*verr_v_8);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_8min = sqrt((perr_h_8).^2+(2*verr_v_8).^2);
%CD8 = CDerr_C_D_8min'

%delta_h10 and v_10 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 10mm.
h2_10=[56,49,33,22.5,16,11.5,9,7,4.5,3.5];% pressure drop due to mesh and frame.
v_10=[27.24,25.46,20.85,17.28,14.31,12.39,10.53,9.23,7.15,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_10 and h1_frame.
newh1_10 = polyval(coeff,v_10);
delta_h10 = h2_10-newh1_10;
C_D10= delta_h10*9790e-3./(0.5*1.148*v_10.^2);%coefficient of drag for 10mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_10.
cof_10 = polyfit(v,delta_h,k);
single_10 = polyval(cof_10,v_10);

%error calculation for 10mm spacing.
perr_h_10 = (sqrt(0.50)./delta_h10)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_10 = [43.5 38 25.5 17.5 12 9 6.5 5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_10 = (1/2)*(0.50./velpre_10)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_10 = perr_h_10+(2*verr_v_10);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_10min = sqrt((perr_h_10).^2+(2*verr_v_10).^2);
%CD10 = CDerr_C_D_10min'

subplot(3,1,1)
%plot for pressure drop(mm)VS velocity (m/s).
%figure(1)
plot(v,delta_h,'-k'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,':bo'),plot(v_2,delta_h2,'-gx')
plot(v_5,delta_h5,'-mp'),plot(v_8,delta_h8,'-c+')
plot(v_10,delta_h10,'-rs')

title('0.56mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','5mm','8mm','10mm')
hold off,%axis([0 40 0 50])
grid on

```

```

%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h2=delta_h2./single_2; delta_h5=delta_h5./single_5;
delta_h8=delta_h8./single_8; delta_h10=delta_h10./single_10;
%Reynolds number Re=rho*v*D/meu
xx= 1.148*0.56e-3/1.883e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_2=v_2.*xx; Re_5=v_5.*xx; Re_8=v_8.*xx; Re_10=v_10.*xx;

subplot(3,1,2)
%plot of Reynolds number VS pressure ratio.
%figure(2)
plot(Re_0,delta_h0,':bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_2,delta_h2,'-gx')
plot(Re_5,delta_h5,'--mp'),plot(Re_8,delta_h8,'-c+')
plot(Re_10,delta_h10,':rs')

title('0.56mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('zero','2mm','5mm','8mm','10mm')
hold off,axis([0 1200 1.5 3])
grid on

subplot(3,1,3)
%plot of coefficient of drag VS reynolds number
%figure(3)

plot(Re,C_D,'--k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,':bo'),plot(Re_2,C_D2,'-gx')
plot(Re_5,C_D5,'-c+'),plot(Re_8,C_D8,'-mp')
plot(Re_10,C_D10,'--rs')

title('0.56mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','2mm','5mm','8mm','10mm')
hold off,axis([0 1200 0 1.5])
grid on

%EOF

```



Following is the MATLAB program for wire mesh of diameter 1.6mm and open area of 67%.

```

%plots of mesh of wire diameter 1.6mm and open area of 67% at an average
%temperature of 12C and atmospheric pressure of 94 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 15/08/2008
% For the project of air flow two layered mesh.

clc,clear
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of air 'v' is varied.
h2 = [42.5,36,23.5,16,11.5,8,6,5,3,2];% pressure drop due to mesh and frame.
v = [30.33,27.69,22.23,18.23,15.45,13.05,11.31,10.11,7.72,6.53];%velocity due to frame and mesh together in place.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*V^2).
C_D = delta_h*9790e-3./(0.5*1.149*v.^2);%coefficient of drag for single mesh.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [54 45 29 19.5 14 10 7.5 6 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%CDsin = CDerr_C_Dmin'

%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that occurs
%when the velocity of air 'v_0' is varied.
h2_0=[58.5,50.5,33.5,23,16,11.5,9,7,4,3];% pressure drop due to mesh and frame.
v_0=[29.19,27.07,22.23,18.23,14.88,12.72,10.92,9.68,7.72,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.149*v_0.^2);%coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [50 43 29 19.5 13 9.5 7 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_0 = perr_h_0+(2*verr_v_0); % The percentage error involved in calculating the coefficient of drag.

```

```

CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min'

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.
h2_5=[60.5,52.35,23.5,16.5,12.9,7,4,3];% pressure drop due to mesh and frame.
v_5=[28.90,26.91,21.84,17.99,14.88,12.72,10.92,9.68,7.15,6.53];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.149*v_5.^2);%coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [49 42.5 28 19 13 9.5 7 5.5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%delta_h8 and v_8 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 8mm.
h2_8=[60,52,35,24,16.5,12.9,7,4,3];% pressure drop due to mesh and frame.
v_8=[28.75,26.91,22.04,18.23,15.17,12.72,10.92,9.68,7.15,5.84];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_8 and h1_frame.
newh1_8 = polyval(coeff,v_8);
delta_h8 = h2_8-newh1_8;
C_D8= delta_h8*9790e-3./(0.5*1.149*v_8.^2);%coefficient of drag for 8mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_8.
cof_8 = polyfit(v,delta_h,k);
single_8 = polyval(cof_8,v_8);

%error calculation for 8mm spacing.
perr_h_8 = (sqrt(0.50)./delta_h8)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_8 = [48.5 42.5 28.5 19.5 13.5 9.5 7 5.5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_8 = (1/2)*(0.50./velpre_8)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_8 = perr_h_8+(2*verr_v_8);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_8min = sqrt((perr_h_8).^2+(2*verr_v_8).^2);
%CD8 = CDerr_C_D_8min'

%delta_h12 and v_12 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 12mm.
h2_12=[59,51.5,34.5,23.5,16,11.5,8.5,7,4,3];% pressure drop due to mesh and frame.
v_12=[27.69,25.94,21.25,17.51,14.59,12.38,10.52,9.23,7.15,5.84];%velocity due to frame and mesh together in place.

```

```

% for calculation of best fit of the data for v_12 and h1_frame.
newh1_12 = polyval(coeff,v_12);
delta_h12 = h2_12-newh1_12;
C_D12= delta_h12*9790e-3./(0.5*1.149*v_12.^2);%coefficient of drag for 12mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_12.
cof_12 = polyfit(v,delta_h,k);
single_12 = polyval(cof_12,v_12);

%error calculation for 12mm spacing.
perr_h_12 = (sqrt(0.50)./delta_h12)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_12 = [45 39.5 26.5 18 12.5 9 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_12 = (1/2)*(0.50./velpre_12)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_12 = perr_h_12+(2*verr_v_12);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_12min = sqrt((perr_h_12).^2+(2*verr_v_12).^2);
%CD12 = CDerr_C_D_12min'

%delta_h15 and v_15 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 15mm.
h2_15=[59.5,52.5,35,24,16.5,12,9,7,4,3];% pressure drop due to mesh and frame.
v_15=[28,26.11,21.45,17.51,14.59,12.38,10.52,9.23,7.15,5.84];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_15 and h1_frame.
newh1_15 = polyval(coeff,v_15);
delta_h15 = h2_15-newh1_15;
C_D15= delta_h15*9790e-3./(0.5*1.149*v_15.^2);%coefficient of drag for 15mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_15.
cof_15 = polyfit(v,delta_h,k);
single_15 = polyval(cof_15,v_15);

%error calculation for 15mm spacing.
perr_h_15 = (sqrt(0.50)./delta_h15)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_15 = [46 40 27 18 12.5 9 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_15 = (1/2)*(0.50./velpre_15)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_15 = perr_h_15+(2*verr_v_15);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_15min = sqrt((perr_h_15).^2+(2*verr_v_15).^2);
%CD15 = CDerr_C_D_15min'

%delta_h18 and v_18 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 18mm.
h2_18=[59,52,35,23.5,16.5,12,9,7,4,3];% pressure drop due to mesh and frame.
v_18=[27.38,25.78,21.05,17.51,14.59,12.38,10.52,9.23,7.15,5.84];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_18 and h1_frame.
newh1_18 = polyval(coeff,v_18);
delta_h18 = h2_18-newh1_18;
C_D18= delta_h18*9790e-3./(0.5*1.149*v_18.^2);%coefficient of drag for 18mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_18.
cof_18 = polyfit(v,delta_h,k);

```

```

single_18 = polyval(cof_18,v_18);

%error calculation for 18mm spacing.
perr_h_18 = (sqrt(0.50)./delta_h18)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_18 = [44 39 26 18 12.5 9 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_18 = (1/2)*(0.50./velpre_18)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_18 = perr_h_18+(2*verr_v_18);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_18min = sqrt((perr_h_18).^2+(2*verr_v_18).^2);
%CD18 = CDerr_C_D_18min'

%delta_h21 and v_21 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 21mm.
h2_21=[58.5,51.5,34.5,23.5,16.5,11.5,9,7,4,3];% pressure drop due to mesh and frame.
v_21=[27.38,25.78,21.05,17.27,14.30,12.38,10.52,9.23,7.15,5.84];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_21 and h1_frame.
newh1_21 = polyval(coeff,v_21);
delta_h21 = h2_21-newh1_21;
C_D21= delta_h21*9790e-3./(0.5*1.149*v_21.^2);%coefficient of drag for 21mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_21.
cof_21 = polyfit(v,delta_h,k);
single_21 = polyval(cof_21,v_21);

%error calculation for 21mm spacing.
perr_h_21 = (sqrt(0.50)./delta_h21)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_21 = [44 39 26 17.5 12 9 6.5 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_21 = (1/2)*(0.50./velpre_21)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_21 = perr_h_21+(2*verr_v_21);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_21min = sqrt((perr_h_21).^2+(2*verr_v_21).^2);
%CD21 = CDerr_C_D_21min'

subplot(3,1,1)
%Plot for pressure drop VS velocity.
%figure(1)
plot(v,delta_h,'-k*'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,'-bo'),plot(v_5,delta_h5,'-gx')
plot(v_8,delta_h8,'mp'),plot(v_12,delta_h12,'-c+')
plot(v_15,delta_h15,'-rs'),plot(v_18,delta_h18,'-bd')
plot(v_21,delta_h21,'-r*')

title('1.6mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','5mm','8mm','12mm','15mm','18mm','21mm')
hold off,%axis([0 40 0 60])
grid on
%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h5=delta_h5./single_5; delta_h8=delta_h8./single_8;
delta_h12=delta_h12./single_12; delta_h15=delta_h15./single_15;
delta_h18=delta_h18./single_18; delta_h21=delta_h21./single_21;
%Reynolds number Re=rho*v*D/meu
xx= 1.149*1.6e-3/1.88e-5;

```

```
Re=v.*xx; Re_0=v_0.*xx; Re_5=v_5.*xx; Re_8=v_8.*xx; Re_12=v_12.*xx; Re_15=v_15.*xx; Re_18=v_18.*xx; Re_21=v_21.*xx;
```

```
subplot(3,1,2)
%plot for pressure ratio VS Reynolds number.
%figure(2)
plot(Re_0,delta_h0,'--bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_5,delta_h5,'-gx')
plot(Re_8,delta_h8,':mp'),plot(Re_12,delta_h12,'--c+')
plot(Re_15,delta_h15,'-rs'),plot(Re_18,delta_h18,':bd')
plot(Re_21,delta_h21,'-r*')
```

```
title('1.6mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('zero','5mm','8mm','12mm','15mm','18mm','21mm')
hold off,axis([400 3500 1 3.5])
grid on
```

```
subplot(3,1,3)
%plot of coefficient of drag VS reynolds number
%figure(3)
plot(Re,C_D,'--k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,'--bo'),plot(Re_5,C_D5,'-gx')
plot(Re_8,C_D8,'--mp'),plot(Re_12,C_D12,'--c+')
plot(Re_15,C_D15,'-rs'),plot(Re_18,C_D18,'--bd')
plot(Re_21,C_D21,'-r*')
```

```
title('1.6mm wire dia,67%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','5mm','8mm','12mm','15mm','18mm','21mm')
hold off,axis([400 3500 0 1.5])
grid on
```

```
%EOF
```

Following is the MATLAB program for wire mesh of diameter 1.6mm and open area of 77%.

```

%plots of mesh of wire diameter 1.6mm and open area of 77% at an average
%temperature of 14.88C,density of 1.135 kg/m^3 and atmospheric pressure of 93.74 kpa.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 08/08/2008
% For the project of air flow two layered mesh.

clc,clear
%'delta_h' is the pressure drop for a single mesh that occurs when the velocity of
%air 'v' is varied.
h2=[32,26,17,11.5,8,5.5,4.5,3.5,2,1.5];% pressure drop due to mesh and frame.
v=[32.44,29.10,23.50,19.26,16.09,13.46,11.37,10.17,7.77,6.57];%velocity due to frame and mesh together in place.
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];%pressure drop due to frame only
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% for frame only.

% calculation of new_h1 corresponding to the velocity.
k = 2;
coeff = polyfit(v1_frame,h1_frame,k);
new_h1 = polyval(coeff,v);
delta_h = h2-new_h1;
% coefficient of drag C_D=delta_h/((1/2)*rho*V^2).
C_D= delta_h*9790e-3./(0.5*1.135*v.^2);%coefficient of drag for single mesh.

%error calculation for single mesh.
perr_h = (sqrt(0.50)./delta_h)*100; % The percentage error involved in measuring delta p when measured in mm taking
the accuracy of manometer to be 0.5mm.
velpre = [61 49 32 21.5 15 10.5 7.5 6 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v = (1/2)*(0.50./velpre)*100; % The percentage error involved in measuring the velocity in units of m/s taking an
accuracy of 0.5mm for the manometer.
CDerr_C_D = perr_h+(2*verr_v);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_Dmin = sqrt((perr_h).^2+(2*verr_v).^2);
%CDsin = CDerr_C_Dmin'

%'delta_h0' is the pressure drop for a two layered mesh at zero spacing, that occurs when the velocity of
%air 'v_0' is varied.
h2_0=[40.5,33,22,15,10,7,5.5,4,2.5,1.5];% pressure drop due to mesh and frame.
v_0=[33.23,30.24,24.22,19.48,16.09,13.46,11.75,10.59,7.77,6.57];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_0 and h1_frame.
newh1_0 = polyval(coeff,v_0);
delta_h0 = h2_0-newh1_0;
C_D0= delta_h0*9790e-3./(0.5*1.135*v_0.^2);%coefficient of drag for zero spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_0.
cof_0 = polyfit(v,delta_h,k);
single_0 = polyval(cof_0,v_0);

%error calculation for zero spacing.
perr_h_0 = (sqrt(0.50)./delta_h0)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_0 = [64 53 34 22 15 10.5 8 6.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_0 = (1/2)*(0.50./velpre_0)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.

```

```

CDerr_C_D_0 = perr_h_0+(2*verr_v_0);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_0min = sqrt((perr_h_0).^2+(2*verr_v_0).^2);
%CD0 = CDerr_C_D_0min'

%delta_h5 and v_5 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 5mm.
h2_5=[42.5,34.5,23,15.5,10.5,7.5,5.5,4.5,2.5,2];% pressure drop due to mesh and frame.
v_5=[31.90,28.93,23.31,18.81,15.54,12.80,10.99,9.74,7.77,6.57];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_5 and h1_frame.
newh1_5 = polyval(coeff,v_5);
delta_h5 = h2_5-newh1_5;
C_D5= delta_h5*9790e-3./(0.5*1.135*v_5.^2);%coefficient of drag for 5mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_5.
cof_5 = polyfit(v,delta_h,k);
single_5 = polyval(cof_5,v_5);

%error calculation for 5mm spacing.
perr_h_5 = (sqrt(0.50)./delta_h5)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_5 = [59 48.5 31.5 20.5 14 9.5 7 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_5 = (1/2)*(0.50./velpre_5)*100; % The percentage error involved in measuring the velocity in units of m/s taking
an accuracy of 0.5mm for the manometer.
CDerr_C_D_5 = perr_h_5+(2*verr_v_5);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_5min = sqrt((perr_h_5).^2+(2*verr_v_5).^2);
%CD5 = CDerr_C_D_5min'

%delta_h10 and v_10 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 10mm.
h2_10=[44.5,36.5,24,16.5,11.5,8,6,4.5,3,2];% pressure drop due to mesh and frame.
v_10=[31.63,28.78,23.50,19.26,15.82,13.13,11.37,9.74,7.77,6.57];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_10 and h1_frame.
newh1_10 = polyval(coeff,v_10);
delta_h10 = h2_10-newh1_10;
C_D10= delta_h10*9790e-3./(0.5*1.135*v_10.^2);%coefficient of drag for 10mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_10.
cof_10 = polyfit(v,delta_h,k);
single_10 = polyval(cof_10,v_10);

%error calculation for 10mm spacing.
perr_h_10 = (sqrt(0.50)./delta_h10)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_10 = [58 48 32 21.5 14.5 10 7.5 5.5 3.5 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_10 = (1/2)*(0.50./velpre_10)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_10 = perr_h_10+(2*verr_v_10);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_10min = sqrt((perr_h_10).^2+(2*verr_v_10).^2);
%CD10 = CDerr_C_D_10min'

%delta_h15 and v_15 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 15mm.
h2_15=[44.5,37,24.5,16.5,11.5,8,6,5,2.5,2];% pressure drop due to mesh and frame.
v_15=[30.09,27.55,22.75,18.80,15.82,13.13,10.99,9.74,7.19,6.57];%velocity due to frame and mesh together in place.

```

```

% for calculation of best fit of the data for v_15 and h1_frame.
newh1_15 = polyval(coeff,v_15);
delta_h15 = h2_15-newh1_15;
C_D15= delta_h15*9790e-3./(0.5*1.135*v_15.^2);%coefficient of drag for 15mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_15.
cof_15 = polyfit(v,delta_h,k);
single_15 = polyval(cof_15,v_15);

%error calculation for 15mm spacing.
perr_h_15 = (sqrt(0.50)./delta_h15)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_15 = [52.5 44 30 20.5 14.5 10 7 5.5 3 2.5];% is the vector of values of pressure used to calculate velocity.
verr_v_15 = (1/2)*(0.50./velpre_15)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_15 = perr_h_15+(2*verr_v_15);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_15min = sqrt((perr_h_15).^2+(2*verr_v_15).^2);
%CD15 = CDerr_C_D_15min'

%delta_h18 and v_18 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 18mm.
h2_18=[44.5,37.5,24.5,16.5,11.5,8,6,5,2.5,2];% pressure drop due to mesh and frame.
v_18=[30.94,28.47,23.13,19.03,15.82,13.13,11.37,9.74,7.77,6.57];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_18 and h1_frame.
newh1_18 = polyval(coeff,v_18);
delta_h18 = h2_18-newh1_18;
C_D18= delta_h18*9790e-3./(0.5*1.135*v_18.^2);%coefficient of drag for 18mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_18.
cof_18 = polyfit(v,delta_h,k);
single_18 = polyval(cof_18,v_18);

%error calculation for 18mm spacing.
perr_h_18 = (sqrt(0.50)./delta_h18)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_18 = [55.5 47 31 21 14.5 10 7.5 5.5 3.5 2.5]; % is the vector of values of pressure used to calculate velocity.
verr_v_18 = (1/2)*(0.50./velpre_18)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_18 = perr_h_18+(2*verr_v_18);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_18min = sqrt((perr_h_18).^2+(2*verr_v_18).^2);
%CD18 = CDerr_C_D_18min'

%delta_h21 and v_21 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 21mm.
h2_21=[44,37,24.5,16.5,11.5,8,6,4.5,2.5,2];% pressure drop due to mesh and frame.
v_21=[30.52,28.02,22.75,18.34,14.68,12.46,10.59,9.29,7.19,5.87];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_21 and h1_frame.
newh1_21 = polyval(coeff,v_21);
delta_h21 = h2_21-newh1_21;
C_D21= delta_h21*9790e-3./(0.5*1.135*v_21.^2);%coefficient of drag for 21mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_21.

```



```

cof_21 = polyfit(v,delta_h,k);
single_21 = polyval(cof_21,v_21);

%error calculation for 21mm spacing.
perr_h_21 = (sqrt(0.50)/delta_h21)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_21 = [54 45.5 30 19.5 12.5 9 6.5 5 3 2]; % is the vector of values of pressure used to calculate velocity.
verr_v_21 = (1/2)*(0.50./velpre_21)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_21 = perr_h_21+(2*verr_v_21);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_21min = sqrt((perr_h_21).^2+(2*verr_v_21).^2);
%CD21 = CDerr_C_D_21min'

%delta_h25 and v_25 is the net pressure drop and the corresponding velocity that
%occurs at a gap of 25mm.
h2_25=[42,35,23,16,11,8,6,4.5,2.5,1.5];% pressure drop due to mesh and frame.
v_25=[29.95,27.39,22.37,18.34,15.26,12.80,10.99,9.74,7.19,5.87];%velocity due to frame and mesh together in place.

% for calculation of best fit of the data for v_25 and h1_frame.
newh1_25 = polyval(coeff,v_25);
delta_h25 = h2_25-newh1_25;
C_D25= delta_h25*9790e-3./(0.5*1.135*v_25.^2);%coefficient of drag for 25mm spacing.

%Calculating value of pressure drop because of single mesh corresponding to
%the velocity of v_25.
cof_25 = polyfit(v,delta_h,k);
single_25 = polyval(cof_25,v_25);

%error calculation for 25mm spacing.
perr_h_25 = (sqrt(0.50)/delta_h25)*100; % The percentage error involved in measuring delta p when measured in mm
taking the accuracy of manometer to be 0.5mm.
velpre_25 = [52 43.5 29 19.5 13.5 9.5 7 5 3 2];% is the vector of values of pressure used to calculate velocity.
verr_v_25 = (1/2)*(0.50./velpre_25)*100; % The percentage error involved in measuring the velocity in units of m/s
taking an accuracy of 0.5mm for the manometer.
CDerr_C_D_25 = perr_h_25+(2*verr_v_25);% The percentage error involved in calculating the coefficient of drag.
CDerr_C_D_25min = sqrt((perr_h_25).^2+(2*verr_v_25).^2);
%Cd25 = CDerr_C_D_25min'

subplot(3,1,1)
%Plot for pressure drop(mm) VS velocity (m/s).
%figure(1)
plot(v,delta_h,'--k'),xlabel('velocity(m/s)'),ylabel('pressure drop (mm of water)')
hold on
plot(v_0,delta_h0,'-bo'),plot(v_5,delta_h5,'-gx')
plot(v_10,delta_h10,':mp'),plot(v_15,delta_h15,'-c+')
plot(v_18,delta_h18,'-rs'),plot(v_21,delta_h21,'-bd')
plot(v_25,delta_h25,'-m*')

title('1.6mm wire dia,77%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','5mm','10mm','15mm','18mm','21mm','25mm')
hold off,axis([2 40 1 40])
grid on
%To non-dimensionalise the values of pressure and velocities into
%pressure/pressure due to single mesh and Reynolds number.
delta_h0=delta_h0./single_0; delta_h5=delta_h5./single_0; delta_h10=delta_h10./single_0;
delta_h15=delta_h15./single_0; delta_h18=delta_h18./single_0;
delta_h21=delta_h21./single_0; delta_h25=delta_h25./single_0;
%Reynolds number Re=rho*v*D/meu

```

```

xx= 1.119*1.6e-3/1.921e-5;
Re=v.*xx; Re_0=v_0.*xx; Re_5=v_5.*xx; Re_10=v_10.*xx; Re_15=v_15.*xx; Re_18=v_18.*xx; Re_21=v_21.*xx;
Re_25=v_25.*xx;

subplot(3,1,2)
% plot of pressure ratio VS Reynolds number.
%figure(2)
plot(Re_0,delta_h0,'--bo'),xlabel('Reynolds number (Re)'),ylabel('pressure ratio')
hold on
plot(Re_5,delta_h5,'-gx')
plot(Re_10,delta_h10,'-mp'),plot(Re_15,delta_h15,'-rs')
plot(Re_18,delta_h18,':bd'),plot(Re_21,delta_h21,'-r*')
plot(Re_25,delta_h25,'--c+')

title('1.6mm wire dia,77%open area','FontWeight','Bold','FontSize',15)
legend('zero','5mm','10mm','15mm','18mm','21mm','25mm')
hold off,%axis([0 4200 0 1.8])
grid on

subplot(3,1,3)
%plot of coeficient of drag VS reynolds number
%figure(3)
plot(Re,C_D,'--k*'),xlabel('Reynolds number (Re)'),ylabel('Coefficient of drag (CD)')
hold on
plot(Re_0,C_D0,'-bo'),plot(Re_5,C_D5,'--gx')
plot(Re_10,C_D10,'-mp'),plot(Re_15,C_D15,':c+')
plot(Re_18,C_D18,'--bd')
plot(Re_21,C_D21,'-r*'),plot(Re_25,C_D25,'-gs')

title('1.6mm wire dia,77%open area','FontWeight','Bold','FontSize',15)
legend('single','zero','5mm','10mm','15mm','18mm','21mm','25mm')
hold off,%axis([0 4200 0 1.8])
grid on

%EOF

```

Following is the MATLAB program for drag coefficient VS porosity for different meshes at zero spacing over the same range of Reynolds number.

```
%The script file porosityplotzero.m plots the drag coefficient vs porosity  
%all meshes at zero spacing.
```

```
% Written by - Ranjit Singh Padda, Student ID - 0050020723  
% Written on 16/08/2008  
% For the project of air flow two layered mesh.
```

```
clc,clear
```

```
%For wire diameter of 0.45 mm and open area of 34%.  
p_034=[106.45,99.50,82.30,59.99,41.31,30.07,22.46,17.35,10.95,8.16];  
v_034=[18.58,17.87,16.09,13.46,10.99,9.29,8.31,7.20,5.09,4.16];  
C_D034= p_034*9790e-3./((0.5*1.134*v_034.^2);  
xx= 1.134*0.45e-3/1.904e-5;  
Re_034=v_034.*xx; %the Reynolds number.  
%the value of Reynolds number at which the corresponding drag coefficient is required.  
newRe_034 = 300;  
%the value of drag coefficient at Reynolds number of 300 using interpolation.  
newC_D034 = interp1(Re_034,C_D034,newRe_034,'linear');  
newC_D034 = [newC_D034';0;0;0;0];  
% zeros have been assumed just to construct 1 by 5 matrix  
%and the zero value of drag coefficient has not been attained anywhere in the experiments.
```

```
%For wire diameter of 0.45 mm and open area of 47%.  
p_047=[93.27,85.68,69.18,48.56,33.72,24.34,18.10,14.48,8.76,6.46];  
v_047=[22.22,21.24,18.91,15.71,13.05,10.92,9.23,8.25,5.84,5.05];  
C_D047= p_047*9790e-3./((0.5*1.15*v_047.^2);  
xx= 1.15*0.40e-3/1.88e-5;  
Re_047=v_047.*xx;  
newRe_047 = [300 500];% values of Reynolds number at which the drag coefficient is required.  
newC_D047 = interp1(Re_047,C_D047,newRe_047,'linear');  
newC_D047 = [newC_D047';0;0;0];  
% zeros have been assumed just to construct 1 by 5 matrix  
%and the zero value of drag coefficient has not been attained anywhere in the experiments.
```

```
%For wire diameter of 1.6 mm and open area of 57%.  
p_057=[56.70,50.02,35.01,23.77,16.31,11.94,8.51,6.58,3.86,2.75];  
v_057=[25.73,24,20.31,16.84,13.75,11.73,10.57,9.27,7.18,5.86];  
C_D057= p_057*9790e-3./((0.5*1.139*v_057.^2);  
xx= 1.139*1.6e-3/1.897e-5;  
Re_057=v_057.*xx;  
newRe_057 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required using interpolation.  
newC_D057 = interp1(Re_057,C_D057,newRe_057,'linear');  
newC_D057 = [0;0;newC_D057'];  
% zeros have been assumed just to construct 1 by 5 matrix  
%and the zero value of drag coefficient has not been attained anywhere in the experiments.
```

```
%For wire diameter of 1.18 mm and open area of 61%.  
p_061=[68.15,60.79,45.03,30.82,21.18,15.32,11.39,8.46,5.05,3.95];  
v_061=[24.36,22.72,19.45,16.06,13.12,10.97,9.73,8.3,6.56,5.08];  
C_D061= p_061*9790e-3./((0.5*1.138*v_061.^2);  
xx= 1.138*1.18e-3/1.895e-5;  
Re_061=v_061.*xx;
```

```

newRe_061 = [500 700 1000 1500];% values of Reynolds number at which the drag coefficient is required using
interpolaton.
newC_D061 = interp1(Re_061,C_D061,newRe_061,'linear');
newC_D061 = [0;newC_D061'];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficeint has not been attained anywhere in %the experiments.

%For wire diameter of 0.56 mm and open area of 67%.
p_067=[37.62,32.47,21.89,15.03,10.74,7.72,6.15,4.71,2.67,2.06];
v_067=[29.64,27.70,22.62,18.47,15.45,13.06,11.31,10.12,7.73,6.53];
C_D067= p_067*9790e-3./(0.5*1.148*v_067.^2);
xx= 1.148*0.56e-3/1.883e-5;
Re_067=v_067.*xx;
newRe_067 = [300 500 700 1000];% values of Reynolds number at which the drag coefficient is required using
interpolation.
newC_D067 = interp1(Re_067,C_D067,newRe_067,'linear');
newC_D067 = [newC_D067';0];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficeint has not been attained anywhere in the experiments.

%For wire diameter of 1.6 mm and open area of 77%.
p_077=[16.86,13.36,9.30,6.71,4.30,2.99,2.43,1.50,1.16,0.55];
v_077=[33.23,30.24,24.22,19.48,16.09,13.46,11.75,10.59,7.77,6.57];
C_D077= p_077*9790e-3./(0.5*1.135*v_077.^2);
xx= 1.119*1.6e-3/1.921e-5;
Re_077=v_077.*xx;
newRe_077 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required using interpolation.
newC_D077 = interp1(Re_077,C_D077,newRe_077,'linear');
newC_D077 = [0;0;newC_D077'];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficeint has not been attained anywhere in the experiments.

%porosity matrix for the different meshes used
porosity = [34 47 57 61 67 77];
dragcoff = [newC_D034 newC_D047 newC_D057 newC_D061 newC_D067 newC_D077];
k = [dragcoff(1,1:2),dragcoff(1,5)]; q = [porosity(1:2),porosity(5)];
l = [dragcoff(2,2),dragcoff(2,4:5)]; r = [porosity(2),porosity(4:5)];
m = (dragcoff(3,3:6)); s = (porosity(3:6));
n = (dragcoff(4,3:6)); t = (porosity(3:6));
p = [dragcoff(5,3:4),dragcoff(5,6)]; u = [porosity(3:4),porosity(6)];

%plot for porosity VS coefficient of drag.
plot(q,k,'*','q,k','r-'),xlabel('porosity'),ylabel('coefficient of drag')
hold on
plot(r,l,'d',r,l,'b--'),plot(s,m,'s',s,m,'g'),plot(t,n,'p',t,n,'b:'),plot(u,p,'s',u,p,'k-')
title('porosity VS drag coefficient at zero spacing','FontWeight','Bold','FontSize',15)
grid on
axis([30 80 0 7]),legend('Re300','Re300','Re500','Re500','Re700','Re700','Re1000','Re1000','Re1500','Re1500')

%EOF

```

Following is the MATLAB program for drag coefficient VS porosity for different meshes at 5 mm spacing over the same range of Reynolds number.

```

%The script file porosityplot5mm.m plots the drag coefficient vs porosity
%all meshes at 5mm spacing.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 18/08/2008
% For the project of air flow two layered mesh.

clc,clear

%For wire diameter of 0.45 mm and open area of 34%.
p_34=[108.23,101.11,82.86,59.81,41.77,30.16,22.55,17.75,9.66,9.66];
v_34=[14.69,14.09,12.81,10.99,08.81,07.77,06.57,05.88,04.17,04.16];
C_D34= p_34*9790e-3./(0.5*1.134*v_34.^2);
xx= 1.134*0.45e-3/1.904e-5;
Re_34=v_34.*xx %the Reynolds number.
%the value of Reynolds number at which the corresponding drag coefficient is required.
newRe_34 = 300;
%the value of drag coefficient at Reynolds number of 300 using interpolation.
newC_D34 = interp1(Re_34,C_D34,newRe_34,'linear');
newC_D34 = [newC_D34';0;0;0;0];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%For wire diameter of 0.45 mm and open area of 47%.
p_47=[96.65,89.33,72.11,50.28,34.72,24.98,18.87,15.26,7.67,7.67];
v_47=[17.01,16.76,14.88,12.03,10.11,8.25,7.15,5.84,4.14,4.13];
C_D47= p_47*9790e-3./(0.5*1.15*v_47.^2);
xx= 1.15*0.40e-3/1.88e-5;
Re_47=v_47.*xx;
newRe_47 = 300;% values of Reynolds number at which the drag coefficient is required.
%the value of drag coefficient at Reynolds number of 300 using interpolation.
newC_D47 = interp1(Re_47,C_D47,newRe_47,'linear');
newC_D47 = [newC_D47';0;0;0;0];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%For wire diameter of 1.6 mm and open area of 57%.
p_57=[59.52,52.16,37.32,25.27,17.63,12.44,9.20,7.27,4.05,3.25];
v_57=[25.89,24.35,20.52,16.84,14.06,11.73,10.16,8.80,6.56,5.86];
C_D57= p_57*9790e-3./(0.5*1.139*v_57.^2);
xx= 1.139*1.6e-3/1.897e-5;
Re_57=v_57.*xx;
newRe_57 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required using interpolation.
newC_D57 = interp1(Re_57,C_D57,newRe_57,'linear');
newC_D57 = [0;0;newC_D57'];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%For wire diameter of 1.18 mm and open area of 61%.
p_61=[70.07,62.66,45.11,30.51,21.18,14.82,11.08,8.97,4.75,3.45];
v_61=[23.46,22.34,19.0,15.79,13.12,10.97,9.28,8.30,5.87,5.08];
C_D61= p_61*9790e-3./(0.5*1.138*v_61.^2);
xx= 1.138*1.18e-3/1.895e-5;
Re_61=v_61.*xx;

```

```

newRe_61 = [500 700 1000 1500];% values of Reynolds number at which the drag coefficient is required using
interpolation.
newC_D61 = interp1(Re_61,C_D61,newRe_61,'linear');
newC_D61 = [0;newC_D61'];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in %the experiments.

%For wire diameter of 0.56 mm and open area of 67%.
p_67=[39.28,34.45,23.16,15.77,11.29,8.09,6.34,4.90,3.17,2.06];
v_67=[27.86,25.96,21.26,17.52,14.60,12.39,10.93,9.69,7.73,6.53];
C_D67= p_67*9790e-3./(0.5*1.148*v_67.^2);
xx= 1.148*0.56e-3/1.883e-5;
Re_67=v_67.*xx;
newRe_67 = [300 500 700];% values of Reynolds number at which the drag coefficient is required using interpolation..
newC_D67 = interp1(Re_67,C_D67,newRe_67,'linear');
newC_D67 = [newC_D67';0;0];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%For wire diameter of 1.6 mm and open area of 77%.
p_77=[20.69,16.50,11.22,7.76,5.18,3.86,2.81,2.39,1.16,1.05];
v_77=[31.90,28.93,23.31,18.81,15.54,12.80,10.99,9.74,7.77,6.57];
C_D77= p_77*9790e-3./(0.5*1.135*v_77.^2);
xx= 1.119*1.6e-3/1.921e-5;
Re_77=v_77.*xx;
newRe_77 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required using interpolation.
newC_D77 = interp1(Re_77,C_D77,newRe_77,'linear');
newC_D77 = [0;0;newC_D77'];
% zeros have been assumed just to construct 1 by 5 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%porosity matrix for the different meshes used
porosity = [34 47 57 61 67 77];
dragcoeff = [newC_D34 newC_D47 newC_D57 newC_D61 newC_D67 newC_D77];
k = [dragcoeff(1,1:2),dragcoeff(1,5)]; q = [porosity(1:2),porosity(5)];
%l = [dragcoeff(2,2),dragcoeff(2,4:5)]; r = [porosity(2),porosity(4:5)]; has
%been commented as there are only two points for Reynolds number of 500.
m = (dragcoeff(3,3:6)); s = (porosity(3:6));
n = [dragcoeff(4,3:4),dragcoeff(4,6)]; t = [porosity(3:4),porosity(6)];
p = [dragcoeff(5,3:4),dragcoeff(4,6)]; u = [porosity(3:4),porosity(6)];

%plot for porosity VS coefficient of drag.
plot(q,k,'*','q,k','r-'),xlabel('porosity'),ylabel('coefficient of drag')
hold on
%plot(r,l,'d','r,l','b--')has been commented as we have only two points
%corresponding to Reynolds number of 500 and the trend the line follows can
%not be established
plot(s,m,'s','s,m','g'),plot(t,n,'p','t,n','b:'),plot(u,p,'s',u,p,'k-')
title('porosity VS drag coefficient at 5mm spacing','FontWeight','Bold','FontSize',15)
grid on
legend('Re300','Re300','Re700','Re700','Re1000','Re1000','Re1500','Re1500')

%EOF

```

Following is the MATLAB program for drag coefficient VS porosity for different meshes at 8 mm spacing over the same range of Reynolds number.

```

%The script file porosityplot8mm.m plots the drag coefficient vs porosity
%all meshes at 8mm spacing.

% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 17/08/2008
% For the project of air flow two layered mesh.

clc,clear

%For wire diameter of 0.45 mm and open area of 34%.
p_34=[107.73,101.11,82.86,59.81,41.77,30.35,22.55,17.75,9.66,9.66];
v_34=[14.69,14.09,12.81,10.99,8.81,7.20,6.57,5.88,4.17,4.16];
C_D34= p_34*9790e-3./(0.5*1.134*v_34.^2);
xx= 1.134*0.45e-3/1.904e-5;
Re_34=v_34.*xx; %the Reynolds number.
%the value of Reynolds number at which the corresponding drag coefficient is required.
newRe_34 = [200 300];
newC_D34 = interp1(Re_34,C_D34,newRe_34,'linear');
newC_D34 = [newC_D34;0];
% zeros have been assumed just to construct 1 by 3 matrix
%and the zero value of drag coefficient has not been attained anywhere in the experiments.

%For wire diameter of 0.45 mm and open area of 47%.
p_47=[97.15,89.01,71.61,49.78,34.72,25.48,18.87,15.26,8.96,6.66];
v_47=[17.01,16.51,14.88,12.03,10.11,8.25,7.15,5.84,5.05,4.13];
C_D47= p_47*9790e-3./(0.5*1.15*v_47.^2);
xx= 1.15*0.40e-3/1.88e-5;
Re_47=v_47.*xx;
newRe_47 = [200 300 400];% values of Reynolds number at which the drag coefficient is required.
newC_D47 = interp1(Re_47,C_D47,newRe_47,'linear');
newC_D47 = [newC_D47];

%For wire diameter of 0.56 mm and open area of 67%.
p_67=[39.64,34.63,23.53,15.95,11.47,8.28,6.53,5.10,3.37,2.56];
v_67=[27.55,25.79,20.85,17.28,14.31,12.04,10.53,9.23,7.10,6.53];
C_D67= p_67*9790e-3./(0.5*1.149*v_67.^2);
xx= 1.148*0.56e-3/1.883e-5;
Re_67=v_67.*xx;
newRe_67 = [300 400];% values of Reynolds number at which the drag coefficient is required.
newC_D67 = interp1(Re_67,C_D67,newRe_67,'linear');
newC_D67 = [0;newC_D67];

%porosity matrix for the different meshes used
porosity = [34 47 57 61 67 77];
dragcoeff = [newC_D34 newC_D47 newC_D67];

k = (dragcoeff(1,:)); q = [porosity(1:2),porosity(5)];
m = (dragcoeff(2,:)); s = [porosity(1:2),porosity(5)];
%n = (dragcoeff(3,2:3)); t = [porosity(2),porosity(5)];has been commented as
%that gives only two points to plot at Reynolds number of 400 and the pattern could not be
%established.

%plot for porosity VS coefficient of drag.
plot(q,k,'*',q,k,'r-'),xlabel('porosity'),ylabel('coefficient of drag')

```

```
hold on
%plot(r,l,'d',r,l,'b--')has been commented as we have only two points
%corresponding to Reynolds number of 400 and the trend the line follows can
%not be established
plot(s,m,'s',s,m,'g')
title('porosity VS drag coefficient at 8mm spacing','FontWeight','Bold','FontSize',15)
grid on
legend('Re200','Re200','Re300','Re300')

%EOF
```



Following is the MATLAB program for drag coefficient VS porosity for different meshes at 10 mm spacing over the same range of Reynolds number.

```
%The script file porosityplot10mm.m plots the drag coefficient vs porosity  
%for all meshes at 10mm spacing.
```

```
% Written by - Ranjit Singh Padda, Student ID - 0050020723  
% Written on 14/08/2008  
% For the project of air flow two layered mesh.
```

```
clc,clear
```

```
%For wire diameter of 0.45 mm and open area of 47%.  
p_47=[96.65,89.01,71.30,49.78,34.72,24.98,18.87,14.76,7.67,7.67];  
v_47=[17.01,16.51,14.59,12.03,10.11,8.25,7.15,5.84,4.14,4.13];  
C_D47= p_47*9790e-3./(0.5*1.15*v_47.^2);  
xx= 1.15*0.40e-3/1.88e-5;  
Re_47=v_47.*xx;  
newRe_47 = 400; % value of Reynolds number at which the drag coefficient is required.  
newC_D47 = interp1(Re_47,C_D47,newRe_47,'linear');  
newC_D47 = [newC_D47';0;0;0];
```

```
%For wire diameter of 1.6 mm and open area of 57%.  
p_57=[61.61,53.08,38.86,26.14,18.31,13.13,9.89,7.77,4.55,3.25];  
v_57=[24.88,23.45,19.88,16.32,13.75,11.35,9.72,8.80,6.56,5.86];  
C_D57= p_57*9790e-3./(0.5*1.139*v_57.^2);  
xx= 1.139*1.6e-3/1.897e-5;  
Re_57=v_57.*xx;  
newRe_57 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required.  
newC_D57 = interp1(Re_57,C_D57,newRe_57,'linear');  
newC_D57 = [0;newC_D57'];
```

```
%For wire diameter of 1.18 mm and open area of 61%.  
p_61=[69.80,62.58,46.15,31.06,21.56,15.70,11.77,9.16,5.25,3.95];  
v_61=[22.72,21.35,18.32,14.96,12.44,10.16,8.80,7.76,5.87,5.08];  
C_D61= p_61*9790e-3./(0.5*1.138*v_61.^2);  
xx= 1.138*1.18e-3/1.895e-5;  
Re_61=v_61.*xx;  
newRe_61 = [400 700 1000 1500];% values of Reynolds number at which the drag coefficient is required.  
newC_D61 = interp1(Re_61,C_D61,newRe_61,'linear');  
newC_D61 = [newC_D61'];
```

```
%For wire diameter of 0.56 mm and open area of 67%.  
p_67=[40.00,34.99,23.53,15.95,11.47,8.09,6.53,5.10,3.36,2.56];  
v_67=[27.24,25.46,20.85,17.28,14.31,12.39,10.53,9.23,7.15,6.53];  
C_D67= p_67*9790e-3./(0.5*1.148*v_67.^2);  
xx= 1.148*0.56e-3/1.883e-5;  
Re_67=v_67.*xx;  
newRe_67 = [400 700];% values of Reynolds number at which the drag coefficient is required.  
newC_D67 = interp1(Re_67,C_D67,newRe_67,'linear');  
newC_D67 = [newC_D67';0;0];
```

```
%For wire diameter of 1.6 mm and open area of 77%.  
p_77=[23.05,18.68,12.03,8.39,5.99,4.18,3.12,2.38,1.66,1.05];  
v_77=[31.63,28.78,23.50,19.26,15.82,13.13,11.37,9.74,7.77,6.57];  
C_D77= p_77*9790e-3./(0.5*1.135*v_77.^2);
```

```

xx= 1.119*1.6e-3/1.921e-5;
Re_77=v_77.*xx;
newRe_77 = [700 1000 1500];% values of Reynolds number at which the drag coefficient is required.
newC_D77 = interp1(Re_77,C_D77,newRe_77,'linear');
newC_D77 = [0;newC_D77'];

%porosity matrix for the different meshes used
porosity = [34 47 57 61 67 77];
dragcoff = [newC_D47 newC_D57 newC_D61 newC_D67 newC_D77];

k = [dragcoff(1,1),dragcoff(1,3:4)]; q = [porosity(2),porosity(4:5)];
l = (dragcoff(2,2:5)); r = (porosity(3:6));
m = [dragcoff(3,2:3),dragcoff(3,5)]; s = [porosity(3:4),porosity(6)];
n = [dragcoff(4,2:3),dragcoff(4,5)]; t = [porosity(3:4),porosity(6)];

%plot for porosity VS coefficient of drag.
plot(q,k,'*','q,k','r-'),xlabel('porosity'),ylabel('coefficient of drag')
hold on
plot(r,l,'d',r,l,'b-'),plot(s,m,'s',s,m,'g'),plot(t,n,'o',t,n,'k')
title('porosity VS drag coefficient at 10mm spacing','FontWeight','Bold','FontSize',15)
grid on
legend('Re400','Re400','Re700','Re700','Re1000','Re1000','Re1500','Re1500')
axis([30 80 0 6.5])
%EOF

```

Following is the MATLAB program to determine the best fit for pressure drop and velocity both due to single mesh.

```

%Script file bestfit.m calculates the model of equation that best fits the
%data for delta h1 and the velocity of air V_0 for wire diameter of 0.45mm
%and open area of 34%.
% Written by - Ranjit Singh Padda, Student ID - 0050020723
% Written on 18/10/2008
% For the project of air flow two layered mesh.

clc,clear
v1_frame=[23.61,20.72,16.57,13.63,11.33,9.41,8.15,7.29,4.70,4.70];% velocity for frame only
h1_frame=[12,9.5,6,4,3,2,1.5,1,0.5,0.5];% pressure drop for frame only
for k= 1:4
    %coeff = polyfit(vmean_0,h1,k)
    coeff = polyfit(v1_frame,h1_frame,k)
    j(k) = sum((polyval(coeff,v1_frame)-h1_frame).^2);
    mu = mean(h1_frame);
    s(k) = sum((h1_frame-mu).^2);
    r2(k) = 1-(j(k)/s(k));

end
s
r2
j
% As the result indicates that the the value of j is least and the value of r2 is close for k=1.
%Hence the fit of order two(quadratic) is the best fit in this case.
coeff = polyfit(v1_frame,h1_frame,2);
figure(1)
plot(v1_frame,polyval(coeff,v1_frame),'k*',v1_frame,polyval(coeff,v1_frame),'k-'),xlabel('velocity (m/s)')
ylabel('pressure drop (mm)'),hold on
plot(v1_frame,h1_frame,'ro',v1_frame,h1_frame,'r--'),title ('pressure drop VS velocity due to frame
only','FontWeight','Bold','FontSize',15)
legend('quadratic','quadratic','original data','original data')
hold off,grid on

%EOF

%To determine the best fit for delta_h and velocity v for single mesh
delta_h =[87.52,79.45,62.43,42.80,30.12,22.07,16.65,12.85,7.95,6.16];
v=[19.71,18.58,16.62,13.78,11.38,9.29,7.77,7.20,5.09,4.16];
for k= (1:4)
    %coeff = polyfit(vmean_0,h1,k)
    coeff = polyfit(v,delta_h,k)
    j(k) = sum((polyval(coeff,v)-delta_h).^2);
    mu = mean(delta_h);
    s(k) = sum((delta_h-mu).^2);
    r2(k) = 1-(j(k)/s(k));
end
s
r2
j
% As the result indicates that the the value of j is least and the value of r2 is close for k=1.
%Hence the fit of order two(quadratic) is the best fit in this case.
coeff = polyfit(v,delta_h,2);
figure(2)
plot(v,polyval(coeff,v),'k*',v,polyval(coeff,v),'k-'),xlabel('velocity (m/s)')

```

```

ylabel('pressure drop (mm)'),hold on
plot(v,delta_h,'ro',v,delta_h,'r--')
title ('best fit for delta h VS velocity due to assembly','FontWeight','Bold','FontSize',15)
legend('quadratic','quadratic','original data','original data')
hold off,grid on

%EOF
% the Script file comparework.m compares the data obtained in the present
% work and the previous work done by other researchers for single mesh.
%Written by Ranjit Singh Padda, 0050020723 , on 10/10/08 for project work.
clc,clear

%k = 2;
%data for wire diameter of 0.45 mm and open area of 34%.
CD_34 = [3.89,3.97,3.90,3.89,4.02,4.42,4.76,4.28,5.30,6.14];
Re_34 = [528.26,497.97,445.44,369.32,305.00,248.99,208.25,192.97,136.42,111.49];
% coeff_34 = polyfit(Re_34,CD_34,k);
% ren_34 = polyval(coeff_34,new_Re)
%data for wire diameter of 0.40 mm and open area of 47%.
CD_47 = [2.68,2.67,2.68,2.66,2.80,2.78,2.84,2.90,3.12,2.98];
Re_47 = [529.49,499.64,428.44,356.99,294.35,247.37,214.10,188.89,142.89,123.56];

%data for wire diameter of 1.6 mm and open area of 57%.
CD_57 = [0.86,0.86,0.89,0.84,0.85,0.83,0.83,0.80,0.95,0.82];
Re_57 = [2715.8,2535.2,2069.3,1712.9,1436.2,1227.7,1053.9,933.8,689.8,630.2];

%data for wire diameter of 1.18 mm and open area of 61%.
CD_61 = [1.08,1.08,1.06,1.09,1.04,1.18,1.12,1.17,0.95,1.12];
Re_61 = [1904.8,1799.9,1484.6,1211.7,1018.3,831.2,720.0,623.6,508.8,416.0];

%data for wire diameter of 0.56 mm and open area of 67%.
CD_67 = [0.38,0.38,0.37,0.39,0.40,0.37,0.35,0.43,0.33,0.42];
Re_67 = [1041.0,945.7,765.8,622.7,517.9,445.9,386.1,330.8,263.9,222.9];

%data for wire diameter of 1.6 mm and open area of 67%.
C_D_67 = [0.42,0.43,0.44,0.45,0.45,0.42,0.42,0.45,0.48,0.42];
Re_67_ = [2965.9,2707.7,2173.8,1782.7,1510.8,1276.1,1106.0,988.6,754.9,638.6];

%data for wire diameter of 1.6 mm and open area of 77%.
CD_77 = [0.15,0.16,0.16,0.16,0.15,0.14,0.22,0.20,0.19,0.22];
Re_77 = [3023.5,2712.2,2190.2,1795.1,1499.6,1254.5,1059.7,947.9,724.2,612.3];

%new_Re = [300 500 700 1000 1500];

% plots the data for single mesh as obtained for comparison with the work
% of others.
%plot(Re_34,CD_34,'--r*'),plot(Re_47,CD_47,'-.bs')

plot(Re_57,CD_57,'--ks'),xlabel('Reynolds number'),ylabel('Coefficient of drag'),
hold on
plot(Re_61,CD_61,':md'),
grid on
plot(Re_67,CD_67,'--cx'),plot(Re_77,CD_77,'-.bo')%plot(Re_67_C_D_67,'-g+')

% other reearchers work to compare withmy work.
% for porosity of 57%
p_57 = 0.57;
ren_57 = [700 1000 1500 2000];

```

```

CDC_57 = -(0.491)+(0.47./(p_57.^1.773))-(7.49./(ren_57.^0.661))+(6.475./((p_57.^2.244)*(ren_57.^0.661)));

% for porosity of 61%
p_61 = 0.61;
ren_61 = [500 700 1000 1500];
CDC_61 = -(0.491)+(0.47./(p_61.^1.773))-(7.49./(ren_61.^0.661))+(6.475./((p_61.^2.244)*(ren_61.^0.661)));

% for porosity of 67%
p_67 = 0.67;
ren_67 = [700 1000 1500];
CDC_67 = -(0.491)+(0.47./(p_67.^1.773))-(7.49./(ren_67.^0.661))+(6.475./((p_67.^2.244)*(ren_67.^0.661)));

% for porosity of 67%
p_67_ = 0.67;
ren_67_ = [700 1000 1500 2000];
CDC_67_ = -(0.491)+(0.47./(p_67_.^1.773))-(7.49./(ren_67_.^0.661))+(6.475./((p_67_.^2.244)*(ren_67_.^0.661)));

% for porosity of 77%
p_77 = 0.77;
ren_77 = [700 1000 1500 2000];
CDC_77 = -(0.491)+(0.47./(p_77.^1.773))-(7.49./(ren_77.^0.661))+(6.475./((p_77.^2.244)*(ren_77.^0.661)));

plot(ren_57,CDC_57,'-k*'),plot(ren_61,CDC_61,'-ro')
plot(ren_67,CDC_67,'-gd')%plot(ren_67_,CDC_67_,':bp')
plot(ren_77,CDC_77,'-mx')
title('comparison between experimental research and my data for single mesh','FontWeight','Bold','FontSize',15)

legend('57%','61%','67%','77%','57% Exp','61% Exp','67% Exp','77%Exp')

%EOF

```