FABRICATING A SIMPLE FAN SYSTEM FOR SMALL LOW SPEED WIND TUNNEL AND STUDYING THE PARAMETER FOR FREQUENCY ADJUSTMENT

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Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Manufacturing Engineering

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BORANG PENGESAHAN STATUS TESIS[æ]

JUDUL: **FABRICATING A SIMPLE FAN SYSTEM FOR SMALL LOW SPEED WIND TUNNEL AND STUDYING THE PARAMETER FOR FREQUENCY ADJUSTMENT**

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Dedication

To my beloved mom

Azizah binti Hashim

My family

and

fellow friends

ACKNOWLEDGEMENT

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Shaiful Hakim for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a bachelor program is only a start of a life-long learning experience. I appreciate his consistent support from the first day I applied to graduate program to those concluding moments. I am truly grateful for his progressive vision about my training in science, his tolerance of my naive mistakes, and his commitment to my future career. I also would like to express very special thanks to Prof. Madya Dr. Aziz, Mr. Suhaimi and Mr. Ismayuzri for their suggestions, help and cooperation throughout the study. I also sincerely thanks for the time spent proofreading and correcting my many mistakes.

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ABSTRACT

Wind tunnel fan frequently come without control box or instrument especially for axial fan that widely sell in the market. This may lead to unfavourable condition which the fan speed could not be remote. We may severally found the fan that could be control by some fix parameter option such as velocity and we only could use that certain speed for testing. The speed of motor also could not be increase. In this research, fabrication of fan system of small low speed wind tunnel that can control speed by varying the frequency was performed. The connection used three phase of Miniature Circuit Breaker, AC inverter and fan motor. AC inverter was installed for controlling the frequency of motor. This AC inverter could remote the frequency according to user mode and could increase the frequency of the motor. The legs and base for the fan were added for attachment to horizontal wind tunnel. An experiment of varying the frequency to get the pressure in the test section was done. Graph was plotted, which is pressure versus frequency. An analysis was done based on the graph. Starting that point, the velocity was calculated in order to plot graph of velocity versus frequency. The relationship of the parameters was established. From this experiment, user could know and adjust the frequency according to the pressure and velocity that they desired simply by rotating the knob of the AC inverter.

ABSTRAK

Terowong angin kebanyakannya tidak mempunyai kotak kawalan atau instrumen terutamanya kipas axial yang banyak dijual di pasaran. Ini akan mengundang situasi di mana halaju kipas tidak boleh dikawal. Kita mungkin kerap melihat kipas yang boleh dikawal parameternya dengan pilihan- pilihan halaju tertentu yang telah ditetapkan dan hanya boleh menggunakan pilihan halaju tersebut dalam experimen. Halaju motor kipas juga tidak boleh dinaikkan lagi. Dalam penyelidikan ini, sistem kipas untuk terowong angin yang kecil dan berhalaju rendah dicipta di mana halajunya boleh di kawal dengan mengubah parameter frekuensi. Sambungan sistem ini menggunakan Miniature Circuit Breaker (MCB), AC inverter dan motor kipas. AC inveter disambung untuk mengawal frekuensi motor. AC inverter ini dapat dikawal mengikut kehendak pengguna serta dapat menaikkan lagi frekuensi motor. Pada kipas tersebut, kaki-kaki dan tapak dibuat untuk menyambungkannya dengan terowong angin yang melintang. Experimen yang mengubah frekuensi untuk mengukur tekanan dalam seksyen ujian terowong angin dijalankan. Graf diplotkan iaitu graf tekanan melawan frekuensi. Analisis dibuat dengan merujuk kepada graf tersebut. Dengan maklumat tersebut, halaju dikira untuk memplot graf halaju melawan frekuensi. Hubungan antara parameter-parameter tersebut dibuat. Daripada experimen ini, pengguna dapat mengetahui dan dapat mengubah frekuensi mengikut tekanan dan halaju yang diinginkan hanya dengan memusing punat pada AC inverter.

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LIST OF SYMBOLS

λ	Power factor
$\Delta ptot$	Total pressure-loss
Pm	Power input from Motor
A1	Test section cross section area
U1	Test section flow speed
ηf	Fan efficiency factor
ηm	Motor efficiency factor
ρ	Density
f	Frequency
P	Pressure
Pd	Dynamic pressure
V	Velocity

LIST OF ABBREVIATIONS

AC	Alternating current
Cfm	Cubic feet per minute
RPM	Revolution per minute
MCB	Miniature circuit breaker
PH	Phase

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wind tunnel is a tools use nowadays to study the air flow that pass through the object such as airplanes, cars, and building structures. It can measure the aerodynamic force; lift, drag, lateral forces, yaw, roll, and pitching moments of the object tested. If the aerodynamic force such as drag force and pressure can be measure, this will help the designer of automobile especially to find the way to reduce the power usage in moving the vehicles.

For automotive, there is new addition which the wind tunnel is equipped with moving belt like a roadway that closer to real situation. In viewing the airflow that could not be seen with naked eyes, there are many ways to visualize it; by smoke, tufts, evaporating suspension, oil, fog and sublimation.

There are many types of wind tunnel. They are low-speed wind tunnel, high-speed wind tunnel, supersonic wind tunnel, hypersonic wind tunnel, subsonic and transonic wind tunnel. In this research, the subsonic wind tunnel will be use due to its small size and low speed.

For this research, the specific part that will be study is the fan. Fan is an important component in wind tunnel operation. Its main function is to blow air into the tunnel for simulating the airflow force act on the object. There is also fan that attached at the back of wind tunnel as the sucker to suck the air out from the tunnel. Design of the fan is critical in determining the size of the blade, number of blade, the shape, the spacing, the angle and so forth to control the type of airflow and their velocity. The standalone fan is connected to AC power supply to rotate the blade. The fan has cover to prevent object or dust that could disturb the rotation and for safety precautions.

1.2 Problem Statements

This research is done to fabricate the simple fan system of subsonic wind tunnel that could vary the speed in frequency parameter. There are some common problems which lead to this research; the fan speed could not be controlled efficiently according to user requirement. It usually fix speed variable and only have certain fix speed option.

In addition, user usually could not estimate the velocity and pressure of airflow in test section by setting the input frequency from fan motor. This is because the wind speed in test section is different from wind speed in diffuser. The inverter also shows frequency parameters only. Therefore, this research attempts to solve these problems.

1.3 Research Objectives

1. To fabricate fan system of subsonic wind tunnel that variable speed can be controlled and remote.

2. To establish the relationship of parameter between frequency and pressure plus frequency and velocity of this wind tunnel.

1.4 Research Questions

1. How to fabricate fan system that the variable speed can be controlled?

2. What is the relationship of parameter between frequency and pressure plus frequency and velocity of this wind tunnel?

1.5 Scope of Research

This research is limited by the fan that only use for small low speed wind tunnel experiments that is for Manufacturing Engineering Faculty students that fits in classroom or laboratory. The fan is only for subsonic wind tunnel that is low in speed.

The relationship that establish also limited to the specification of the wind tunnel use in this experiment.

1.6 Significances of Research

Due to high cost of large size wind tunnel, this small, lower cost wind tunnel project can be used by Manufacturing Engineering Students to study about the air flow. It also gives significance to the other researcher to increase the frequency of fan. The relationship could be used for the user to set immediate pressure or velocity.

1.7 Expected Outcomes

The end of this research, the outcome that has been expected is the system of subsonic wind tunnel fan that the speed could be remote is fabricated. Besides, the relationships between parameter such as frequency, pressure and velocity will be established.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This chapter touches on literature review of wind tunnel and fan. It is limited to small low speed wind tunnel which is subsonic. It covered the power and flow losses, material of fan blade, pitch angle of fan blade, importance of reducing turbulence flow, importance of enclosed fan, axial fan blade loads, pitot tube as pressure measurement instrument, and reading the pressure parameter, causes of mean velocity variation, methods for improving the flow, axial flow fans, vane axial fans, maximum flow speed in test section and component used for turbulence control.

2.2 Power and Flow Losses

“A quick, back-of-the-envelope calculation predicted top centerline velocities in the neighborhood of about 40 m/s, or close to 90 mph. Of course, this calculation was incredibly optimistic as the power losses due to honeycomb, screens, and contraction were completely neglected, and maximum experimental velocities were only about 15 m/s, or about 33.5 mph.” (Tatman N, 2008)

“The available pressure rise through the fan indicates the capability of the fan to recover the flow losses caused by both the presence of a model and model support mechanism, and the wind tunnel walls, screens, etc., in the flow stream when the test velocity is as indicated.” (Hoehne V. O., 1967)

Both journals said that the power or flow losses will happen in experimental due to existence of honeycomb, screens, wind tunnel wall, model and so forth. So velocity of experimental will be different from the one that calculated.

“By measuring the dynamic pressure in the test section, q1, for a variation of fan rpm the power factor, λ, of the wind-tunnel can be estimated. The power factor is a measure of the total pressure-loss of the wind-tunnel circuit and can be compared to the computed total pressure-loss. It is defined as follows,

$$\lambda = \frac{\Delta p_{tot}}{\eta_f q_1} = \frac{P_m \eta_m}{A_1 U_1 q_1}$$

where Δptot is the total pressure-loss of the wind-tunnel circuit, Pm is the power input from the motor, A1 is the test section cross section area, U1 is the test section flow speed and ηf , ηm are the fan and motor efficiency factors respectively” (Lindgren B. *et al*, 2002)

2.3 Material of Fan Blade

“A commercially available Hartzell MP96-6 cooling tower fan is used to pump the air through the tunnel. The fan blades are fabricated of fiberglass, which would facilitate blade chord modifications to improve undesirable test flow conditions if needed. The pitch angle of each blade is adjusted individually with tooling that is designed specially for this purpose.” (Hoehne V.O., 1967)

“The fan itself has three cambered blades, also made from sheet metal, and the whole unit is rated for an output of 5700 cubic feet per minute (cfm).” (Tatman N., 2008)

From these two researches, they use different material for making fan blade. For research Heohne V.O, he use fibreglass while Tatman N. use sheet metal. The fibreglass will make the chord easily modified. But in this project, the existing fan only comes in plastic and metal.

2.4 Pitch Angle of Fan Blade

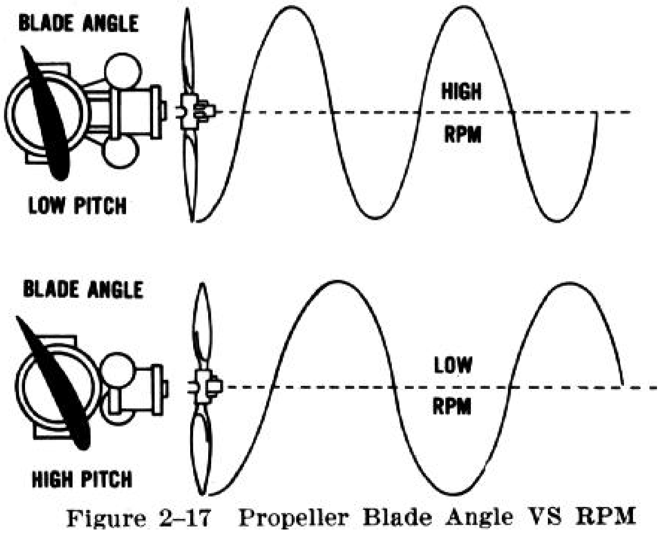

Figure 2.1: Fan Blade Angle versus RPM

A low pitch, high RPM setting, for example, can be utilized to obtain maximum power for takeoff; then after the airplane is airborne, a higher pitch and lower RPM setting can be used to provide adequate thrust for maintaining the proper airspeed. This may be compared to the use of low gear in an automobile to accelerate until high speed is attained, then shifting into high gear for the cruising speed. [1]

From this statement, it could be understand that controllable and adjustable pitch of blade could save power. This is because for starting-up, low pitch could be use because it is less friction and drag. When the high speed is reached, the high pitch will be use to maintain the speed of fan.

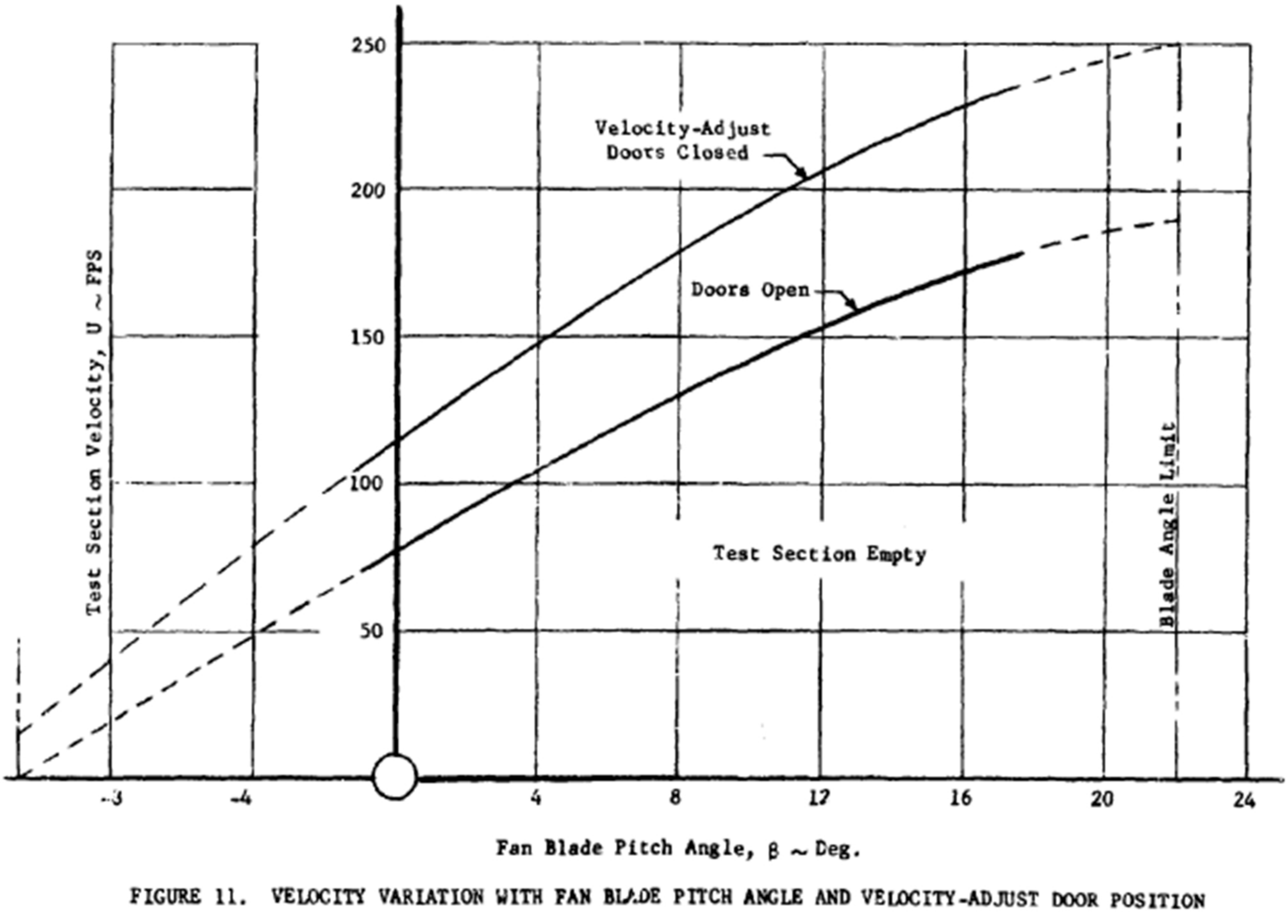

Figure 2.2: Velocity Variation with Fan Blade Pitch Angle and Velocity-adjust Door Position

Source: Hoehne V.O., 1967

“Figure II shows the variation of air velocity with fan-blade pitch angle and with position of the velocity-adjust doors. These data depict flow conditions with the test section empty.” (Hoehne V.O., 1967)

This graph shows that when the pitch angle increased, which mean the twist of blade increased, the test section air velocity also increased.

In this journal it also state that “The test conditions existing when the data in Figure 18 were recorded with three turbulence screens installed were achieved at two fan blade-pitch angle settings (8 and 10 degrees). This suggests pitch angle effects on turbulence within this range of variation are negligible. Further tests with spheres will be made, but wide ranges of pitch angle are impossible because the dependence of the critical Reynolds on sphere diameter limits the velocity range and, therefore, the blade pitch range."

"If the blower efficiency is not too important, these blades could be designed in the same way as corner vanes or cascades by choosing a leading edge angle of 4-5° and a zero trailing edge angle" (Mehta R.D *et al*,1979)

In this journal, it indicates that the choosing design of blade leading edge is 4-5° to avoid higher turbulence level and reduction of blower efficiency.

2.5 Importance of Reducing Turbulence Flow

"It is widely accepted that in a wind tunnel with a high turbulence level, premature transition from laminar to turbulent flow over the model surface may occur. This phenomenon is very critical when testing laminar flow models. The differences in the experimental values obtained in different wind tunnels having similar conditions and the same Reynolds number are due to the turbulence levels in those tunnels [5-18]." (Soltani M.R. *et al*,2010)

"A large contraction ratio helps reduce freestream turbulence and promotes cross-sectionally uniform flow in the test section." (Hoehne V. O,1967)

"One of the most important aspects of the flow quality in a wind-tunnel is the level of turbulence intensity. During the design of the wind-tunnel, a lot of work was devoted to ensure that the parts used for turbulence damping, such as screens, honeycomb and contraction would work well." (Lindgren B. *et al*, 2002)

These three journals show that the turbulence flow is not desirable and should be reduced in the test section as much as possible. This is because turbulence flow may affect the experimental values.

2.6 Importance of Enclosed Fan

"The motor delivers 15 kW of power. It is mounted axially behind the fan and it is enclosed in a steel plate cylinder to minimize the disturbance on the flow. Therefore, extra air for cooling the motor is provided from outside the wind-tunnel circuit through two cylindrical pipes." (Lindgren B. *et al*, 2002)

The statement explains that the enclosed fan is more desirable because it is automatically could prevent the disturbance of the flow from the outside.

2.7Axial Fan Blade Loads

"The use of axial fans can, however, create some flow quality problems, if they are subjected to very high loads, but even with more moderate loads they can create a low frequency pulsating variation of the streamwise flow component. In the present tunnel this is essentially, but not completely, avoided by a relatively low fan blade load." (Lindgren B. *et al*, 2002)

The above statement means that the high loads of fan blade could disturb flow quality in axial fans. Therefore, low fan blade load should be maintained.

"The load on the fan blades is also determined by the total pressure-loss of the wind-tunnel circuit. An increasing pressure-loss increases the blade load." (Lindgren B. *et al*, 2002)

Meanwhile this statement said that the total pressure-loss affect the blade load. The tip is to reduce the pressure-loss in order to reduce the blade load.

2.8 Pitot Tube as Pressure Measurement Instrument

"The measurement consisted in traversing a pitot tube across the guide-vanes at the center of their span and also to measure the static pressures upstream and downstream of corner 1." (Lindgren B. *et al*, 2002)

"A wide variety of velocity-measuring devices exist, and for the sake of brevity I will only touch on a few of the most popular. Pitot tubes are used to measure differences in pressure, usually with the aid of a manometer. In modern experimentation, it is common to utilize a device that combines a pitot tube with a static pressure measurement device so that both static pressure and stagnation pressure (total pressure) can be measured simultaneously. These devices are called pitot-static tubes, and can measure the different in total and static pressure, from which velocities can be calculated using the relation between dynamic pressure and fluid velocity." (Tatman N., 2008)

It is noted that these couple of research said that pitot tube can be used as pressure measurement instrument. It can be installed with manometer or pressure measurement device.

2.9 Reading the Pressure Parameter

"When using pitot tubes, care must be taken with regard to proper orientation of the tube, as a difference of only a few degrees from parallel to the flow lines could alter readings." (Tatman N., 2008)

The statement express that the orientation of the pitot tube is crucial due to a difference of degrees from parallel to the flow line will result in difference reading.

2.10 Causes of Mean Velocity Variation

"Variations in mean velocity can be caused by flow separations in the tunnel return circuit, flow separations in the contraction, poor corner vane design or incorrectly set vanes (resulting in the vanes over or under turning the flow), and poor design of the fan or straightening vanes (resulting in a rotation of the whole flow downstream of the fan)." (Lincoln P.E, 2000)

In this journal, variation of mean velocity may be cause by:

1. flow separations in the tunnel return circuit
2. flow separation in contraction
3. poor corner vane design
4. incorrectly set vanes
5. poor design of fan
6. poor design of straightening vanes

2.11 Methods for Improving the Flow

"Honeycombs and screens are known to improve the quality of the flow in the test section of a tunnel, both in terms of improved longitudinal and lateral mean-velocity distributions and reduced longitudinal and lateral turbulence intensities. Screens reduce longitudinal components of mean velocities and intensities more than lateral components, as for a contraction, whereas honeycombs reduce lateral components of mean velocities and intensities more than longitudinal components." (Lincoln P.E, 2000)

Lincoln said that the honeycombs and screen installation are the methods to improve the quality of the flow in test section by upgrading the longitudinal and literal mean-velocity distribution and also degrade the turbulence intensity.

2.12 Axial Flow Fans

"Axial Flow Fans are the devices that discharge the working fluid parallel to its axis of rotation. The working fluid is generally air and mostly they are operated in the incompressible range. Axial flow fans are generally used in mines, tunnels, underground transportation, all kinds of vehicles and industrial facilities for air conditioning and ventilation purposes in normal and emergency situations."(Cevik F., 2010)

The statement elaborated about the axial fan operation and the use of it. Axial flow fan, which generally use for tunnel, could be installed at the wind tunnel to blow or suck air.

2.13 Vane Axial Fan

"A vane axial fan is very similar to a tube axial fan, except it has additional guide vanes to direct the flow into a more suitable path to the impellers or to remove the swirl component of the velocity to have additional gain of static pressure. The hub diameter is 50% to 80% percent of the impeller diameter. Vane axial fans can generate high volumetric flow rates and fairly high static pressure rise compared to the previous axial fan types." (Cevik F., 2010)

The journal explains the vane axial fan specifications. The researcher also said that the axial fan is better in generating high volumetric flow rates and static pressure.

2.14 Maximum Flow Speed in Test Section

In the research by Lindgren B. and Johansson A.V, it is stated that, for the subsonic wind tunnel the maximum flow speed in the wind tunnel is 40 m/s. Flow speed in test section of subsonic wind tunnel should not be high because it is low speed wind tunnel.

“The main design criteria are listed in the table below,

1. Closed circuit wind-tunnel.
2. Good flow quality (mean flow variation, turbulence intensities & temperature variation).
3. Contraction ratio, CR, of 9.
4. Test section aspect ratio of 1.5 and the maximum test section length possible in the available space.
5. Maximum flow speed in the test section of at least 40 m/s.
6. Low noise level.
7. Low cost.” (Lindgren B. *et al*, 2002)

2.15 Component Used for Turbulence Control

The following statement indicates that the function of screen. It could be used to minimize the turbulence in wind tunnel if it places at the entrance of the nozzle.

“There are several factors that screens are used in wind tunnels. One reason can be stated as to protect the fan. The other reason can be stated as to control flow separation in wide angle diffusers. It is also used for turbulence control for flow conditioning at the nozzle entrance.” (Çevik F., 2010)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss the method, the process, and procedures of this research in detail. In addition, it is also discuss the materials, instruments and flow chart that will be use to complete this research.

3.2 Materials

The material use is steel plate for base and legs of fan, bolt and nut, welding filler, and plywood.

3.3 Instruments

In this research, the instruments use are three phase miniature circuit breaker (MCB), isolation switch box, power source socket, board, cable and cable lug, welding torch, three phase axial fan with motor, three phase AC inverter to control fan speed, pitot tube, digital pressure sensor, tube (manometer), digital manometer.

3.4 Procedures

The first step in this research is to define the problem statements of the research. It is the precedence of next step which is defines project objectives and scope of research.

After that, the literature of wind tunnel and fan are studied generally. To be more specific, the fan system and parameter relationship are the topic which is given attention most. The ideas by other researchers are studied to extract information about both system and relationship.

Next, the fabrication of fan system will be done along with wind tunnel fabrication for attachment and as the aid in this study. Then, the system will be test whether they are run properly or not. If the system are installed and fabricated properly, the next step could be proceed. Otherwise, the fabrication will be take place again which involve redesign and modify it sufficiently.

Later, the experiment of parameters relationship which involves frequency, pressure and velocity will be carried out. The pressure will be measured while velocity will be calculated. The data of them will be jotted down and the result will be discovered. If the data are logic, then analysis could be done. Otherwise, the experiment must be carried out once again to get good and logic result. The relationship then will be analyzed.

Finally, the result and findings will be discussed and overall conclusion of the systems will be made.

3.5 Flow chart

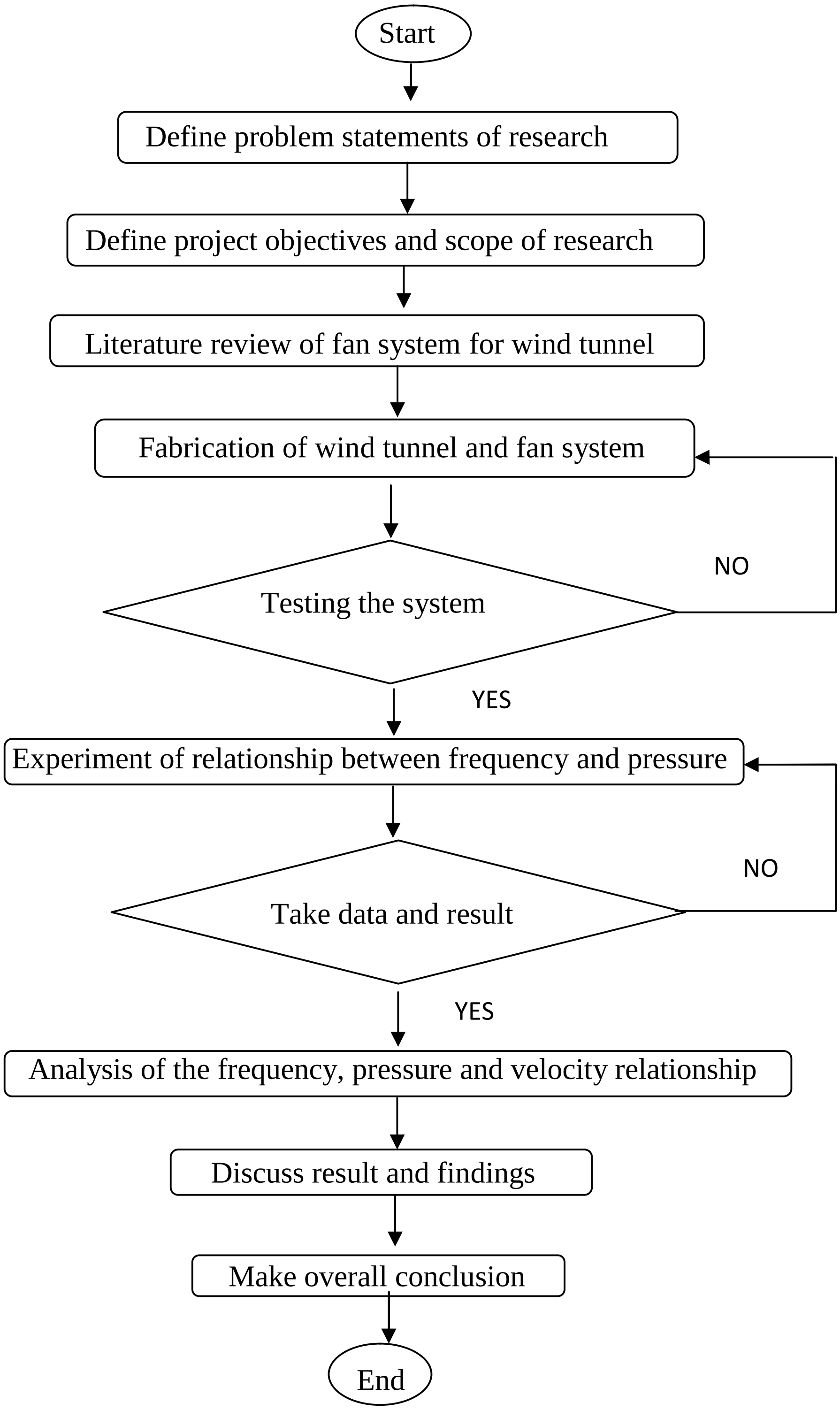

Figure 3.1: Flow Chart of the Project

3.6 Fabrication of Wind Tunnel

Wind tunnel was fabricated together with my group members who have major task in research of making the tunnel. The specification was according to her research.

The following is the specification of the wind tunnel.

- Settling Chamber
  - 900mmx900mmx100mm
- Contraction Section
  - Contraction Ratio : 9:1
  - 900mmx900mm (Large area)
  - 300mmx300mm (Small area)
  - Length :500mm
- Test section
  - 300mmx300mmx700mm
- Diffuser
  - Diffuser angle : 7^{o}
  - 600mmx600mm (Large area)
  - Length : 1220mm

3.7 Fabrication of Fan System Connection

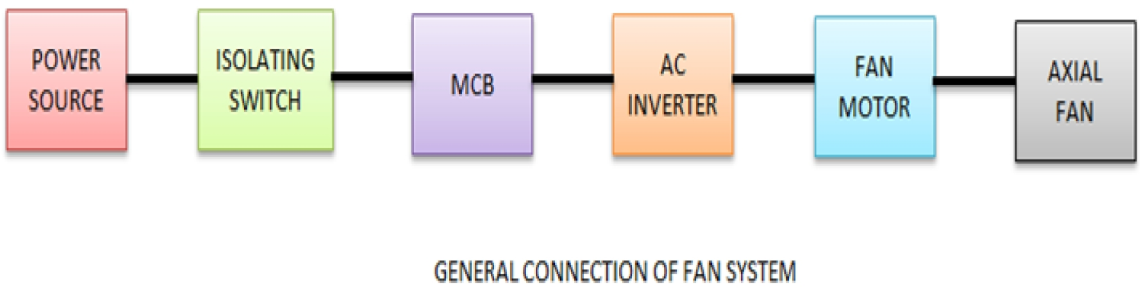

Figure 3.2: Connection of Fan System

3.7.1 Miniature Circuit Breaker (MCB)

MCB generally function as a switch that prevent component from damage due to short circuit or overload electricity. The three phase motor should be handled with high precaution because it is too dangerous and could cause accident that lead to death.

Therefore, if any fault detected, the MCB will interrupt the circuit and separate them. Hence, the component such as AC inverter and motor will be protected from damage and danger could be prevented. It was placed before AC inverter and motor in the circuit. The MCB also in three phases which following the phase of the fan motor.

3.7.2 AC Inverter

The brand of AC inverter use in this project is Delta. The purpose of installing AC inverter is to control speed of the fan according to user desire in frequency variable. It was installed between MCB and motor. The setting parameter that was set is 02.00 and 02.01 which the function are source of first master frequency command and source of first operation command respectively. The setting could be referred to the manual book of the inverter. Below is the figure on how to set the parameter on the digital keypad of the inverter.

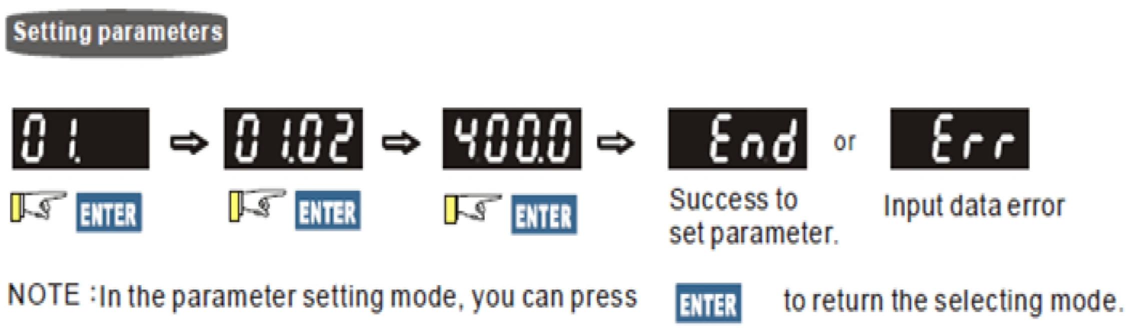

Figure 3.3: Procedures to Set the Parameter of AC Inverter

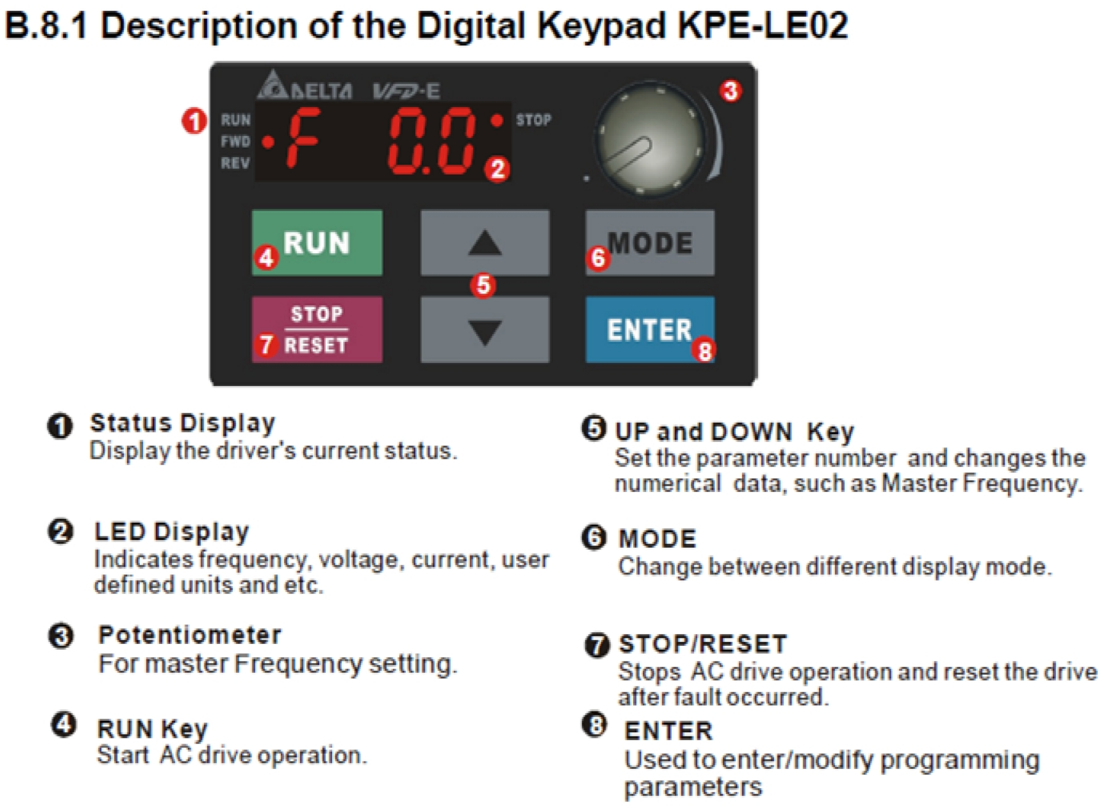

Figure 3.4: Description of the Digital Keypad of the AC Inverter

3.7.3 Axial Fan

Type of fan that used in this wind tunnel is vane axial fan. It comes with 400V, 3PH, 50Hz, 4 poles and 1.1 kW. This fan was installed at the outlet to suck air from the back. The fan had no leg and support. Therefore, four legs were fabricated and attached to the fan by bolt and nut. The length of the legs were calibrated with the high of tunnel so that the center of tunnel in line with center of fan. At the end of legs, a steel plate was welded to them to make them rigid. The plywood was cut in circle shape at inside according to fan diameter and it will be the connector of the fan and tunnel.

3.8 Installation of Pitot Tube

Pitot tube is an instrument which functions to measure pressure of fluid flow. In wind tunnel system, the pitot tube is placed in the test section to measure the pressure of airflow. It is connected to pressure sensor which the job is to show the amount of pressure in the test section. The pressure in test section can be read at the digital pressure sensor display. But in this research, there were some problems encountered. As the solution of this problem, the trial of using water head in manometer to measure the pressure was undergone but the pressure still could not be detected. For last attempt, the digital manometer with pitot tube was used. Using this device, the pressure successfully detected and the data of dynamic pressure in test section were shown at the display screen of digital manometer.

Figure 3.5: Digital Manometer

Figure 3.6: Connection of Clear Tube to Pitot Tube

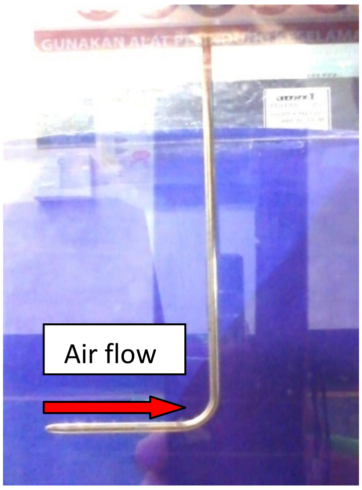

Figure 3.7: Position of the Pitot Tube in Test Section Regarding to Airflow

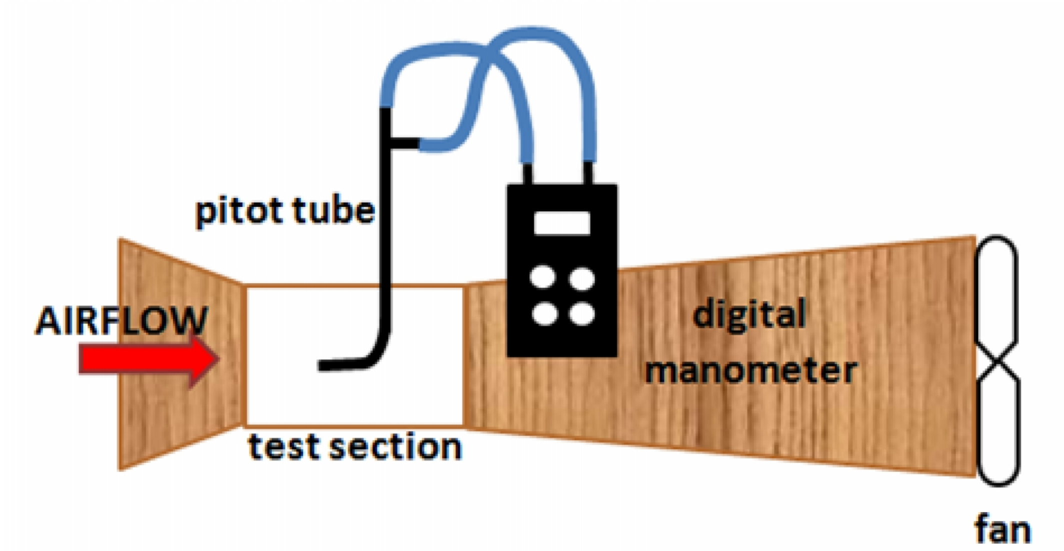

Figure 3.8: Overall Connection of Pitot Tube to Digital Manometer

3.9 Measurement of Pressure Parameter Relationship

The fan was run and the speed was controlled by AC inverter. The AC inverter was control it by varying the frequency at knob of the digital keypad. The frequency that displayed and the pressure that showed at the digital manometer which had been installed in test section was jotted down. The steps were repeated in the frequency range every 10Hz; from 0Hz to 50Hz. The limit was set 50Hz due to high vibration and sound produce by fan. Then, the data were transferred in table and the graph of pressure versus frequency was plotted.

3.10 Calculation of Velocity Parameter

From the table of pressure that was obtained from experiment, velocity was calculated using formula. The table of the data calculated was presented in the table. Hence, the graph of velocity versus frequency was plotted. It shows the velocity in the test section. Then their relationship was established and analyzed.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter discusses the results that are obtained from the fabrication of the fan system and the experiment. The experimental results are displayed in table and graph for better understanding. Later, they are analyzed and discussed.

4.2 Fan Fabrication System Results

The following figures indicate the results of fan system that was fabricated and the schematic diagram for the fan system connection.

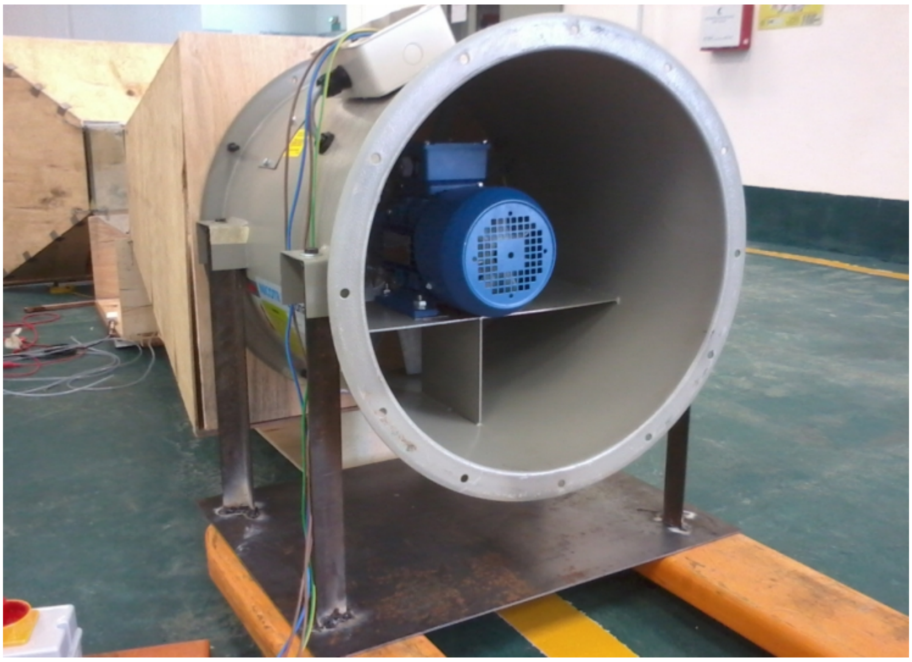

Figure 4.1: The Legs and the Base of the Fan

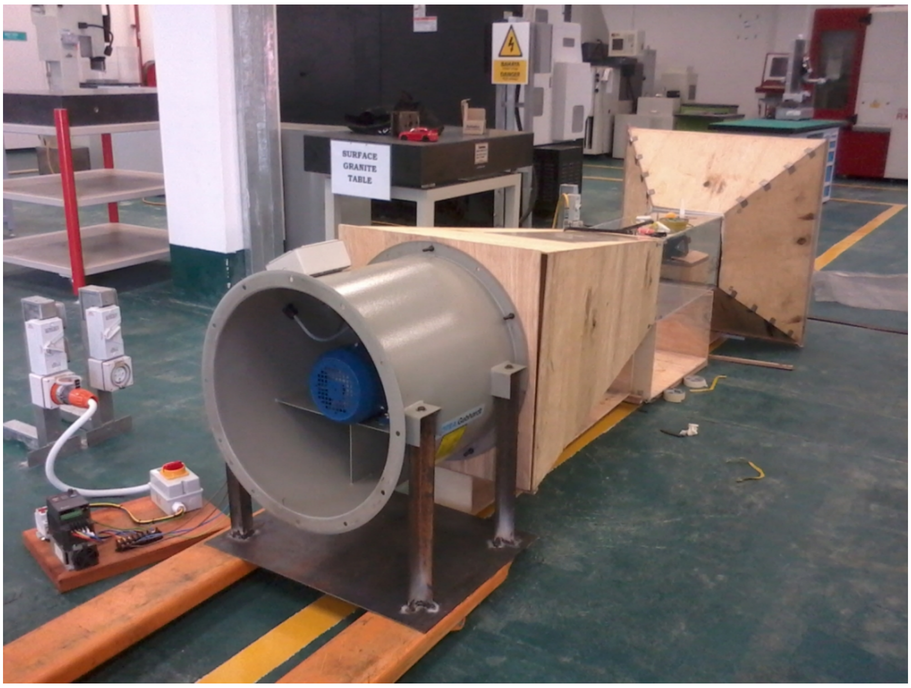

Figure 4.2: Attachment of Fan System to Wind Tunnel

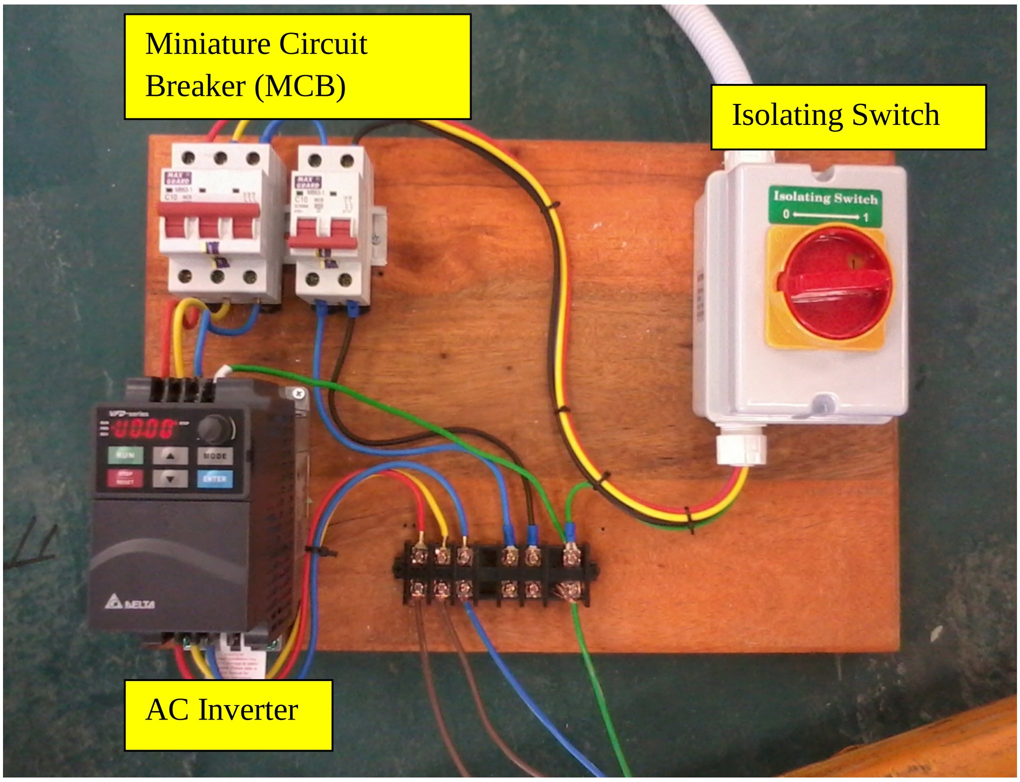

Figure 4.3: Circuit Connection of MCB and AC Inverter

To use the fan system, user should do the following steps:

1. Connect the 32A socket to the power source.
2. Switch on the isolating swith by rotating the knob clockwise.
3. Switch on the Miniature Circuit Breaker (MCB) by pulling the lever up. Be sure to not touch any instrument because 3 phase have high degree of dangerous.
4. Set the parameter A: 02.00 is set to 4, 02.00 is set to 0, 00.03 is set to 1. (refer manual book for more detail). This step only necessary for the first time use.
5. Press run keypad and adjust frequency on the knob. Press stop keypad to stop.

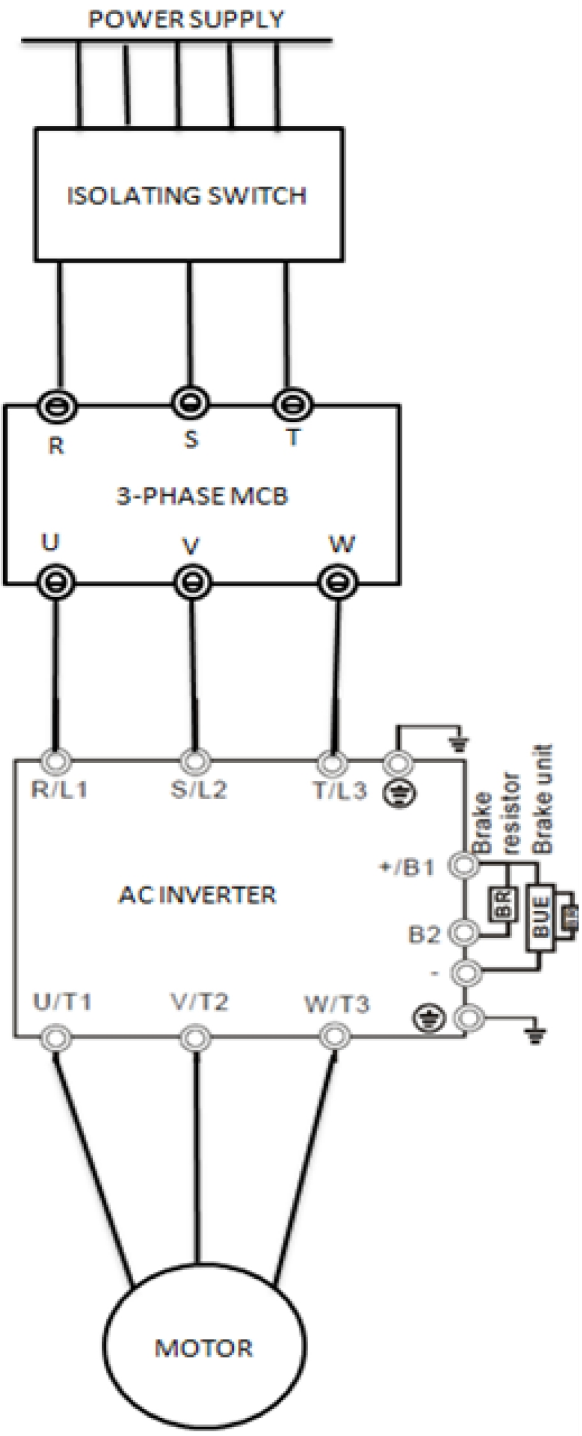

Figure 4.4: Schematic Diagram for MCB and AC Inverter Connection

4.3 Experimental Results

4.3.1 Pressure Measurement

Table 4.1: Pressure Measurement Result by Various Frequencies

Frequency, f (Hz)	Pressure, P (Pa)
0	0
10	4
20	29
30	74
40	121
50	199

The following graph was plotted by using the above pressure measurement table.

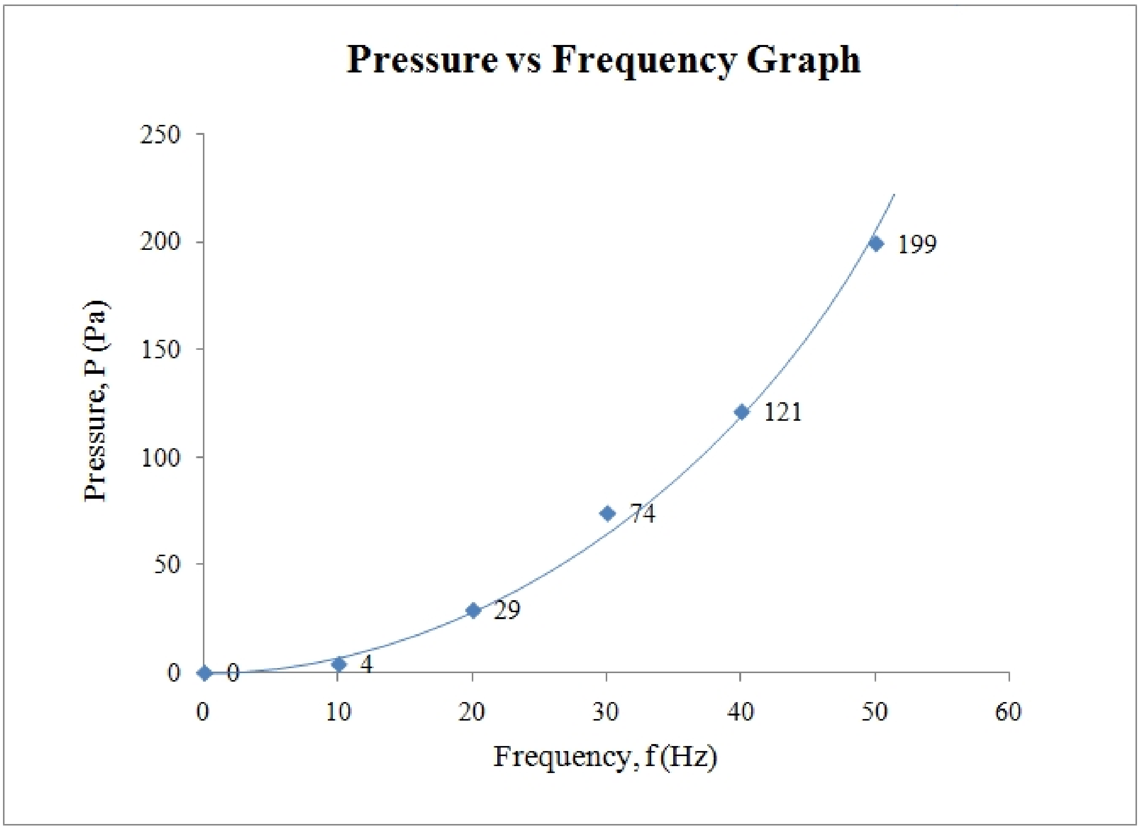

Figure 4.5: Graph of Pressure against Frequency

The graph shows the relationship of pressure against frequency of the airflow in the test section. It is noted that the pressure is directly proportional with frequency. Pressure increases when frequency increases. The graph shows the positive correlation of the two parameters.

The line only could be drawn through some point, not through all the points. This might be due to some errors or disturbances such as the airflow is not uniformed and the airflow is not fully laminar which result in moving continuously of digit on digital manometer.

Therefore, the graph is drawn using best fit line. There is calculation method that determines best fit line but it is too complicated. Hence, the easier method was used which is drawing the line that minimizes the average distance from it to each of the data points.

4.4 Calculation Results

4.4.1 Velocity, V of Gas

$$V = \sqrt[2]{\frac{2Pd}{\rho}}$$

where Pd is dynamic pressure and ρ is density of air which is about 1.1614 kg/m^3 at room temperature. Therefore:

$$V = \sqrt[2]{\frac{2(4)}{1.1614}}$$

$$= 2.6245 \text{ m/s}$$

The table of velocity based on frequency was established. Hence, graph of velocity versus frequency was plotted.

Table 4.2: Velocity Calculation Result by Various Frequencies

Frequency, f (Hz)	Velocity, V (m/s)
0	0
10	2.6245
20	7.0668
30	11.2886
40	14.4350
50	18.5119

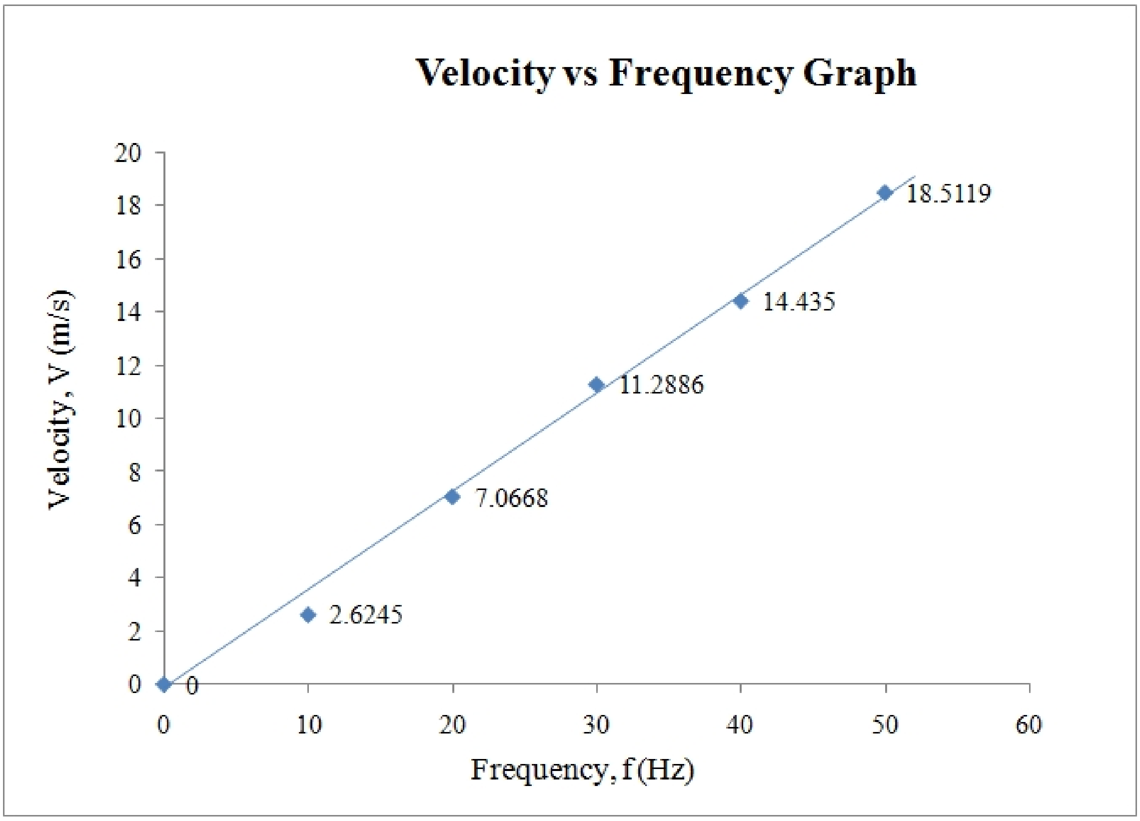

Figure 4.6: Graph of Velocity against Frequency

The above graph displays the relationship of velocity against frequency of the flow in test section. Here, it could be seen that the relationship of velocity against frequency is directly proportional which means when frequency increases, velocity also will be increase. They have positive correlation.

The graph also indicates that the relationship between two variables graphed on both coordinate systems is linear which a straight line could be drawn using best fit line method. Similar with the graph before, the line only could be drawn through some point, not through all the points also might be due to some external errors or disturbances of the airflow.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter concludes the whole project including previous chapter in a nut shell. This final year project is focused on a couple of topic which is the fabricating the fan system and the relationship of pressure and velocity to the frequency. The conclusion will touch on both of these focused areas.

5.2 Conclusions

5.2.1 Fan System of the Wind Tunnel

The fan system that designed could be used to adjusting the speed of the fan in frequency parameter. The usage of Delta AC inverter is helpful to accomplish the experiment of this project. It is a component that can vary the frequency, and even increase the motor frequency level. The three phase connection electrical hazard is quite high and could not be handled alone. The analysis of wind flow in the wind tunnel will be more ease when the desired speed could be adjusted.

The fan connection also could be implemented at other industries that involve the use of fan and variable speed or the industries that require using high frequency of fan. This also can be useful for automotive fields and buildings structures which use fan for their wind tunnel. The wind tunnel that fabricated also could be use for experimental aid in laboratory for students.

5.2.2 Parameters Relationship

The experimental result could be useful to user of the wind tunnel to setting velocity and pressure at the test section according to their experimental requirement parameter if they build the wind tunnel that have similar specification with this wind tunnel. The user can directly set the frequency of the motor by rotating the knob of AC inverter which only displays output frequency.

This project used pitot tube with pressure sensor and a manometer tube at first but the pressure in the test section could not be detected. This situation may due to some fault when installation and it is end up measured using pitot tube with digital manometer.

5.3 Recommendations for Future Research

To improve the fan system, connection that display and control the velocity is needed which will help user to vary the speed of the fan. So that the experiment of wind tunnel that have velocity of fan for parameter variable, will be done easily. Another element to improve is the vibration of the fan that affects the whole wind tunnel. Components like vibration insulation mount and cushion pad could be installed at the bottom of fan so that they will act as damper and absorb the vibration from fan.

For further study, the airflow of the wind should be streamline and fully laminar. Although there is screen, the airflow is still not fully laminar. Honeycomb could be used to improve the airflow so that there will be near zero turbulence in the wind tunnel.

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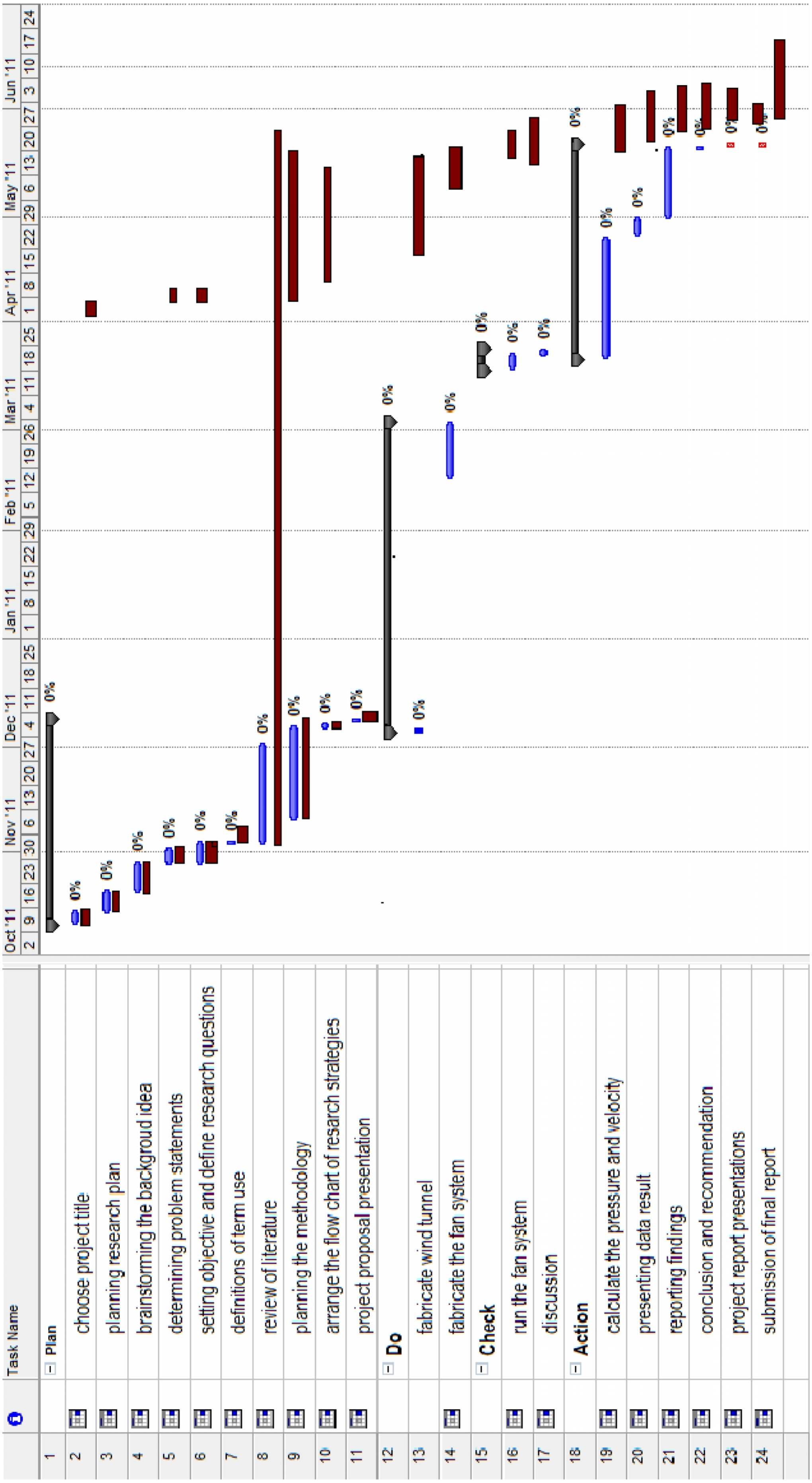
APPENDIX



Task Name
1 Plan
2 choose project title
3 planning research plan
4 brainstorming the backgroud idea
5 determining problem statements
6 setting objective and define research questions
7 definitions of term use
8 review of literature
9 planning the methodology
10 arrange the flow chart of resarch strategies
11 project proposal presentation
12 Do
13 fabricate wind tunnel
14 fabricate the fan system
15 Check
16 run the fan system
17 discussion
18 Action
19 calculate the pressure and velocity
20 presenting data result
21 reporting findings
22 conclusion and recommendation
23 project report presentations
24 submission of final report
Oct '11
Nov '11
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