"Saya akui bahawa saya telah membaca karya ini dan pada pandangan saya karya ini adalah memadai dari segi skop dan kualiti untuk tujuan penganugerahan Ijazah Sarjana Muda Kejuruteraan Mekanikal (Termal-Bendalir)

Tandatangan :....................

Nama Penyelia 1 :....................

Tarikh :....................

DR MOHD YUSOFF SULAIMAN
PENSYARAH
FAKULTI KEJURUTERAAN MEKANIKAL
KOLEJ UNIVERSITI TEKNIKAL KEBANGSAAN MALAYSIA
KARUNG BERKUNCI 1200, AYER KEROH,
75450 MELAKA.

Tandatangan :....................

Nama Penyelia 11 :....................

Tarikh :....................

DESIGN AND FABRICATE AN OPEN-CIRCUIT MINIATURE SIZED WIND TUNNEL

AZRIL BIN OTHMAN

Submitted To The Faculty Of Mechanical Engineering In Partial
Fulfillment Of The Requirements For The Degree Of
Bachelor In Mechanical Engineering
(Thermal – Fluid)

Faculty Of Mechanical Engineering
Kolej Universiti Teknikal Kebangsaan Malaysia

Nov 2005

"Saya akui bahawa laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya jelaskan sumbernya"

Tandatangan : ______________.

Nama Penulis : AZRIL BIN OTHMAN

Tarikh : 16/12/2005 .

This project is dedicated to my parents...

Othman bin Hashim...

Rusiah bt. Sidu...

Brothers and...

Sisters...

They gave me all the courage, inspiration, motivation, and financial aid for the success and accomplishment of this project.

ACKNOWLEDGEMENT

First of all in the name of Allah, thanks because give me brightness in darkness to completed this *Projek Sarjana Muda* (PSM) and report successfully. There is no regret when go through a thorny road with the guide from The Most Merciful.

In this opportunity, I would like to express my sincere gratitude to my supervisor Dr. Mohd. Yusoff Sulaiman for his invaluable guidance, indispensable help and continuous encouragement throughout the course and the success of this project.

Also, thank you very much to Mechanical Engineering Faculty, KUTKM for full cooperation and contribution towards the completion of my PSM. To all my friends especially Mohd Rizan Bin Mohd Akil , thank you for your encouragement and your good ideas.

Finally, to my family, they gave me all the courage, inspiration, motivation, financial aid and love I need in my quest for the success and accomplishment for this project.

ABSTRAK

Projek ini dijalankan adalah bertujuan untuk merekabentuk dan memfabrikasi sebuah terowong angin yang boleh digunakan didalam makmal untuk tujuan pengajaran. Projek ini dijalankan dengan mengenalpasti setiap bahagian terowong angin yang sedia ada dan juga kriteria yang perlu ada pada setiap bahagian. Jenis trowong angin yang akan dibangunkan didalam projek ini adalah dari jenis " Open-Curcuit Low Speed Wind Tunnel". Projek ini juga bertujuan untuk mencari elimen yang boleh diterapkan kedalam pembikinan terowong angin dimana ianya boleh mengurangkan kos dan dapat meningkatkan kecekapan terowong angin tersebut.

ABSTRACT

This project has been carried out to design and fabricate a small scale wind tunnel which can be used for laboratory teaching purpose. This project carried out by learning each part of the wind tunnel and also finding the criteria of each part of the wind tunnel from the latest wind tunnel had been design. The type of the wind tunnel that wants to build is open-circuit low speed wind tunnel. This project also wan to find the element that can be adopted in the wind tunnel designing, where it's can reduce the cost but it's can increase the efficiency of the wind tunnel.

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SYMBOLS	DEFINITION
A	Area or cross-sectional area
C	Contraction ratio
c_f	Skin friction coefficient
C_f	Dimensional resistance coefficient
C_D	Drag coefficient
D	Diameter
D_e	Cross-section diameters
F	Force per unit breadth
H	Enthalpy
ΔH	Total head
k	Tunnel factor
n	Number of screens
l_i	Distance between settling chamber entry to first screens
l_c	Length of contraction
D_1	Diameter ratio
δU_s	Variation of the velocity
U_s	Average velocity
t	Contraction contour
S	Model area
U_α	Stream velocity
p	pressure
P	Power input to driving unit
Δp	Pressure drop

Re	Reynolds number
s	Entropy
S	Model area where drag coefficient is base
t	Half height of breadth
T	Fan trust
U	Air velocity
x	Axial distance in streawise direction

GREEK SYMBOLS	**DEFINITION**
a	Deflection coefficient of screen
β	Screen open-area ratio
δ	boundary layer thickness
δ*	boundary layer displacement thickness
η	efficiency
θ	Boundary layer momentum thickness or half the diffuser angle.
υ	Viscosity
μ	Kinematics viscosity
ρ	Density
λ	Power factor
τ	Shear force
ε	Model interference factor

SUBSCRIPT	**DEFINITION**
c	contraction
d	diameter
D	diffuser
e	equivalent
f	friction
F	fan
i	Inlet to settling chamber

o	Outlet from diffuser
∞	Open-circuit
s	Screen or settling chamber or stagnation
w	Test section

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CHAPTER 1

INTRODUCTION

A wind tunnel is a device used to producing a moving air stream for experimental purposed. Stevenson (1969) stated that the main purpose of wind tunnel is to provide a uniform and turbulent-free stream of air. Anderson (1989) stated that wind tunnels are ground-based experimental facilities, designed to produce flows of air (or sometimes other gases) that simulate natural flows occurring outside the laboratory.

Apparently, low speed wind tunnels are one type of tools in the teaching of aerodynamics or fluid mechanic. The basic test methods for large and small wind tunnels are similar. The term low speed wind tunnels refer to wind speed with air speed less than 133 m/s or where the effect of compressibility can be neglected.

The Tunnel is called an open circuit if the tunnel discharges its flow to the atmosphere (or laboratory, or pressure vessel, or other unprepared environment). If the cross-section of the return path is many times that of the test section, it is hoped that the discharged air will lose most of its mean vorticity, unsteadiness and turbulence before it is re-ingested. In the case of suck-down tunnels the fan is usually placed at the end of the diffuser. As the kinetic energy of the air discharged from the diffuser is usually only a small percentage of the kinetic energy of the air in the test section, the power required by an open-circuit tunnel may be less than that required by a closed-circuit tunnel of the same aerodynamic design, because no power is wasted in the drag of the corner vanes.

Open-circuit tunnels which take in air from the atmosphere or the laboratory are sensitive to draughts. It is more difficult to fit a filter to a suck-down tunnel because the air entering the intake must have roughly uniform total pressure over the cross section or the "turbulence management" devices (screens and honeycombs) will not be able to deliver adequately uniform total pressure to the test section.

The purpose of wind tunnel design is to achieve the required conditions for the model test with minimum power consumption and at the smallest possible cost. The aerodynamic conditions of dynamical similarity with the flow around the full-scale body of which the model is a scale copy. In practice, however, the power required operating the tunnel, or the cost of the tunnel, often making it impossible to achieve complete dynamic similarity, and a compromise is necessary. In these circumstances it is usual to satisfy the most important of the similarity condition and to tolerate discrepancies in the others.

For a low speed tunnels, the predominant factors are inertia and viscosity, and the influence of compressibility is negligible. Thus, provide that the Reynolds numbers of the model experiment and full-scale flight are equal, a difference in velocity is unimportant.

The design of low speed wind tunnel is a combination of art, science and common sense, the last being the most essential. It is difficult and unwise to predict firm rules for tunnel design. This mainly due to wide variety of tunnel designs and the lack of understanding of flow trough wind tunnel component like the diffuser, screens and the driving unit itself.

1.1 Objective of project

The main objective of this project is to analysis of how to design and fabricate an open-circuit miniature sized wind tunnel based on basic specification as below:

Type	:	Open circuit suction wind tunnel.
Test section x-section	:	150mm x 150mm
Test section length	:	600mm
Speed range	:	10 m/s – 20 m/s

1.2 Scope project

1. Literature review of wind tunnel and wind tunnel design methods.
2. Material and part procurements.
3. Design and fabricate the wind tunnel and test.

CHAPTER 2

CONCEPTS OF FLUID FLOW

2.1 Uniforms and Steady Flow

There are four possible types of flow:

a) Steady uniform flow. Conditions do not change with position or time. The velocity and cross-sectional area of the stream of fluid are the same at each cross-sectional; for example, flow of the liquid through a pipe of uniform bore running completely full at constant velocity.

b) Steady non-uniform flow. Conditions change from point to point but not with time. The velocity and cross-sectional area of the stream may vary from cross-section to cross-section, but, for each cross-section, they will not vary with the time; for example, flow of a liquid at a constant rate through a tapering pipe running completely full.

c) Unsteady uniform flow. At given instant of time the velocity at every point is the same , but this velocity will change with the time; for example, accelerating flow of liquid through a pipe of uniform bore running full, such as would occur when a pump is started up.

d) Unsteady non-uniform flow. The cross-sectional area and the velocity vary from point to point and also change with the time; for example, a wave traveling along channel.

2.2 Laminar and Turbulent Flow

If water run through a pipe of diameter D with and average velocity V, the following characteristics are observed by injecting neutrally buoyant ye. For 'small enough flow rates' the dye streak (a streak line) will remain as a well-defined line as it flows along, with only slight blurring due to molecular diffusion of the dye into the surrounding water. For a somewhat larger 'immediate flow rate' the dye streak fluctuates in time and space, and intermittent bursts of irregular behavior appear along streak. On the other hand, for 'large enough flow rates' the dye streak almost immediately becomes blurred and spreads across the entire pipe in random fashion. These tree characteristics, denoted as laminar, transitional, and turbulent.

The curves represent the x component of the velocity as function of time in the flow. The random fluctuations of the turbulent flow (with the associate particle mixing) are what disperse the dye throughout the pipe and cause the blurred appearance illustrate.

2.3 Conservation Property of Fluid Flow

Flow changes at very moment but the mass flow per unit time, the total energy and the momentum of the flow remain unchanged.

2.3.1 The Flow of Crowd on the Platform (Mass Conservation)

When the train arrives, a platform will be filled with people getting of the train. These people slowly walk to the end of the platform. Is there is an escalator, the width of the passage becomes narrower but the people move faster, so as to proceed smoothly. Hence, the number of the people per unit time is the same.

The same phenomena occur in the flow of water. In a continuous flow, the mass rate of the flow (flow quantity) pass through each section of pipe does not change even if the pipe diameter changes. If the pipe diameter is reduced, the flow velocity increases so as to keep constant mass flow at each section as shown in Figure 2.1.

2.3.2 The Roller Coaster (Conservation of Fluid Energy)

At a high elevation, the speed of roller coaster is low, but when it comes at a lower level, the speed becomes very high. This is due to the fact that the increase in potential energy at the higher level is equal to the decrease in kinetic energy and reverse is true at the lower level Figure 2.2. This is conservation of energy.

2.3.3 Space Shuttle Launch

What is the source of the power for the launch of space shuttle? When the rocket is first ignited, the exhaust gas of the mass 'm' gushes out at a velocity 'v' and the force acting on the rocket equals the momentum 'mv'. As the mass and the velocity of exhaust gases increase, the force acting on rocket also increases to lift the rocket.