"I admit that I have read this report and from my opinion that it is suffice from aspect of scope and quality for a purpose of awarding Bachelor of Mechanical Engineering (Thermal-Fluid)".

Signature : .....

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Date : 14/12/05

THE DEVELOPMENT OF SMALL SCALE HOVERCRAFT UNIT

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This report was handed to Faculty of Mechanical Engineering to fulfill parts of the requirement for awarding the Bachelor of Mechanical Engineering (Thermal-Fluid)

Faculty of Mechanical Engineering
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November 2005

ADMISSION

" I admit that this report was done all by myself except the summary and passage that I have clearly stated the source on each one of them"

Signature : .....

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Date : 12/12/2005

This work is dedicated to my beloved mother and all of my family. Your loves are forever...

To all my classmates, do remember our friendships. It was a happy moment to be with you guys in these past few years...

Lastly to my sweetheart, I love you very much and wish that we're meant to be together...forever

ACKNOWLEDGEMENT

I would like to take this opportunity to say thank you to my dearly supervisor, Mr. Ahmad Anas bin Yusof for his guidance and advice in order to successfully complete this project.

Thanks to fellow FKM lecturers and technicians for their help. I would also thankful to my classmates, my housemate and especially to Azizi bin Adnan, Ahmad Faizol bin Ismail and Azril bin Othman for their technical involvement and support in this project.

Special thanks to my beloved family for supporting me on this project, financially and mentality until I've finished this project and thesis. Alhamdulillah, all praise to ALLAH with his blessings, I finally finished this project successfully.

ABSTRACT

This thesis presents the development of a small-scale hovercraft unit which providing full hovercraft basic functions and had been carried out by the author to fulfillment of the requirement for the award of the degree of bachelor of Mechanical Engineering. This designed hovercraft which has two stage of development and include two models. The first model is for PSM 1 and the second and fully functions model is for PSM 2.

Basically, the hovercraft design and construction process is quite similar to the boat or aircraft design. In this report, I had made all the required analysis's and used some formulas for thrust and lift, drag components calculations and other important parameters to realization the development of these air cushion vehicle models. Also, the planned model 3D drawing of this hovercraft with their general arrangement was completed and attached together with this thesis. The aim of this report is to provide the literature study, all necessary methodology, constructions and analysis's as part of the requirement in submitted the report to the PSM supervisor and shall fulfill the project objectives and scopes.

Even though hovercraft research and development is still new technology in Malaysia and no domestic consumption in this technology, through this development project, it shall help this industry a step further because this project can be categorized as successful and working as expected. Finally, I wish KUTKM will give the priority and budget to anyone who interest to continue to improve this project and conduct R&D for the development of this technology in the near future.

ABSTRAK

Thesis ini mengisarkan tentang pembangunan hoverkraft bersaiz kecil yang mana menampilkan fungsi-fungsi asas sebuah hoverkraft yang dijalankan bagi memenuhi syarat penganugerahan Sarjana Muda Kejuruteraan Mekanikal. Proses merekabentuk dan membangunkan model hoverkraft ini tarbahagi kepada dua tahap dan melibatkan pembinaan dua model. Model yang pertama adalah untuk PSM 1 dan model yang kedua untuk PSM 2.

Secara asasnya, proses merekabentuk and pembinaan hovekraf adalah lebih kurang sama dengan bot atau pesawat. Di dalam laporan ini, saya telah membuat semua analisis yang diperlukan dan menggunakan beberapa formula bagi pengiraan daya tujah, daya angkat, komponen seretan dan beberapa parameter penting yang lain bagi merealisasikan pembangunan model kenderaan kusyen udara ini. Lukisan 3 dimensi untuk model juga di sediakan bersama thasis ini lengkap bersama dimensi-dimensi dan urutannya secara am. Matlamat laporan ini adalah untuk menyediakan kajian literatur, kaedah-kaedah yang diperlukan, pembinaan dan analisa-analisa sebagai sebahagian daripada keperluan untuk laporan yang perlu dihantar kepada penyelia PSM dan memenuhi objektif-objektif dan skop-skop projek.

Walaupun penyelidikan dan pembangunan hoverkraf adalah sesuatu yang masih baru di Malaysia dan tiada lagi kegunaan secara domestic di sini, melalui pembangunan projek ini, ianya akan membantu industri in selangkah kehadapan kerana projek ini adalah boleh dikategorikan sebagai berjaya dan berfungsi seperti yang dijangkakan. Akhirnya, saya harap agar KUTKM dapat memberi keutamaan dan suntikan modal kepada sesiapa yang berminat menyambung dan memperbaiki projek ini serta mengendalikan pembangunan dan penyelidikan dalam teknologi ini di masa hadapan.

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P	=	Hovercraft total power (kW)	25
W	=	Hovercraft weight (tons)	25
D_p	=	Profile or aerodynamic drag	28
D_m	=	Momentum drag	28
D_i	=	Induced drag	29
D_s	=	Skirt drag – total	31
D_{sw}	=	Skirt drag – wetting drag	31
Ds_{wm}	=	Skirt drag – wave making drag	31
D_{srw}	=	Skirt drag – rough water drag	31
D_h	=	Side hull drag	32
Q	=	Lift air flow, m3/s	33
L	=	Skirt footprint perimeter, m	33
W	=	Total weight, N	33
S_c	=	Footprint area, m2	33
H_c	=	Cushion pressure, cm	33
K	=	Constant, 0.0272	33
H	=	fan power, kW	34
P	=	cushion pressure, Pa	34
Q	=	fan airflow, m3/s	34
m	=	Maximum moment of the structure	54
y	=	Distend from the keel to central of gravity of the structure	54
I	=	Second moment of inertial.	54
Ac	=	Area of air cushion	72
Pc	=	Air cushion pressure	72
Q	=	Volume air flow from gap	72
Ag	=	Area of air gap	72
Pr	=	Perimeter (peripheral length)	72
Hg	=	Height of air gap	72

Ve	=	Velocity of escaping air	72
Wt	=	Total craft weight	72
ρ	=	Air density @ sea level (1.227 kg/m^3)	72
yf	=	Fan Efficiency	72
Hp	=	Horse power	72
Ah	=	Hull Area	72
W	=	Width	72
L	=	Length	72
Pf	=	Fan pressure	77
P_L	=	Lift fan power	77
D_A	=	Aerodynamic drag	81
ρ	=	Air density @ 20°C = 1.227 kg/m^3	81
V	=	Hovercraft speed (m/s)	81
A_f	=	Hovercraft frontal area (m^2)	81
C_{Dp}	=	Coefficient of aerodynamic drag	81
h	=	Hover air gap	83
C_w	=	Wave making drag coefficient	83
W	=	Hovercraft width (m)	83
g	=	Gravity (m/s^2)	83
l_c	=	Cushion length (m)	83
B_c	=	Cushion breadth (m)	83
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CHAPTER 1

INTRODUCTION

1.1 Preface

The air cushion vehicle concept can be traced back in 1716. However, the practical form of today's hovercraft is in 1955. Since then, many types of land, marine and amphibious air cushion vehicles have developed [Alan Blunden, 1987]. All about hovercraft are described in other chapters. The topics are covered from first principles to the state-of-the-art, with proper reference to the literature.

This project is focus on development of a small-scale hovercraft unit and will be discussed later. With these specialized applications of amphibious hovercraft, its can be used over land, water or even on rough ground. Among them were used for search and rescue, patrol, law enforcement and others.

The design must consider the stabilization and thrust system for propulsion, depending on type of propeller and power plant (engine or electric motor) that will be used. This decision is made after all the forces acted to hovercraft were determined.

1.2 Project Arrangement

Overall the project activities can be illustrated as below:

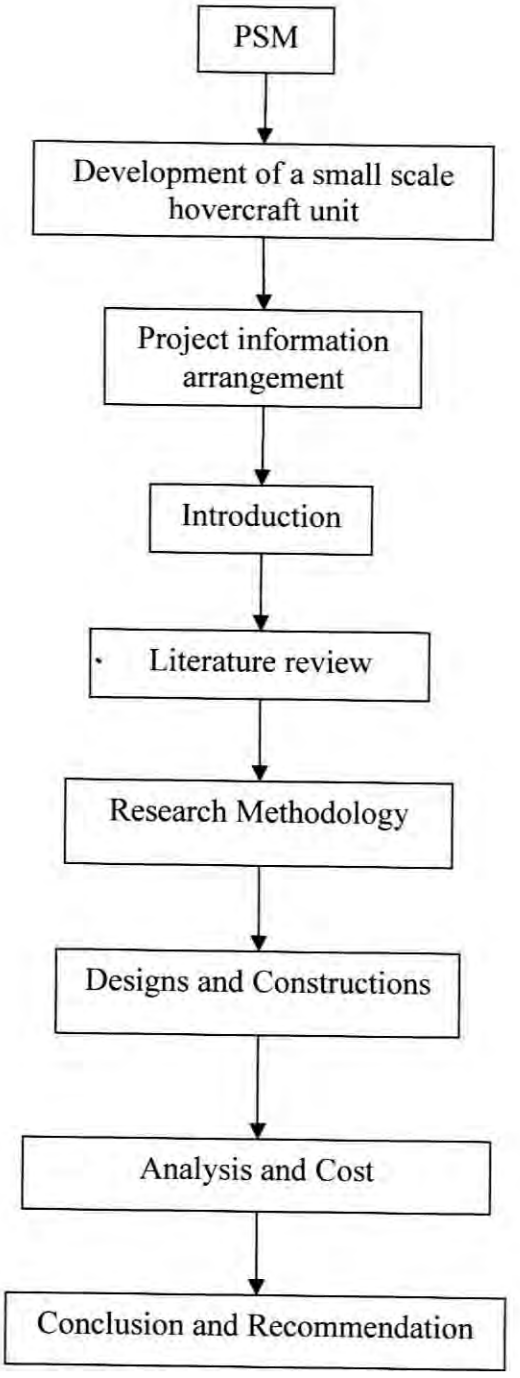

Figure 1.1 *Project Arrangements*

1.3 Objectives

The objectives of this project are:

a) To develop a small scale hovercraft unit for educational and research purpose
b) To develop an appreciation of system engineering concepts in BMCT student.
c) To promote study in practical applications of engineering and scientific principles.
d) To assume primary weight, resistance and principles dimension for this hovercraft
e) To design hovercraft suitable to their specialized applications (amphibious)
f) Suggestion for choosing material and power plant that match to this hovercraft

1.4 Project Scopes

Scopes for this project as follow:

a) To find the design fundamental for a small hovercraft.
b) Make the research for small hovercraft background and construction.
c) Find principles dimension for hovercraft that will design and make comparison with other hovercraft.
d) To find drag component and lift force that stride to hovercraft and than make assumption for thrust. With this assumption, the suitable propeller and power plant can be determined.
e) To complete the drawing of small hovercraft design.
f) To find the best material to be used and estimate the cost for model construction.

g) To recognize all hovercraft applications and limitations and also to define a small hovercraft in their classification.

1.5 Problem identified

The problems which leads to this project are:

a) There's no such model or teaching equipment in KUTKM that can be used for education, research or stimulate the air cushion vehicle concept.
b) The functional scaled model is needed for performing and implementing many mechanical fields from fluid dynamic, design, structural to automotive.
c) An initial model for future research and development to improve efficiency, expend the usage and further innovations for air cushion vehicles.

1.6 Design Requirements

For designing this hovercraft model, there's some requirement to fulfill the objective and bachelor level of study, the requirements in design of small hovercraft are:

a) The model must be well designed and powered.
b) Implicate the mechanical principle like aerodynamic, airfoil and fluid dynamic.
c) The model must perform basic function of hovercraft and able to travel on various kind of terrain including water.
d) This model must able to produce enough air cushion to hover its body and also can lift some loads.

e) The hovercraft must able to produce enough thrust to move along the ground by itself and with some loads.

f) Preferably mobile type of model that will carry its own power supply without external source.

1.7 Expected Result

Among the project activities, there must some expected result. The primary goal is to prepare a full drawing of preliminary design of small hovercraft. The designed hovercraft must accordance from previous hovercraft. The principal dimension of hovercraft is depending on their ability to support the determined payloads. This hovercraft model is for study and research purposes while still perform its basic functions.

Thus, it must have all the required characteristics of the hovercraft even this is a small scale model. This amphibious hovercraft will be fabricated with polystyrene or Styrofoam and coated with fiberglass layer to produce rigid and tough body and used single or dual power plant (engines or electric motors) for thrust and lift systems. Because of their consumption for this craft to lift some loads, high-speed engine or motor is applied to the lift power.

These lift power should be controllable to get sufficient pressure in the cushion and suited with the applied loads. Skirt materials must flexible and has sufficient stiffness, hence it can operation off-the-road, on water surface or even on the rough terrain.

CHAPTER 2

LITERATURE STUDY

2.1 What is Hovercraft?

A hovercraft is a vehicle that is hovering just above the ground, or over snow or water, by a 'cushion of air' [Razak, 2000]. To understand the principle of the air cushion effect, assuming of dropping a cork tablemat on to the tablecloth, so that it falls completely silent. If the mat was dropped perfectly horizontal, it is brought to a stop quite gently by the air trapped underneath it. The air escapes, of course, but it makes a temporary 'cushion'.

In a hovercraft a similar cushion of air is maintained by pumping in a steady supply air, to keep pace with the linkage round the sides. There is always some leakage because the craft has to be free to move, but the designers use various methods to keep leakage as small as possible so that only minimum power is required to keep up the air supply [James M. Pruett, 1973].

The various ways of creating the air cushion and reducing leakage, are described in later chapters, and it shown in very simple example below (Fig 2.1).

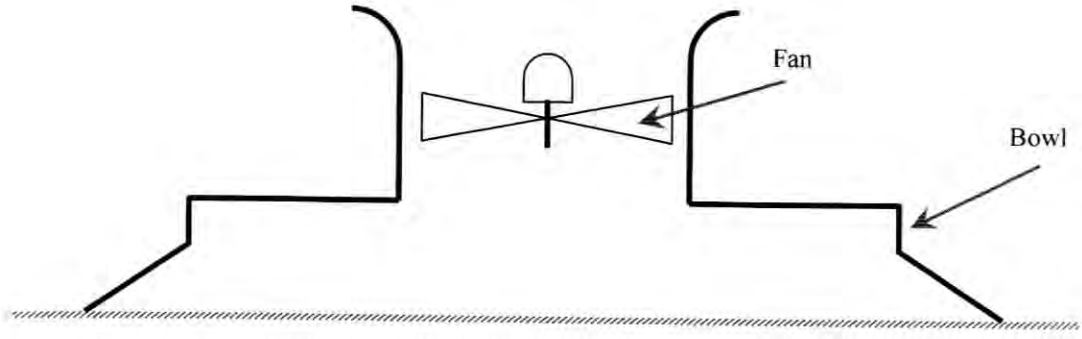

Figure 2.1 *Simple example of hovercraft*

This is purely imaginary hovercraft to show the idea in its simples form. It is rather like a bowl, upside down, fitted with an engine and a propeller which sucks air in through the hole at the top and forces it into the hollow part beneath.

When the fan is rotated, the air pressure inside the 'bowl' begins to increase quite quickly and pushes against the sides of the bowl (Fig 2.2), just as it pushes against the skin of a balloon when you blow it up. The difference is that this bowl is not elastic, and instead of forcing the rubber to stretch, the air pressure forces the bowl up off the ground.

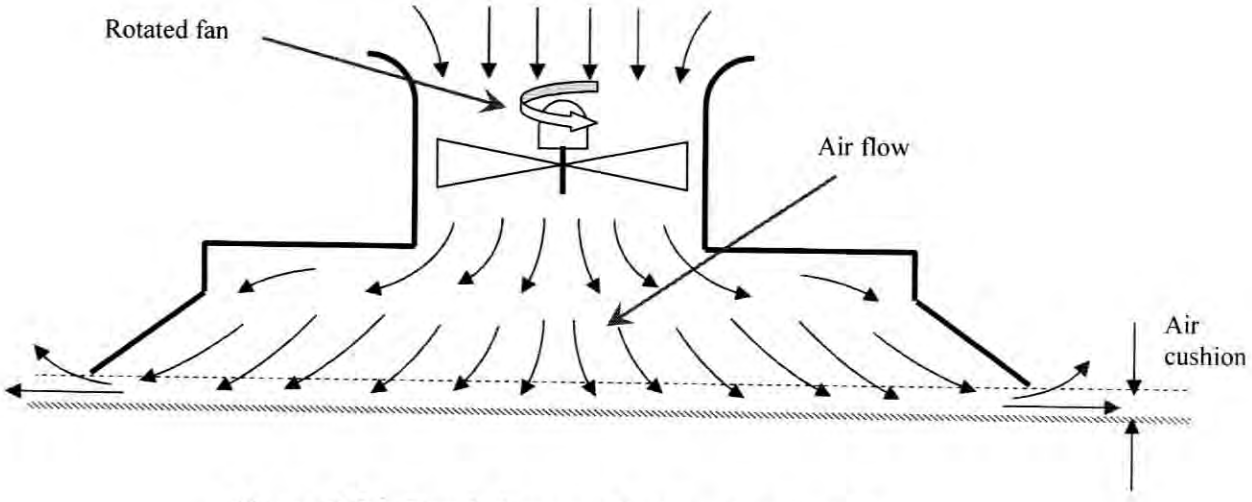

Figure 2.2 *Simple hovercraft air cushion supply.*

As soon as the bowl rises the air has a way of escape all round the bottom edge, but as long as the fan keeps on pumping air in fast enough to keep pace in the rate of leakage of the bowl will remain supported and the faster the air is pumped in the higher the bowl will rise.

This Surface Effect Ship (SES) is one of the assorted types of Ground Effect Machine (GEM). A hovercraft has been a public transportation in Europe since the 1960's [Malcolm W. Cagle, 1970]. Basically a model hovercraft is designed for research and study purpose from its principle operations to development and improvement of the current model. GEMs are air cushion vehicles. The load of this vehicle is supported by a volume air under the vehicle. All movement and motion of this vehicle is generated by either aerostatic or aerodynamic force or both.

A well designed hovercraft is superior to a boat over water because it has less drag and requires less horsepower to push it. This results in higher speeds and better fuel consumption. The hovercraft gets about twice the fuel mileage of a boat with similar size or capacity [Liang Yun & Alan Bliault, 2000]. Rising fuel prices and shortage of fuel will make the hovercraft more desirable in the future. It also gives a smoother ride than a boat because it maneuvers above the water, not on it. It travels over water with no concern for depth or hidden obstacles. It will go against the current of a river at the same ground speed as going along the current. The hovercraft also works very well in rapids or water where standing waves up to a meter high have been encountered for a medium scaled hovercraft [Malcolm W. Cagle, 1970].

The special qualities of hovercraft shall be discussed in later chapters and for the moment they may be enough to hint at some of the reasons why people have thought that it would be worth going to a great deal of trouble and spending a great deal of money to make practical hovercraft.