EFFECT OF AIR CUSHION ON THE RESISTANCE REDUCTION OF MULTI-PURPOSE AMPHIBIOUS VEHICLE (MAV) IN CALM AND WAVES WATER

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Dedicated to...

My beloved mother Rahilah binti Bustamy,

Universiti Teknologi Mara,

Marine Technology Center.

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ABSTRACT

In a recent year, shipping industry had been extensively developed as a countermeasure from economic growth of a country, rise of raw materials price as well as the regulations for CO2 emission from international shipping operation The combustion process of ship engine will emit the greenhouse gases which are carbon dioxide (Co2), Sulphur dioxide (Sox), Nitrogen dioxide (Nox), as well as particulate matter which contribute to greenhouse effect. A concern from the public on this situation had lead the academician and transportation industry to extensive developed and explored on fuel-efficient and energy concept ship. Multi Amphibious Vehicle (MAV) is a transport that able to navigate on land and water including under water. MAV have a blunt-shape bow where it produces a large bow wave forming and hydrodynamic resistance resulted increase on power consumption. A higher in resistance also resulted in a bow submerging and swamping on the MAV. So, the air cushion concept is introduced to reduce these problems. In this research, the resistance acting on Multi Amphibious Vehicle (MAV) hull navigated in calm and regular waves condition is investigated experimentally and numerically. A simplified MAV model for computing resistance of air cushion effect on regular head waves is established. Simulations were carried out in finite element analysis ANSYS CFX 15.0 in two different wave height conditions which were 0.5m and 0.75m to study on the MAV resistance and also its motion. The resistances and the motion of MAV model with and without the air cushion effect were compared in a graph of total resistance versus MAV speed. The maximum resistance reductions occur at forward speed 6kn with 0.2 l/s air flow rate injection for both wave height 0.5m and 0.75m at 10.89% and 8.65 %. It is noticeable that, air cushion effect also gives a slightly improvement on ship motion in heaving and pitching.

ABSTRAK

Sejak kebelakangan ini, industri perkapalan telah berkembang pesat hasil daripada pertumbuhan ekonomi negara, kenaikan harga bahan-bahan mentah serta peraturan-peraturan bagi pelepasan gas karbon dioksida daripada operasi perkapalan antarabangsa. Proses pembakaran enjin kapal akan mengeluarkan gas-gas rumah hijau terdiri daripada gas karbon dioksida (CO2), sulfur dioksida (Sox), Nitrogen dioksida (Nox), serta zarah yang menyumbang kepada kesan rumah hijau. Kebimbangan daripada orang ramai mengenai keadaan ini telah membawa ahli akademik dan ahli industri pengangkutan umtuk membangunkan kapal jimat bahan bakar dan tenaga. Multi Amphibious Vehicle (MAV) adalah pengangkutan yang mampu untuk mengemudi di darat dan air termasuk di bawah air. MAV mempunyai muncung kapal yang tumpul di mana ia menghasilkan gelombang ombak yang besar dan menghasilkan rintangan hidrodinamik yang tinggi menjurus kepada peningkatan dalam penggunaan kuasa. Rintangan yang tinggi juga menyebabkan MAV teenggelam. Jadi, konsep kusyen udara diperkenalkan untuk mengurangkan masalah ini. Dalam kajian ini, rintangan yang bertindak ke atas rangka kapal Multi Amphibious Vehicle (MAV) dalam keadaan berombak dan tenang. Simulasi Komputer menggunaka software ANSYS CFX 15.0 dalam dua keadaan ketinggian gelombang yang berbeza iaitu 0.5m dan 0.75m untuk mengkaji rintangan dan pergerakan MAV Rintangan dan gerakan model MAV dengan dan tanpa kesan kusyen udara dibandingkan dalam graf rintangan berbanding kelajuan MAV. Penurunan rintangan maksimum berlaku pada kelajuan 6kn dengan suntikan kadar aliran udara 0.2 l / s untuk kedua-dua 0.5m ketinggian ombak dan 0.75m pada 10.89% dan 8.65%. kesan kusyen udara juga dapat dilihat memberi sedikit pengurangan terhadap pergerakan MAV.

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INTRODUCTION

1.1 Introduction

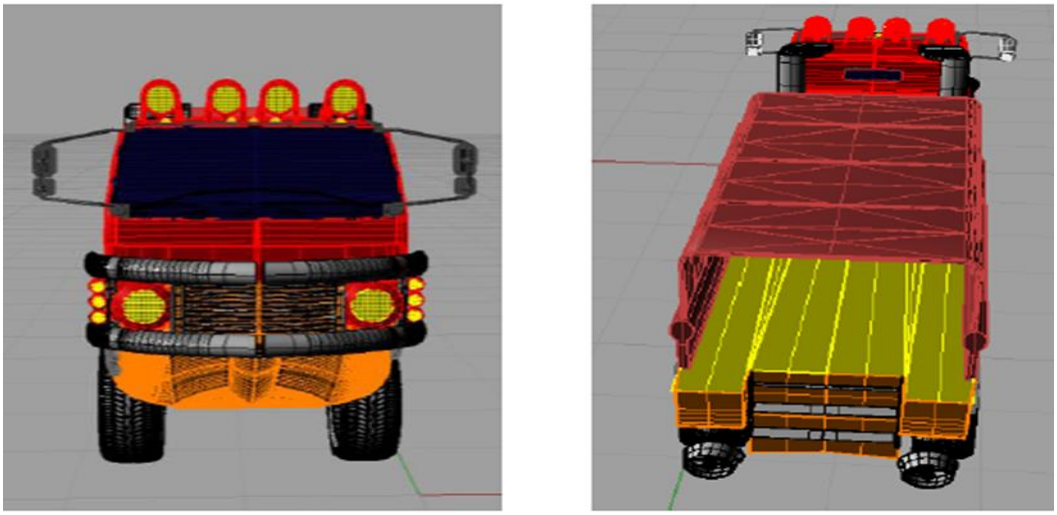
Nowadays, the world economy had been growth rapidly result in massive global supply chain activity. In a supply chain activity, shipping industry plays an important role for logistic purpose. Most of the ships using diesel as a fuel for combustion process in order for a ship to sail in the seaway. This process will emit emit the greenhouse gases which are carbon dioxide (Co2), Sulphur dioxide (Sox), Nitrogen dioxide (Nox), as well as particulate matter which contribute to greenhouse effect. A commitment to reduce the impact of greenhouse gases requires a further enhancement compliance with Energy Efficiency Design Index (EEDI). This situation had lead the academician and transportation industry to extensive developed and explored on energy saving ship and fuel efficient operation ship.

Scholars had come up with the introduction of air cushion vehicles. Generally, air is injected at the bottom of ship hull and stimulated the artificial cavitation. Several years back, a Russian scientist (Butuzov et al., 1999a) had developed this concept in order to minimize a viscous resistance on ship. He concluded that, artificial air cavity concept gave a promising impact on viscous drag reduction. This is because of decrease in wetted surface of a ship caused by lift effect and lubrication.

(Nikseresht et al., 2008) support the result and elaborated more on the important features of air cushion operation. In air cushion operation, injecting fan, hull shape and skirt plays an important role. The investigation focused on the

behavior of fan, which is function to inject the air at the bottom of wetted hull. Parameters of a fan especially air volume flow, pressure rise and fan rpm is important for a further investigation. The air cushions are not only focused on marine crafts, but it is also widely use at heavy floating structures operation. The tow-out of the Khazzan Dubai oil tank (Sullivan et al., 1982) is one example of air cushion not only for ship application.

The main purpose of air cushion is to reduce resistance also produce the ability of craft to travel on both land and water called amphibious ability. These day, amphibious vehicles not only used in normal operation but also widely utilized in military service for years (Koto et al., 2014). According to (Nakisa et al., 2015) an air cushion Multipurpose amphibious vehicle as shown in Figure 1.1 is a vehicle that able to traverse the water with a lowest hull surface friction which supported by air cushion that generated from pumped air bubbles. The air compressor will slide along and at a same time balance the air cushion bubbles to prevent the air loss. Less energy is required to cruise the ship forward as the friction at the bottom of the amphibious ship has been greatly reduced. As stated by (Nakisa et al, 2015) usually it is powered by two water jets of speed at 13km/h and designed for land operation where the operations in water is limited at a specified speed. So, the floatability and stability of these vehicles are optional features for deep river operations.



(a) (b)

Figure 1.1: MAV front and isometric view (Nakisa et al., 2015)

1.2 Problem Statement

Multi Amphibious Vehicle (MAV) have a blunt-shape bow which producing a large bow wave forming when cruise at high speed. This condition caused a higher resistance than usual and at a critical speed it will resulted in submergence of bow or swamping effect. The use of air cushion effect is well known in order support marine vehicles and heavy floating structures. A number of institutes had done a research on air cushion concept as it expected to give a prominent result. Generally, previous study is still brief on air cushion effect on resistance reduction and motion especially on MAV. In addition, previous study focused more on air cushion effect in calm water condition. Therefore, in this project air cushion effect on MAV resistance and motion will be study in regular wave condition

1.3 Objectives

I. To analyse the effect of air cushion on resistance reduction of MAV in calm and regular waves condition.
II. To determine the effect of air cushion on MAV motion in regular waves condition.

1.4 Scope of study

This research will be done in two parts using simplified MAV model. Firstly, it will be carried out experimentally and followed by a simulation. The experimental carried out is deep and calm water resistance test held in UTM MTC towing tank and the effect of air cushion on hydrodynamic resistance will be analysed. There will be a variation in parameter especially forward speed and cavity depth whereas the air is blown from the compressor at a constant flow rate to form cushioning effect. In the simulation study using ANSYS CFX 15.0, the same simplified MAV geometry modelling will be used. Also, the cushioning effect on the MAV motion will simulated in regular waves water condition. The results of the hydrodynamic

resistance of MAV will compared with and without air cushion effect in waves and calm water condition.

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