RESISTANCE REDUCTION THROUGH AIR LAYER FORMATION BENEATH A VESSEL

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"For my beloved father and mother,
who all have given full support and love;
To my dedicated lecturer,
for the encouragement and guidance,
and for those who seeks for knowledge,
I dedicate this work with great respect and honour."

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ABSTRACT

Air bubble lubrication system is one of the techniques for ship energy saving in lowering ship frictional resistance. Air lubrication technique can reduce the skin friction using air layer or artificial air cavity generated beneath a vessel by air injection. This research presents the study on resistance reduction on a displacement hull model with microbubble generated beneath the vessel. Microbubble barriers were made in order to trap the generated microbubble more effectively beneath the vessel model. The subject of the study was a tanker model (MTL 036) with main dimension: L = 2.956 m, B = 0.436 m and T = 0.174 m. Resistance test was carried out at Marine Technology Centre, Universiti Teknologi Malaysia. The experiment conducted in two different conditions: resistance test without microbubble and resistance test with microbubble. The model was towed using the towing carriage and the resistance force (x-axis) and side force (y-axis) were recorded from 0.704 m/s to 1.14 m/s (equivalent to 10 knots to 16 knots in full scale). The model test results show that the total resistance with microbubble is lowered by 6 % to 13.9 % at the speed of 0.704 m/s and 0.849 m/s. The rate of resistance reduction decreases when the speed of the model increases. The highest resistance reduction was obtained at the speed of 0.849 m/s where 13.9 % reduction in resistance is achieved. The micro-bubble barriers are found to be able to effectively trapped the air beneath the model and reduce the total resistance effectively

ABSTRAK

Sistem pelinciran gelembung udara adalah salah satu teknik untuk penjimatan tenaga kapal dalam mengurangkan rintangan geseran kapal. Teknik pelinciran udara boleh mengurangkan geseran kulit menggunakan lapisan udara atau rongga udara tiruan yang dihasilkan di bawah kapal melalui suntikan udara. Kajian ini adalah untuk menkaji kesan gelembung udara yang dijana pada badan kapal model anjakan dan keberkesanan halangan. Subjek kajian adalah model kapal tangki (MTL 036) model dengan dimensi utama: L = 2,956 m, B = 0,436 m dan T = 0,174 m. Ujian rintangan air telah dijalankan di Pusat Teknologi Marin, Universiti Teknologi Malaysia. Eksperimen dijalankan dalam dua keadaan yang berbeza: ujian rintangan tanpa microbubble dan rintangan ujian dengan microbubble. Model ini telah ditarik menggunakan pengangkutan tunda dan daya ketahanan (x-paksi) dan daya sisi (y-axis) diukur pada kelajuan penundaan 0.704 m/s hingga 1.14m/s(bersamaan dengan 10 knot hingga 16 knot pada skala sebenar). Dari kajian, ia menunjukkan bahawa rintangan dengan gelembung udara adalah lebih rendah berbanding dengan rintangan tanpa gelembung udara 6% hingga 13.9%. Berdasarkan keputusan itu juga menunjukkan bahawa pengurangan rintangan adalah berkesan . Penghadang gelembung udara adalah berkesan untuk mengurangkan geseran kapal.

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CHAPTER 1

INTRODUCTION

1.1Background of Research

Throughout history the oceans have been important to people around the world as a means of transportation. Twenty-four hours a day and all year round, ships carry cargoes to all corners of the globe. That's make maritime transport like a backbone of world trade and globalization. In order to continue as one of the most effective ways in carrying goods around the world, there will be improvement in the vessel efficiency performance.

Ship efficiency is related to low fuel consumption. Ship resistance is the most important factor in fuel consumption and the major factor in ship resistance is skin friction resistance. Frictional resistance is a major resistance component of the ship resistance which is approximately 60% to 70% of the total resistance. By reducing the frictional resistance will affect to the total resistance, consequently the fuel consumption will decrease.

Previously, a few methods of drag reduction had been introduced to reduce vessel skin friction resistance. The air lubrication system is one of the techniques for ship energy saving by reducing the skin friction. The air lubrication technique can reduce the skin friction using air layer or artificial air cavity generated beneath the vessel by air injection [Buhnell and Hefner, 1990].

Thus the vessel is floating on a thin layer of air bubbles generated beneath of the vessel, which help to reduce resistance between the hull and water. Recently, Mitsubishi Heavy Industries developed MALS (Mitsubishi Air Lubrication System), which has been applied to two module carriers of NYK-Hinode Line, a coal carrier built by Oshima Shipbuilding, a ferry of Japan's A-Line Ferry. It was announced that net power savings up to about 13% were obtained from the sea trials of the module carriers (Mizokami et al.,2010; Mizokami et al., 2011; Tanaka, 2011).

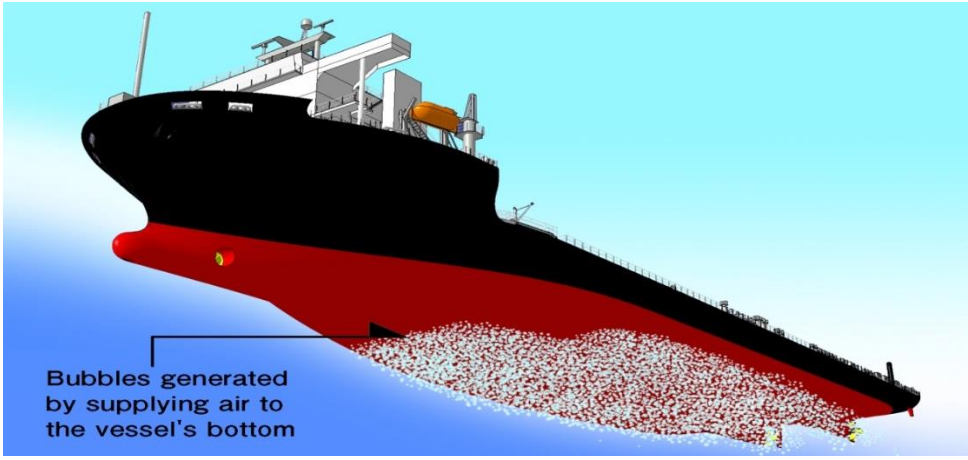

Figure 1.1: Mitsutbishi Air Lubrication System (MALS) Pump Air Bubble onto The Bottom of a Ship'sHull to Reduce Frition (Mitsubishi Air Lubrication System)

Air layering is formed when air is injected into the boundary layer of the wetted surface. Then an air-water mixture flow containing both air bubbles and water is formed. If the amount of the air injected increase, an air bubble will combine and form a layer that covers the surface. The frictional drag on the surface covered with a continuous air layer can be reduced effectively as if the wetted surface area was reduced because the friction with water may change into that with air (Bushnell and Hefner, 1990).

Therefore, on the surface covered with a transitional air layer, it is expected that both air bubbles and patches of continuous air contribute to the frictional drag reduction (Elbing et al. 2008) described that a reduction in the local frictional drag can be achieved from about 20% to 80% on the surface covered with a transitional air layer.

1.2 Problem Statement

Economy is one of the factors need to be considered in ship design. In terms of economy the vessel needs to improve their efficiency. Ship efficiency is related to low fuel consumption. Ship resistance is the most important factor in fuel consumption and the major factor in ship resistance is skin friction resistance. There are a few methods of drag reduction had been determined to reduce the skin friction resistance of the vessel.

In order to reduce the friction without changing the existing hull of the vessel is by introducing an air layer method on the vessel hull. This method is suitable for the practical user for a vessel as the reduced rate can reach as high as 80% (Madavan et al. 1983). It's had proved by a previous study by Mc Cormick and Bhattacharyya in 1973.So by designing or introducing the air layer that can generate beneath of the vessel has a great potential for power saving as the resistance also will reduce.

However, it is difficult to trap the air layer beneath the ship's hull. Based on a previous study, the air layer generated is more effective located after the mid-ship. So, it had been assumed that the generated air layer might be dispersed with the wave making by the vessel. In order to avoid the air layer from disperse is by adding barrier. Previously, set up consisting of two counter-rotating cylinders were used to remain trapped the air layer (Van Gils et al. 2011). Thus, this project is conducted to determine how the air layer with barrier can be design beneath the vessel and to identify the amount of resistance reduction with the generated air layer.

1.3 Research Objective:

1) To design barrier that can trap air layer beneath the vessel.

2)To determine the amount of resistance reduction of a tanker model with the trapped air layer beneath a vessel.

1.4 Scope of Research

1) Study and propose various methods of air generation.
2) A displacement hull to be used as the subject of the study.
3) Propose and modify existing hull design to maximize air layer beneath a vessel.
4) Model resistance test to be conducted at Marine Technology Centre.
5) Compare model test results before and after air layer formation.

1.5 Project planning

Master project 1

No	Task	Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Background of study															
2	Problem identification															
3	Identification of objective and scope of study															
4	Literature review															
	i) Ship Resistance Component															
	ii) Drag Reduction															
	iii)Method to reduce drag reduction															
	iv) Method to generate air bubble for air layer															
	v) Characteristic of microbubbles for air layer															
5	Finalizing Research Methodology															
6	Experimental design													● M1		
7	Experimental equipment preparation															
8	Research proposal write-up and presentation															● M2

M1 : Completing Experimental Design

M2: Submittion of research proposal

Master project 2:

No	Task	Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Model Testing Preparation															
2	Resistance Test							● M3								
3	Data processing and analyzation										● M4					
4	Recommendation and Conclusion															
5	Result : Report Writing															
6	Final Presentation and Thesis preparation															
7	Thesis submission															● M5

M3: Completing the resistance test   M4: Complete data Processing and analyzation   M5: Submit Complete thesis

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