FURTHER DEVELOPMENT OF SHIP ADDED RESISTANCES IN HEAD WAVES

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ABSTRACT

This paper presents the result of analysis of ship added resistances in head waves for 100 m product tanker model no 7698 by using experiment techniques and also theoritical predictions. The study was carried out with two main objetives; firstly to evaluate the difference and accuracy of added resistance prediction of the tanker between theoritical and model experiment. Secondly is to develop a computer program for the theoritical prediction calculation of added resistances in waves using FORTRAN 77. The paper begins with the literature review on ship added resistances in waves and focusing on the theoritical prediction namely the strip theory. This strip theory is used to determine the hydrodynamic coefficients and also the ship motions and finally this coefficients are used to predict the added resistance of a ship in waves. Meanwhile the program will be used to calculate the added resistance using momentum and energy method. Alternatively, a hydrodynamic software, namely Seakeeper® is used to obtain the result as to compared it with the experiment results. In addition, the relationship of the ship generated waves with the added resistances are studied as to see how one can link with the energy dissipated by the ship waves with the added resistances. Finally the paper declares the effectiveness and accuracy of each method used in the prediction of added resistances in waves.

ABSTRAK

Tesis ini mengemukakan keputusan kajian analisa rintangan tambahan kapal didalam gelombang seragam dari arah hadapan kapal. Kapal yang digunakan didalam ujikaji ini adalah kapal tangki produk model 7698. Ujikaji ini dijalankan secara ujikaji model mengunakan tangki tunda dan juga mengunakan kaedah-kaedah ramalan rintangan yang sedia ada. Kajian ini mengandungi dua (2) objektif utama; pertama ialah untuk mengkaji dan menilai sejauh mana ketepatan dan beza antara kaedah ramalan dengan ujikaji model. Kedua adalah untuk membangunkan dan menciptakan satu program komputer yang akan digunakan untuk mengira rintangan tambahan didalam gelombang mengunakan bahasa FORTRAN 77. Tesis ini dimulakan dengan pendekatan ilmiah tentang rintangan tambahan didalam gelombang dan menfokuskan ke arah kaedah-kaedah ramalan terutamanya kaedah yang dikenali sebagai ‘strip theory’. Kaedah ‘ strip theory’ ini akan digunakan untuk menentukan pekali-pekali hidrodinamik dan juga gerakan kapal dan dimana akhirnya pekali-pekali ini akan digunakan untuk menentukan rintangan tambahan didalam gelombang. Manakala program yang akan dibangunkan akan mengunakan kaedah momentum dan tenaga. Sebagai alternatif, satu perisian komputer hidrodinamik iaitu dikenali sebagai Seakeeper® akan digunakan untuk menghasilkan keputusan rintangan tambahan kapal yang akan dibandingkan kelak dengan keputusan ujikaji model. Sebagai tambahan, hubungkait diantara gelombang hasilan kapal dengan rintangan tambahan kapal akan dikaji untuk melihat kaitan diantara keduanya. Akhirnya, tesis ini akan melaporkan keberkesanan dan ketepatan setiap kaedah yang digunakan didalam ramalan rintangan tambahan kapal didalam gelombang.

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LIST OF NOMENCLATURE

Symbols

A_{yy}	-	Coefficient of added mass moment of inertia for pitching motion
a	-	Virtual mass, or virtual mass moment of inertia
a_z	-	Added mass for heaving
B	-	Coefficient of pitch damping moment
B_n	-	Waterline breadth for nth section
b	-	Coefficient for damping force or damping moment
b_n	-	Damping coefficient per unit length
C	-	Coefficient for pitch restoring moment
c	-	Coefficient for restoring force or restoring moment
E	-	Wave energy per unit area of free surface
h_w	-	Height of wave
I_{yy}	-	Mass moment of inertia for pitching
k	-	Wave number
k_{yy}	-	Radius of gyration for pitching
LBP	-	Length between perpendiculars
L_w	-	Wavelength from crest to crest
L_s	-	Length of ship equivalent to LBP
R_{AW}	-	Mean resistance increase in waves, that is, resistance in waves minus resistance in still water

T_e	-	Period of encounter
T_w	-	Wave period
T_z	-	Natural period (in smooth water) for heaving
T_θ	-	Natural period (in smooth water) for pitching
T_ϕ	-	Natural period (in smooth water) for rolling
u	-	Horizontal component of water velocity vertical component of water velocity
V_w	-	Wave velocity or celerity
z	-	Heaving motion
z_a	-	Heaving amplitude
β	-	Sectional area coefficient
ε	-	Phase angle between motions and waves
ε_1	-	Phase angle between wave motion and exciting force (or moment)
ε_2	-	Phase angle between exciting force (or moment) and motions
ζ	-	Instantaneuous wave elevation
ζ_a	-	Wave amplitude
$\overline{\zeta_a}$	-	Apparent wave amplitude
θ	-	Pitch angle
θ_a	-	Pitch amplitude
μ	-	Heading angle
ω_e	-	Frequency of encounter
ω_w	-	Wave frequency
ω_z	-	Natural (circular) frequency for heaving

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CHAPTER 1

INTRODUCTION

1.0 Background of Study

Added resistance in waves is another component of ship's resistance. It is sometimes being misunderstood as wave making resistance. Basically, added resistance in waves is another partial component of the resistance that responsible for speed reduction in a seaway especially in high seas condition. Therefore added resistance prediction represents an important challenge for ship-owners due to its economic implications in terms of choice of engines, fuel consumption and route-time evaluation. Design offices should consider seriously this problem already in the early stages of the design.

Usually, the performance evaluation of a ship in a seaway is primary based on the calm water resistance without properly considering the weather conditions prevailing on the operating route. Even if the calm water resistance is used as a first estimation of the power required, an allowance is added to this value of the resistance to consider the effect of the environment. Therefore in this study it is aim to look into the comparison of the various theoretical method with the towing tests method as a continuous effort from past students master dissertation.

2.0 Problem Statement

In carrying out these experimental and theoretical predictions, several issues will be addressed as follow:

i. What is the influence of the ship speeds and the wave frequencies on the added resistances in waves?
ii. How accurate is the present method of theoretical prediction of added resistance in waves? Is it reliable?
iii. What is the relationship of ship generated waves to the added resistance in waves? If there is any, can we use this relationship to predict the added resistance in waves?

3.0 Objectives of the research

The research work is carried out in order to achieve the following objectives:

i. To evaluate the difference and accuracy of added resistance prediction of a 100 m product tanker between theoretical and model experiment.
ii. Develop a computer program in order to calculate the added resistances in waves using FORTRAN 77.
iii. Investigate the influences of the following parameters to added resistance due to waves either from the speed of the vessel and the also the wave frequencies (wave length)
iv. Investigate the relationship of ship generated waves with the added resistance in waves as ship dissipates energy to the waves created by it at aft and energy is proportional to the squared of the wave amplitudes.

v. Additionally hydrodynamics analysis computer software namely Seakeeper® can be used as to compare the results obtained experimentally and validate the computed results.

4.0 Scopes of the research

The scope of the research is listed as follows:

i. Conduct literature research on ship added resistances due to head waves mainly on the familiarization on the Strip Method and Potential Flow Theory.
ii. Develop a computer program to calculate the ship added resistance in waves using strip theory to generate the hydrodynamic coefficients, ship's heave and pitch motion and using momentum and energy method or radiated energy method in order to get the added resistance values.
iii. Conduct experiments using the tanker model in a towing tank for calm water resistance test.
iv. Conduct experiments using the tanker model in a towing tank in regular waves.
v. Determine added resistance due to waves by subtracting resistance in waves to the resistance in calm water
vi. Familiarization of Maxsurf software namely Maxsurf Pro® for inputs of linesplan and hulls particulars and Seakeeper® for predicting added resistances due to waves.
vii. Estimate added resistance due to waves by using theoretical method using SEAKEEPER namely Gerritsma and Beukelman's method and Salvesen's method.
viii. Validate the theoretical prediction results with the model experiment test results. Compare and analyze both results.

5.0 Research Flow Chart

This topic discusses the approach of the project that has been taken to ensure the objectives of the project will be achieved. It also presents the project flow chart. Basically the project begins with deciding the objectives and the scopes. This is done by having discussion with the project supervisor namely, Ir. Dr. Mohamad Pauzi Abdul Ghani.

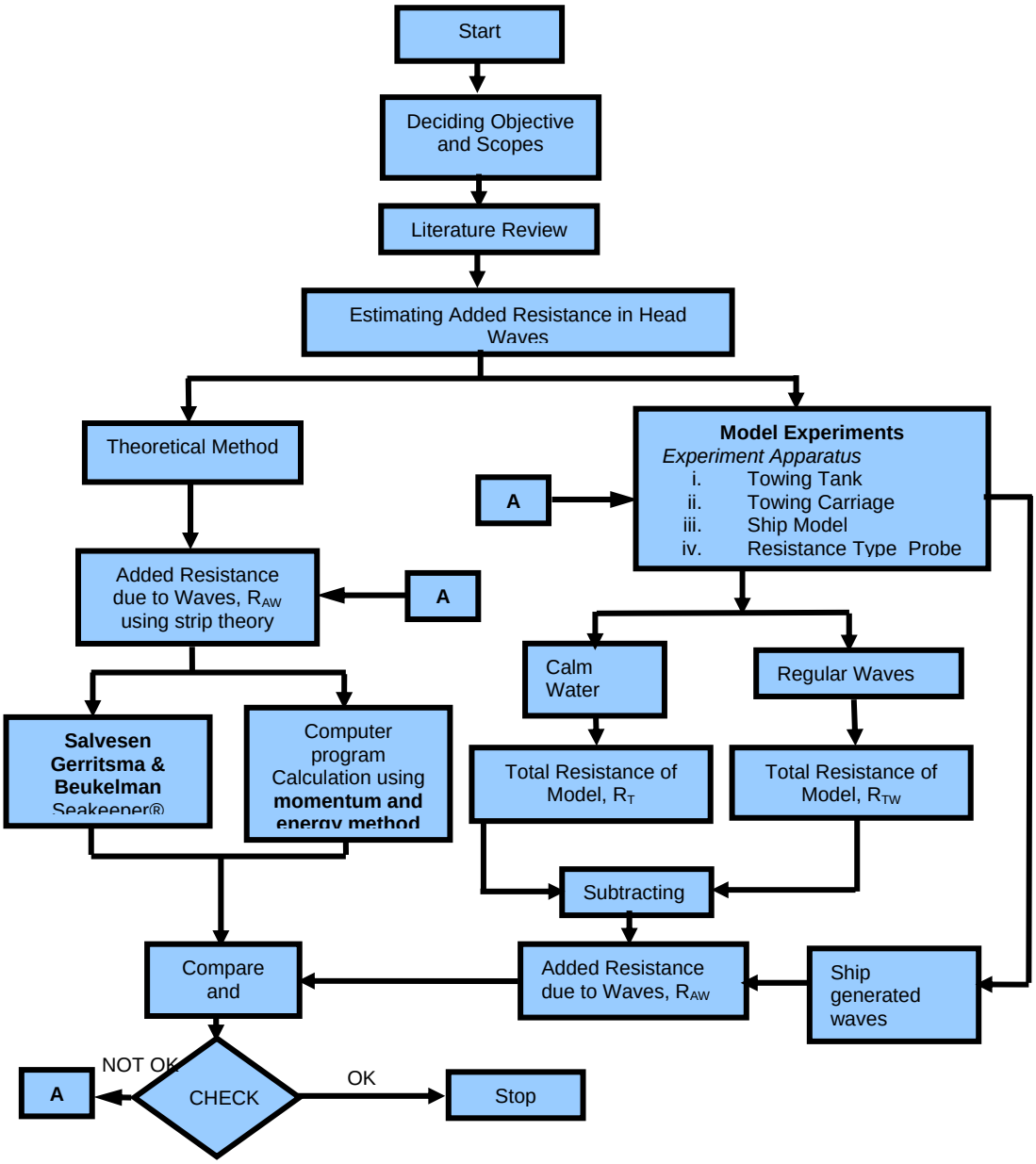

Figure 1.1: Research Project Flow Chart

Later after the objectives and the scopes are agreed, literature research and review are done to select and pinpoint the approach of on how the research to be done. Basically, as agreed in this research project, there are two approaches in determining the added resistances of a ship in head wave, which are experimentally and theoretically. In experiment works, both resistances are taken in calm water and in regular waves, and concurrently the ship generated waves are taken by using resistance probe. Theoretically, few methods are chosen to predict the added resistances in head waves, and here two approach are determined which is using computational software namely Seakeeper® and also a program will be developed using one of the method in predicting added resistances in waves.

The flow chart of this research project is available in figure 1.1. The experimental or theoretical prediction works will be repeated if any discrepancy found during the estimation of added resistances in waves.