INITIAL INVESTIGATION OF SHIP RESISTANCE AT RIVER MOUTH AREA

MUHAMMAD NASUHA MANSOR

UNIVERSITI TEKNOLOGI MALAYSIA

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MUHAMMAD NASUHA MANSOR

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To my beloved wife Nordiana binti Jamil whose sacrifice a lot during this period of study and support that made me stronger every single day. For my family and friends who gave their utmost support.

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ABSTRACT

Lateral drift is one of the phenomenons when ship operates in open sea. It is possibly occurs due to waves and/ or wind and/ or current. In this study, the phenomenon of lateral drift effect onto ship resistance is investigated. As the early stage of this research, the study is focused on ship resistance prediction in calm water condition. In executing this research, the principle that will be used is by using the selected ship resistance prediction method as a basis. Any parameters in the formula which are influenced by drift effect will be reviewed. In this study, two cases are considered, namely Case 1 and Case 2. For Case 1 it is mainly considered the factor of ship velocity influencing the total resistance with lateral drift effect. For Case 2, other parameters are taken into account, which is length and breadth, as well as ship velocity. Due to the presence of drift angle, the velocity is separated into longitudinal and lateral component, and consequently, the process of total ship resistance determination is solved separately in longitudinal and lateral as well. At the end, the resultant of total ship resistance is determined using trigonometric solution. Thus, this becomes the total ship resistance, R_{TOTAL} with lateral drift effect and it varies with the variation of drift angles. This principle of investigation considerably as an initial step in gaining some insights about this complicated problem. The result indicates that there is significant difference of total ship resistance, R_{TOTAL} produced with lateral drift effect, comparing to the condition without lateral drift effect.

ABSTRAK

Lateral drift merupakan salah satu fenomena yang berlaku ketika kapal beroperasi di laut terbuka. Ia berkemungkinan berlaku disebabkan oleh ombak dan/ atau angin dan/ atau arus. Di dalam kajian ini, fenomena kesan *lateral drift* terhadap rintangan kapal akan disiasat. Di peringkat awal, kajian ditumpukan ke atas anggaran rintangan kapal di air tenang. Dalam penyelesaian masalah ini, sebagai asas, prinsip yang akan digunakan ialah dengan menggunakan kaedah anggaran rintangan kapal sedia ada yang terpilih. Formula anggaran Holtrop dan Mennen dipilih dalam mengambil kira kesan *lateral drif*t terhadap rintangan kapal. Semua parameter dalam formula ini yang dipengaruhi oleh *lateral drift* akan dikaji, dan dalam kajian ini, dua kes akan diambil kira. Untuk kes 1, faktor halaju kapal yang mempengaruhi nilai rintangan dengan kesan *lateral drift* hanya akan diambil kira. Untuk kes 2, parameter- parameter yang lain selain dari halaju diambil juga kira iaitu panjang dan lebar kapal. Disebabkan adanya sudut *drift*, halaju kapal di pecahkan kepada komponen memanjang dan sisian. Oleh yang demikian, proses penentuan nilai rintangan kapal juga akan diselesaikan secara berasingan, dalam keadaan memanjang dan melintang. Kemudian, paduan nilai rintangan kapal akan ditentukan dengan menggunakan penyelesaian trigonometri. Nilai paduan ini dikenali sebagai jumlah rintangan kapal, R_{TOTAL} dalam keadaan kesan *lateral drift*. Nilai ini berbeza dengan kepelbagaian nilai sudut *drift.* Prinsip asas pengkajian ini adalah merupakan langkah awal dalam memperolehi gambaran awal mengenai masalah yang rumit ini. Keputusan yang diperolehi menunjukkan ianya terdapat perbezaan yang ketara terhadap jumlah rintangan kapal keseluruhannya, dengan mengambil kesan kira *lateral drift*, jika dibandingkan dengan keadaan tanpa kesan ini.

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LIST OF SYMBOLS

V_S	Ship velocity/ speed
β	Drift angle
$V_{S\,(L)}$	Longitudinal ship velocity/ speed
$V_{S\,(T)}$	Lateral ship velocity/ speed
V_C	Current speed
α	Current direction angle
$V_{C\,(L)}$	Longitudinal current velocity/ speed
$V_{C\,(T)}$	Lateral current velocity/ speed
L	Length of ship
L_{WL}	Length of waterline
L_{PP}	Length perpendicular
L_R	Length of run
LCB	Longitudinal centre of buoyancy
B	Breadth
T	Draught
S	Wetted surface area of the ship
Δ	Ship displacement (weight)
∇	Volume displacement
C_P	Prismatic coefficient
C_M	Midship coefficient
C_{WP}	Waterplane area coefficient
C_B	Block coefficient
S_{APP}	Wetted surface area of appendages
A_{BT}	Transverse sectional area of the bulb at the position where the still-water surface intersects the stem

h_B	Position of the centre of the transverse area A_{BT} above the keel line
i_E	Half angle of entrance
A_T	Immersed part of transverse area of transom at zero speed
ρ_{SW}	Density of salt water
ν_{SW}	Viscosity of salt water
G	Gravity acceleration
R_n	Reynold's number
F_n	Froude's number
F_{nT}	Froude's number based on the transom
F_{ni}	Froude's number based on the immersion
P_E	Effective power
R_T	Total Resistance
R_{TOTAL}	Total ship resistance with lateral drift effect
R_F	Frictional resistance
R_{APP}	Appendages resistance
R_W	Wave- making resistance
R_B	Additional resistance due to presence of bulbous bow
R_{TR}	Additional pressure resistance due to immersed transom
R_A	Model- ship correlation resistance
R_R	Residuary resistance
C_T	Total resistance coefficient
C_F	Frictional resistance coefficient
C_{AS}	Steering resistance coefficient
C_{AA}	Air resistance coefficient
C_a	Correlation factor
C_R	Residuary resistance coefficient
$Corr$	C_R Correction factor
d_i	regression coefficient

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CHAPTER I

INTRODUCTION

1.1 Preface

In this research, the study about one of the ship performances in actual sea is carried out. It is about the initial investigation of ship resistance specifically at river mouth area. This river mouth area is highlighted since one of the main effect which experienced by a moving ship is a lateral drift. As an initial study, this effect will be focused and taken into account onto the ship resistance. This specific case of study is initiated due some previous researches about the effect of lateral drift on the other ship performances. One of the remarkable studies was carried out by Faizul A. A and Yakusawa H. (Faizul and Yakusawa, 2007), which about the influence of lateral drift on seakeeping performance. They found out and summarized that as far the ship motion study is concerned, the effect of lateral drift is not negligible. Due to this finding basically motivates this initial study, which considering on the ship resistance study. Before the discussing more about this lateral drift and the effect on ship resistance, an overview about introduction of this topic will be outlined first.

In ship design stage, there are a number of important scopes or disciplines that need to be concerned in detailed. All of the related scopes basically with one aim; to get an optimum performance of the ship that to be designed. For this particular project, one of the studies will be focused and discussed in deeper, which is the ship resistance. As we know, ship resistance study is one of the essential parts in ship design in order to determine the effective power, P_E required by the ship to overcome the total resistance, R_T and certain speed, V_S. From there, total installed power then can be calculated and determined for that ship. Prediction in preliminary design stage is one of the important practices in ship design.

Concerning of fuel price growth basically increases the requirements to the quality of ship resistance and propulsion study on the design stage. To evaluate the resistance of a ship, in practice, designer has several options available. Figure 1.1 in general summarized four basic classes of approach to the ship resistance determination; the traditional and standard series, the regression based procedures, the computational fluid dynamics approach and the direct model test. The choice of method basically depend not only the capability available but also on the accuracy desired, the fund available and the degree to which the approach has been developed. Other than that, types of the ship and the limitation also are taking into account.

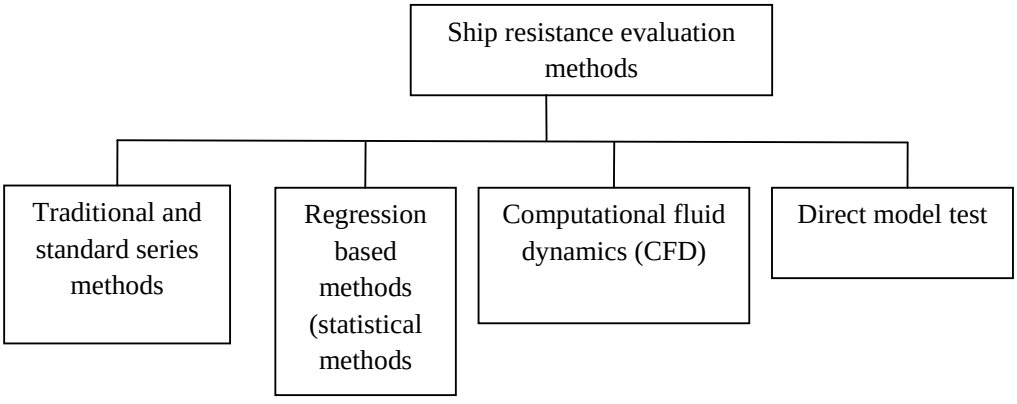

Figure 1.1: Methods of Ship Resistance Evaluation (Carlton, 1994)

Traditional and standard series methods considerably more reflects to the application of the theory of ship resistance, which will be discussed more on the next chapter. The last method is considered the most accurate among others because it use model with geometrically similar to the ship and applicable to any kind of ships. The others are only can be used to predict ship resistance between certain limits or only for a ship that have similar particulars to such group.

In executing this study, there are several stages that will be approached and discussed orderly. As well known, ship resistance can be evaluated either in calm water or in wave's condition. Particularly in ship design practice, for the early stage, the prediction of ship resistance is highlighted more in calm water condition. Thus, power required to attain a certain speed in seaway have been determined from the still water performance after making allowance of 15 to 30% for wind or/ and waves or/and current. The prediction is applied (early stage) basically using a numerical/ statistical/ regression prediction method. There are a number of reliable methods that had been applied in predicting ship resistance in calm water and further discussion about that will be outlined later on Chapter II. Besides the ship resistance prediction in calm water, another approach is determining a ship resistance in wave. To this extent of ship resistance evaluation, in practice, experimental data of ship resistance in waves is necessary and contributes the most reliable and good result for predicting ship resistance in waves. The result is taken and summarized as an added resistance, where by subtracting the result of ship resistance in calm water with the results of ship resistance in waves.

However, from one point of view, effects of drift angle are important for all types of structures and vehicles, including those for land, sea, air, and space. Same goes to ship, where practically, when ship traveling at certain forward speed in actual sea or river, she experiences the effects of wind and current drifting forces. The ship will move with certain drift angle, considerably in this case influences on the ship resistance. This effect basically has not been studied in detail previously (ship resistance prediction). It is therefore important to capture the influence of lateral drift and investigate in ship resistance performance.

As far as lateral drift effects is concerned, there is a necessary and additional steps to be taken to extent those mentioned approach (ship resistance evaluation). In completing this research, for the first stage, ship resistance prediction in calm water will be studied first, by investigating the lateral drift effect. Thus, since this calm water condition is focused, the effect of lateral drift caused by wind and current will be concerned in this study. Due to that, several methods of ship resistance prediction will be detailed in and accompanying with basis ship resistance theory, extended study will be carried out to consider lateral drift effect for this ship resistance prediction (calm water). At this earlier stage of research, study and investigation of those prediction methods will be made, and a number of parameters or elements in those formulas will be identified and used as a basis in considering the influence of the lateral drift effects. This principal and approach basically is used in order to get some insight views on this topic. This could be regarded as an initiation and invantion of research activity.

1.2 Problem Statement

In practical, one of the natures when she operates in its real environment is traveling with the effect of current. This current effect exist either in open sea, coupled with effect of waves and strong winds, or in calm water condition. Focusing on calm water condition, for this present study, it can be viewed one of the area that could contribute very significant effect is at river mouth area. This area specifically can be seen especially during low and high tides time. One of the most important effects when she operates in these times and this area is a lateral drift effect. Due to this severe current effect which causes lateral drift, it considerably influences on the ship resistance. Hence, the captain has to reconsider the power required at the desired speed of his ship to travel at this area with a lateral drift effect. This effect basically

has not been studied previously and it is therefore important to capture the influence of lateral drift and investigate in ship resistance performance.

1.3 Research Objectives

The objectives of this present study are:

1. To investigate the effects of severe lateral drift on ship resistance.
2. To propose the suitable ship resistance prediction method by taking the effect of high speed current and/ or wind (lateral drift) into account.
3. To develop a calculation program based on the purpose ship resistance prediction method.

1.4 Research Scopes

In ensuring this study can be completed successfully, several scopes will be covered during completing this research. The scopes that have to be covered phase by phase are:

1. Literature review on ship resistance theory, ship resistance prediction method and lateral drift effect.
2. For lateral drift effect, literature is reviewed due to severe current effect, with a bigger drift angle will be specified.
3. Correlate the effect of lateral drift in ship resistance study.
4. Since prediction of ship resistance with lateral drift effect will be focused, the most suitable and applicable prediction method will be identified as a basis.

5. Derive the suitable ship resistance prediction method.
6. Develop the calculation software for predicting ship resistance with lateral drift effect in severe case.
7. Make a comparison between the computed result of ship resistance in severe lateral drift effect and ship total resistance in normal condition.

1.5 Significant of Research

During the design stage, designers/ naval architects perform their best effort in achieving as accurate as possible in designing the ship. This activity definitely includes in the ship resistance determination. Concerning this practice initially made this research significantly necessary, especially when it is considered in specific case. It is viewed that this effect of lateral drift could contribute very significant, specifically at river mouth area due to existing of current effect. Due to this current effect makes the lateral drift effect more severe, and it is believed it will influence on the ship resistance performance. This effect basically has not been studied previously in ship resistance point of view. Hence, by taking into account this specific condition in ship resistance determination, a better, specific and more accurate result possibly can be obtained at early of design stage.