

**HYDRODYNAMIC COEFFICIENTS OF MANOEUVRING FOR  
SMALL VESSELS**

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## ABSTRACT

Manoeuvring analysis of a small vessel is more complex as compared to the conventional merchant ship. For small vessels such as fishing vessels, those have a relatively small prismatic coefficient as compared to large ships, would have less restoring force. On the other hand, the hydrodynamic heeling moment caused by yaw and sway at higher operational speed will become significantly high. As a consequence, the roll motion should not be neglected in the analysis of manoeuvring for small vessel, as it is in the case of big ships. The analysis for small vessels would involve at least 4-degrees of freedom and non-linearity of the forces and motions would have to be considered. During turning (yawing), the centrifugal force acting and also the developed hydrodynamic pressures surrounding the hull will induce a rolling moment. This moment will force the vessel to list either inward or outward with the turning path depending on the height of the centre of the mass. Conjunction with the development of the ship simulator in marine technology laboratory, a study on the hydrodynamic coefficient of manoeuvring has been conducted on fishing vessels. The mathematical model of manoeuvring has been reviewed in order to incorporate the heel angle effect. By conducting the experiment in the towing tank, the coefficients in the mathematic model are obtained. In this study, the effects of heel angle on the hydrodynamic coefficients have been studied. The coefficients that obtained from model testing have been used in the time domain simulation and the manoeuvring criteria of the vessel have been simulated.

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## **CHAPTER I**

### **INTRODUCTION**

#### **1.1 Research Background**

For ship motion analysis, the use of simulator has become more significant. Somehow in this country, ship simulation is still in a very preliminary stage, where ship motion is analysed by model testing method. Even though, model testing is very time consuming, need a lot of man power and very costly and it involves various types of high technology equipment.

For this reason, a real-time Ship Simulator has been developed to investigate and to predict the ship motions in variable seas environment. The simulator program available in Universiti Teknologi Malaysia is developed based on standalone personal computer (PC) system platform and network PC system platform.

This simulation program successfully demonstrated most of the critical seakeeping motions, which included various capsizing sequences (Yeak, 1997). This program also included strong non-linear coupling from heave and pitch onto roll and yaw (Maimun, 1993). On the extensions of the simulation program, the effect of diffraction on large amplitude of vessel motion has been described very thoroughly by Yeak (1997). However, for the simulation of surfriding and broaching conditions, the seakeeping approach itself is not sufficient for these applications. It is found that the forces and moments for a manoeuvring vessel are not only

predominated by seakeeping forces, but also the manoeuvring forces (Renilson, 1982).

The hydrodynamic equation incorporated in existing simulation program involved is only linear manoeuvring equation. This is not only unsuitable to simulate the conditions described above, but also insufficient to simulate the normal turning or zigzag manoeuvre in calm water. As a consequence, the hydrodynamic of manoeuvring should be focused in order to have a more realistic simulation.

The linear equation using perturbation method adopted by SNAME (Crane, 1989) is a simplified in linear form for easier analysis. However, it is limited for small motion. As compared to big vessel, generally, the Froude numbers for small vessel are much bigger than the big vessel; this is similar for non-dimensioned yaw and sway motion of small vessel. The linear equation used previous study was limited to predict the real manoeuvring path for small vessel. In order to study the manoeuvring characteristics in 6 degrees of freedom (6 DOF), the motion of small vessel is focused in this study.

Beside the non-linearity, small vessel motion will involve a least equations in 4 degree of freedom, which are surge, sway, yaw and roll in additional. The small vessel with smaller prismatic coefficient will have less restoring moment due to the smaller water plane area. Hence, the centrifugal force during a turning will cause a significant heel angle. The under water hull form would become asymmetry during a heel. As understood, the hydrodynamic coefficients are highly depending on the hull form geometry, as a result, the hydrodynamic coefficient will be affected by the heel angle. Different from big vessel, which is usually in 3 degree of freedom, the additional roll motion for small vessel become very interesting for this research.

## 1.2 Aim Of The Thesis

The Aim of this research is the searching of hydrodynamic coefficients related to manoeuvring of small vessels. In this research, the small vessel manoeuvring criteria will be focus. The non-linear equation of motion of small vessels will be studied. In additional, the heel angle effect on the manoeuvring derivatives and their coupling effect will be analysed.

### 1.2.1 Objective

- (a) To conduct literature survey on the important hydrodynamic coefficient that affect manoeuvring of small vessels.
- (b) To derive suitable experimental techniques to obtain the hydrodynamic coefficients.
- (c) To incorporate the hydrodynamic coefficient in existing simulation program and gauge the sensitivity of coefficients with respect to capsizing sequences.

## 1.3 Frame of Approach

For the study of hydrodynamic coefficients of manoeuvring of small vessels, firstly the mathematical model on the manoeuvring equation will be studied. A suitable mathematical model will be used as the reference to incorporate the heel angle effect. Base on the mathematical model, towing tank testing will be conducted in order to obtain the hydrodynamic derivatives. Besides that, the heel angle effect on hydrodynamic coefficient also had been studied.

From the experimental, each parameter is tested separately. The effect of each particular parameter could be studied mean while others parameter are controlled. By this method, a function of certain parameter could be obtained easily. However, for a real motion of a vessel during manoeuvring, the dynamic of motion will involved all parameters and will be complex. Each single parameter effect obtained form experimental should be combined into one system of motion in order

to study the real motion behaviour. However, this could not been done in the captive model testing method. As the alternative, by the simulation approach, the parameters could be combined virtually. By using the coefficient values obtained from experimental, an in house time domain simulation will be develop by utilising MATLAB-Simulink software for simulation purpose.

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