CHAPTER 1

INTRODUCTION

1.1 Background

The applications of twin-hull vessels particularly SWATH vessel and conventional Catamaran have widely designed regarding for purpose of providing better seakeeping quality than mono-hull vessels inherently.

Holloway and Davis (2003) and Kennell (1992) stated that inherent to the advantages of SWATH vessels, as compared to the conventional Catamaran is its smaller waterplane area that provided smaller wave excitation forces, lower amplitude motion associated with its lower accelerations responses and better seakeeping performances. Dubrovskiy and Lyakhoviyskiy (2001), Fang (1988) and Kennell (1992) mentioned that due to its smaller waterplane area, the SWATH vessels have larger natural period as twice as long the natural periods of roll, pitch, and heave of a mono-hull of comparable size.

Based on Dubrovskiy and Lyakhoviyskiy (2001) and Ozawa (1987) have presented the advantages of conventional Catamaran features compared to the SWATH vessels have shallower draft and lower cost of construction. Their larger waterplane areas as compared to the SWATH vessel has increased the stiffness as result as improve vessel’s longitudinal stability.

Conversely, the particular drawbacks of SWATH vessel and conventional Catamaran geometrically cannot be neglected. It is shown that the SWATH vessel with its small waterplane area is tender in large pitch motion due to low stiffness resulted as increase in speed. Djatmiko (2004), and Dubrovskiy and Lyakhoviyskiy (2001), Katayama (2002), and Kennell (1992) stated that the low value of this parameter is linked to its insufficient values of longitudinal metacentric height (GM_L). Consequently, this may lead to pitch instabilities, which caused slamming, deck-wetness, excessive trim or even bow diving and degrade the passenger comfortability.

Having considered some extensive reviews of several obtainable advantages both SWATH and conventional Catamaran hull forms, an alternative hull form design is proposed to overcome and minimize their drawbacks. The proposed design concept represents a combination of conventional Catamaran and SWATH hull features. In addition, this new modified hull form configuration conceptually was emphasized on the variable draught operations i.e. shallow draught and deep draught. Then, this vessel is called "**Semi-SWATH vessel**."

Holloway (1998 and 2003) investigated that as the hybrid design hull form; the Semi-SWATH configurations generally offered two ways that make the most of Semi-SWATH vessel's benefits. First, its primary premise is to maintain a good seakeeping quality. Second, it is intended to prevent the bow diving phenomena at high-speed. It means the maturity of Semi-SWATH vessel is going to provide an improvement of conventional Catamaran and SWATH vessel drawbacks considerably.

Furthermore, the placement both of fixed bow fins and controllable stern fins on each lower hull of Semi-SWATH vessel will provide additional pitch restoring moment to improve not only the longitudinal stability but also reduce the vertical motion responses. Consequently, the serious inconveniences will degrade the vessel performance during sailing especially at high-speed head sea waves can be alleviated. Haywood, Duncan, Klaka, and Bennett (1995) stated that the seakeeping of the Semi-SWATH vessel is going to be better evidently.

The simulation program of Semi-SWATH vessel incorporated with fixed fore and controllable aft fins were developed to evaluate the seakeeping performance during operation at both medium speed (15 knots) and high-speed (20 knots). The mathematical model comprising of heave and pitch motions, which incorporated with the fins stabilizers on the simulation was presented in a simple block diagram using Matlab-SIMULINK. In this simulation, a conventional PID controller was developed and applied on the controllable aft fins. Segundo, et al (2000) developed simulation program using PID controller to alleviate vertical accelerations due to waves. The results of simulation had been validated by experiments in the towing tank confirm that by means of flaps and a T-foil, moved under control, vertical accelerations can be smoothed, with a significant improvement of passengers comfort. In addition, Caldeira, et al (1984), Ware, et al (1980a), (1980b), 1981, and 1987, and Chinn, et al (1994) applied conventional optimal PID controller design to improve the vertical motion response of marine vehicles.

In this PID controller method, some parameter of tuning controller will involve some chosen controller gain parameters of PID (K_p, K_i, *and* K_d are the proportional, integral, and derivative gains, respectively). Those parameters are obtained using method of Aström and Hagglund. Then, they will be considered to satisfy certain control specifications by minimizing the error after achieving steady state. This controller mode is applied by controlling the aft fin's angle of attack properly, the sailing style of Semi-SWATH vessel must be adjusted to be in even keel condition. The theoretical prediction results will be validated with the model experiments carried out in the Towing Tank of Marine Technology Laboratory, Universiti Teknologi Malaysia.

1.2 Research Objective

1. To evaluate the seakeeping performance of Semi-SWATH vessel before and after installation both of fixed fore and controllable aft fins in regular head sea using time domain simulation and validated by model test in Towing Tank.

2. To apply a ride control system on the controllable aft fins, the conventional PID controller will be used to achieve a better quality the Semi-SWATH seakeeping performance.

1.3 Scopes of Research

1. The mathematical dynamics equations model covers Semi-SWATH vessels with fins in two degrees of freedoms i.e. heave and pitch motions operating in regular head sea.
2. The numerical method simulation is based on Time-Domain using Matlab-SIMULINK.
3. In the simulation, the regular waves generated using MATLAB for any wavelength of interest as well as experiment done (range of regular wave lengths: $0.5 \leq \lambda/L \leq 2.5$ and steepness of the incident wave: $H/\lambda = 1/25$)
4. The hydrodynamic coefficients of Semi-SWATH vessel motions will be obtained using numerical program, which was developed by Adi Maimun and Voon Buang Ain (2001).
5. The proper fin stabilizers were selected using NACA-0015 section due to high lift curve slope and low drag.
6. Lift Coefficient (C_L) will be obtained using CFD software (Shipflow 2.8).
7. A conventional PID controller will be applied on the Semi-SWATH vessel to improve the stability and performance of plant system with adequate reliability.
8. A parameter tuning of PID controller is obtained using method of Aström and Hagglund i.e. K_p, K_i, *and* K_d. Then, they will be applied to satisfy certain control specifications by minimizing the error after achieving steady state.
9. The simulation program result will be validated of by the Semi-SWATH model test carried out in Towing Tank of Marine Technology Laboratory, Universiti Teknologi Malaysia.

1.4 Research Outline

An achievement of the excellent seakeeping qualities for ship design requires extensive consideration as guidelines to reflect the safety, effectiveness, and comfort of vessel in waves. The present research follows a systematic procedure to modify concept design of twin-hull vessel by minimizing their drawbacks. This study starts from the review of SWATH and conventional Catamaran hull forms. The final design of the new modified hull form will deal to enhance the vessel's stiffness associated with improving seakeeping qualities at high-speed in head seas waves condition. Then this vessel is called Semi-SWATH vessel.

The flexibility of the Semi-SWATH vessel can be operated in two variable draughts i.e. shallow draught and deep draught with still maintain seakeeping quality. In these variations of operational draughts, the Semi-SWATH vessel will be operated in two speed services i.e. medium speed (15 knots) and high-speed (20 knots). Furthermore, the effects of vertical motions on the Semi-SWATH vessel (heave and pitch motions) when encountering head sea at those service speed will be investigated considerably.

For this reason, an advanced prediction analysis both numerically and experimentally to achieve a desired goal will be done. In stage of the Time-Domain Simulation approach theoretically will be used to predict and analyze the seakeeping performance in head sea waves, which was developed using Matlab-SIMULINK. Then, the mathematical model comprising of heave and pitch coupled motions before and after attached fixed bow and active stern fin stabilizers are investigated. Then, the conventional PID controller is applied on the active stern fin stabilizer by tuning its angle of attack to enhance the improvement of ride quality ideally to be even keel riding condition. Then, the real-time simulation results will be validated by experimental model test carried out in Towing Tank at Department of Marine Technology, Universiti Teknologi Malaysia.

Finally, the seakeeping evaluation of Semi-SWATH vessel is identified based on the motion response, which presented by Response Amplitude Operators (RAOs).

The outline of thesis organization is shown in Figure 1.1.

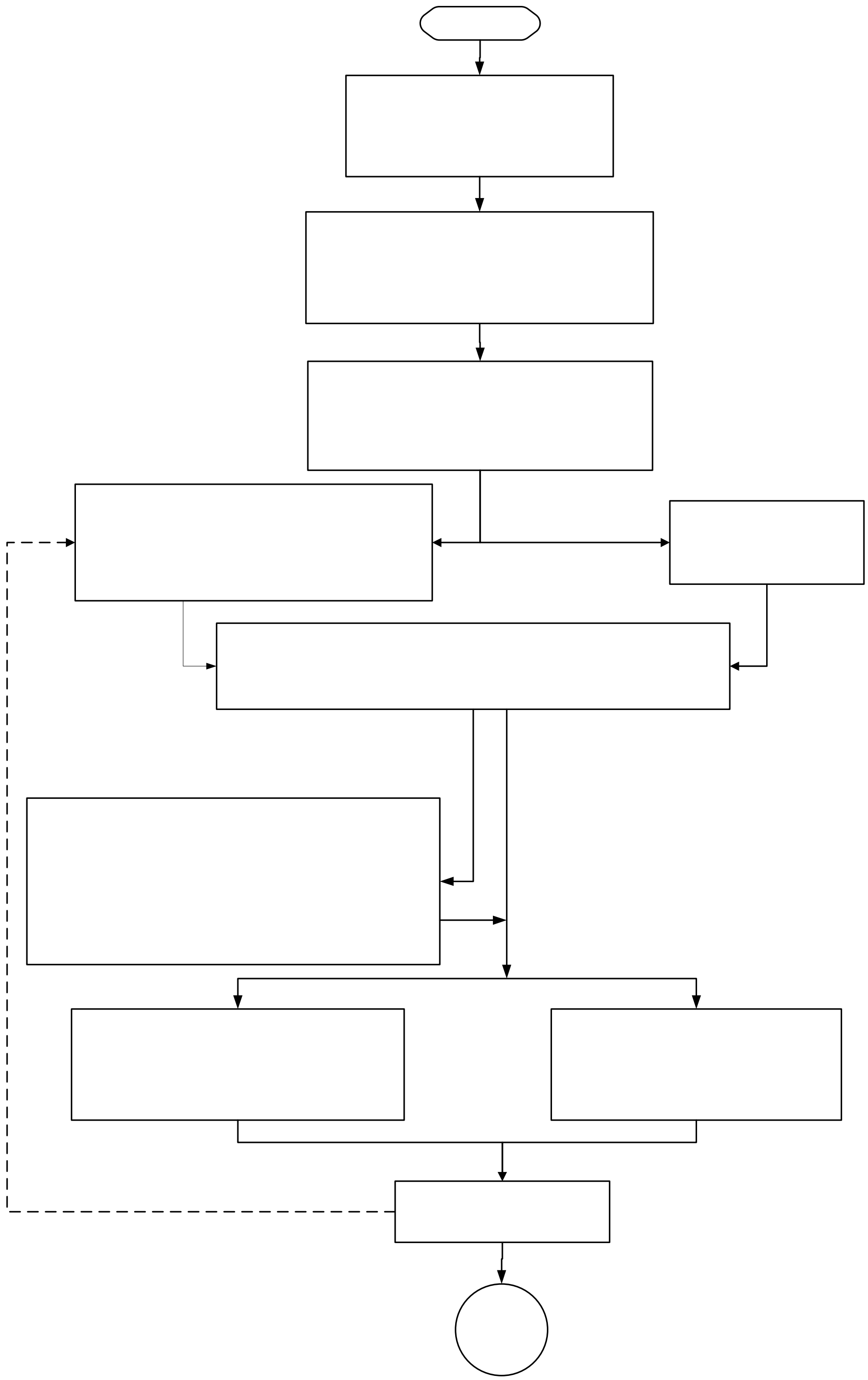

Figure 1.1 Outline of the thesis organization