THE LITTLE REVIEW OF INFLUENCE OF SHIP'S LONGITUDINAL CENTER OF BUOYANCY ON THE SHIP

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ABSTRACT

The researc presents the influence of longitudinal center of buoyancy (LCB) on the ship resistance, then determine the optimized LCB to have minimum ship resistance. The initial hull form is modified by Lackenby method. The new hull form wave resistance is calculated by panel method, together with Simplex optimization algorithm to find the hull form with minimum wave resistance. The total resistance of initial hull form and optimized hull form are calculated by RANSE (Reynold Average Navier Stokes Equation) CFD method to determine the amount of reduction on total ship resistance. With the research objectives set out, the author organizes this research into four main parts as follows. Part 1: The Little Review; Part 2: Materials and Methods; Part 3: Numerical simulation; Part 4: Results and Discussions.

Keywords: *Ship resistance, optimization, EEDI, Panel method.*

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1. INTRODUCTION

Nowadays, the new-built ships are highly required to use efficiency energy and to reduce the amount of exhausted CO2. In 2010, the International Maritime Organization (IMO) has given the Energy Efficiency Design Index to measure the amount of CO2 which the ship has eliminate during her operation. Thus, it requires the designers to give the methods to reduce EEDI. One of the methods is the reduce ship resistance by optimization of the hull form. When the ship resistance decreases, the amount of consumed fuel also reduces and the amount of exhausted CO2 reduces accordingly.

2. MAIN CONTENTS

In the process of designing the ship hull form, there are several important factors that affect the ship resistance such as: the position of the floating center of buoyancy, the length of the parallel body, the shape of the bow and stern, the shape of the water line, the shape of the sections [14]. This paper presents the influence of one of these important factors on ship resistance, which is the position of the center of buoyancy. The buoyancy center of the initial hull was changed, but still kept the main dimensions (namely ship length, ship breadth, draft, displacement) through Lackenby method [1].

Currently there are many methods to estimate a ship's resistance in the early design stage. One can mentioned the method using regression formulas through ship model testing such as Holtrop & Menden, Hollenbach [3]. The advantage of these methods is that they quickly produce ship resistance results but have relatively large errors and especially it is difficult to apply in this case when there is only one parameter, the center of buoyancy, changed. The second most commonly used method currently is computational fluid dynamic (CFD). This method has been widely applied in the world because it gives relatively accurate results compared to the results of model testing, as well as it is more economically beneficial than the model testing method because the model is not manufactured. However, the disadvantage of this method is that the calculation time is relatively long for a case of calculating the resistance, so it is difficult to apply the optimal calculation. When calculating the optimum, it is necessary to calculate the resistance on the large number of hull forms to find the one with the least resistance

The hull form design based on standard series are resulted from empirical data by model test. There are some well-known series such as Series 60, Taylor series, BSRA, MARAD and so on. However, each series is developed to specific type of vessels, so it is quite difficult to optimize the new hull form.

Form parameter-based hull design start with the fundamental parameters of the ship such as length, beam, draft. Then detailed data can be provided, for example, the shape of bow, stern, the angle of water entrance and many other parameters. The advantage of method is that one can develop the new hull form with few steps, but the performance of the hull form is not guaranteed. .

The longitudinal center of buoyancy shows the distribution of the displacement along the hull. This position, together with the prismatic coefficient (C_P), directly affects the wave produced by the vessel. The optimal position of the LCB in terms of resistance is normally expressed depending on the block coefficient (C_B), the Froude number, the prismatic coefficient (C_P), and the section shape [14].

H. Lackenby [1] proposed a systematic modification of the hull form. In this method the sectional area curve is changed by changing the following parameters: prismatic coefficient (CP), the longitudinal center of buoyancy (LCB). The details of this method are explained in details in Principles of Naval Architecture [4]. In this study, the constraint is that the ship displacement is kept constant, the authors only change the longitudinal center of buoyancy.

Thus, we can completely rely on wave resistance to "rank" the resistance of the hull. The second reason is that in order to find out the hull has the smallest resistance, we have to calculate a lot of different hulls, so the calculation time plays a very important role. Using the panel method can give us result in a few minutes (compared to 10-20 hours for the RANSE CFD method). In addition, although regression methods such as Holtrop Menen, Hollenbach also show very fast results, these methods can hardly be used to "rank" the hulls when there is only small change in the longitudinal of buoyancy.

RANSE (Reynold Averaged Navier Stokes Equation) CFD is a numerical method. This method is often applied to solve general hydrodynamic problems, including the flow around the hull. It considers the viscosity of the water and give an accurate result for resistance calculation of the vessel (comparing with experimental result). There have been many authors using this method to calculate the resistance of the ship and the error results are within 2% compared with the model test [9] [10] [11]. However, the disadvantage of this method is time consumption.

Nelder Mead Simplex optimization algorithm was first published in 1965 [7]. This is one of the methods to find extreme values without using derivatives. It is widely applied in nonlinear optimization problems in practice. Practically, to find the extreme of a function f(x), the method of using the first derivative is not feasible, because we do not know or it is difficult to construct the equation form of f(x). Meanwhile, the Nelder-Mead method only needs the value of the function f(x).

3. CONCLUSIONS

The method is to use the panel method, which calculates drag by dividing the hull and water free surface into panels. This method ignores the viscosity of the liquid, also known as the potential flow method, so only the wave resistance can be calculated. The remaining resistance components can be estimated by experimental formulas. By using this method, it is possible to realize the difference in ship resistance when changing one of the hull parameters such as the longitudinal of buoyance (LCB).

4. ACKNOWLEDGEMENT

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