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NUMERICAL INVESTIGATION OF THE EFFECT ON FOUR BOW DESIGNS FLAT HULL SHIP

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ABSTRACT: Flat hull ship has some advantages in the manufacturing aspect which are relatively easy to fabricate and does not require high technology equipment. This ship has a weakness where the resistance of flat hull ship is bigger than the other ships among streamlined bow. A factor that influences the ship resistance is the type of bow. So, this study is needed to investigate the effects of bow design and ship resistance. This study aims to reveal the influence of various bows design on resistance and speed of flat hull ship. This study method is numerical analysis using Maxsurf software. The analysis was carried out on four types of bow direction for flat plate hull types, namely Raked Bow, Maier Form, Raked Bow II, and Plumb Bow. The result shows that the flat hull ship with the Raked Bow had the lowest resistance and power. Meanwhile, the flat hull ship with raked bow II had the highest resistance. These results can be a guide for the shipping industry on development and production, and for other researchers in developing the flat hull ship.

Keywords: Flat Hull Ship, Resistance, Bow Design, Numerical Analysis

1. INTRODUCTION

Flat hull ship is an alternative of ship types to develop and produce because its production does not require high technology and equipment. The flat hull ship was firstly developed by Prof. Gallin from TU Delft in 1977-1979 for a container ship called "Pioneer" [1]. Furthermore, flat hull ship was developed by Hadi Tresno Wibowo from Universitas Indonesia [2]. The current Indonesian government is very enthusiastic to develop this type of ship. This flat hull ship can be used for fishing boat, water sports, tourist boats and marine security guard ships [3] [4]. Raw materials for this shipbuilding are widely available in the market. Using the steel plates is very effective in reducing the investment costs of shipbuilding. This construction greatly facilitates workmanship because there is no need to do a bending process to form a curved ship body; cutting and welding steel plates are done faster; and ship construction is more concise and stronger [2].

The weakness of this flat hull ship type is the resistance. The flat hull ship has a high resistance from the ship with an arch type [1]. This finding is in line with the results of Wibowo's study which revealed that flat plate hull ships have greater obstacles compared to arched hull ship [2]. Furthermore, the result also revealed that flat plate ships have a high resistance value from the curved plate ship [5]. The shortcomings of the flat hull ship need to be improved by conducting research to solve the problem of the ship's resistance. The magnitude of the resistance value of a ship will affect the amount of power needed to move the ship resulting in high fuel consumption and ship operational costs [6-9]. The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) issued a regulation to increase energy efficiency on ships to reduce carbon emissions [10]. The efficient use of fuel can minimize ship operational expenses, and this needs to be solved by researchers from the ship design field [11].

In order to minimize ship barriers, a study is needed to produce ship designs with optimum efficiency on the ship's resistance aspects. One thing can be effect the ship's resistance is the shape of the bow of the ship. The bow of the largest ship gets resistance and voltage from the outside force. The shape of the bow of the ship is closely related to obstacles, speed, engine power, and fuel consumption [12]. Therefore, an investigation is needed to study the differences of the bow shape design on the flat hull ship against the large obstacles experienced by the ship. This study aims to reveal the resistance and power needed by the flat hull ship in the comparison on four types of bow designs so that the most efficient form of direction is obtained by numerical analysis/ simulation method using Maxsurf software. The results of this study are expected to be a guideline for the flat hull ship industrial development and production and for other researchers in developing flat hull ships.

2. RESISTANCE TESTING

Ship resistance on a ship mainly comes from water forces acting on the ship movement in the opposite direction. Resistance can occur as the component of the fluid force acting parallel to the axis of the ship's motion [1]. Each ship that moves on the surface of the water at a certain speed will experience resistance opposite to the direction of the ship [13].

To reveal ship resistance from various types of the bow can be done by experimental testing on towing tank or numerical analysis using computerized simulation. Experimental testing of ship design on towing tanks can be done through the manufacture of ship models (prototypes) and ship testing on towing tanks. This certainly requires high costs, more time and high complexity. Experimental methods for testing ships are very expensive and depends on the availability of facilities, while computational fluid dynamics (CFD) or computerized simulation are capable of being accurate and proven on prediction ship design results [14].

Development of computer technology is currently very helpful in testing the design of the ship. Due to the rapid development of current computer simulation technology, it is increasingly accurate in predicting ship design [15]. The results of ship design in the form of simulation can be tested by using computer simulation. In computer testing, a model of ship testing can be reduced of costs and shorten the time to analyzing the design of the ship.

3. METHOD

This research is a numerical analysis to predict and estimate the resistance and speed in the flat hull ship using computer software. Maxsurf software was used to simulate the ship design. Maxsurf CAD package and analysis modules provide convenience to users to create, modify and analyze design models with a minimum amount of time [16]. Maxsurf is widely used as a tool for analysing ship design results, i.e. to find the optimal form of trimaran yachts that are viewed from the side of resistance and seeping criteria [17], to calculate the resistance of three symmetric trimaran sailing on the surface of deep and calm water [18], and to predict the resistance experienced by ships due to the use of Open FOAM in ship catamaran [19]. The method used in this study to express the resistance of the tested ship is the Holtrop method in the Maxsurf feature [20]. Generally, computer numerical analysis calculates the total resistance experienced by the ship, which consists of the sum of frictional resistance (RF), residual resistance (RR), the sum of viscous resistance (RV) and wave making resistance (RW). Viscous resistance is multiplied frictional resistance by form factor (1 + K) [9].

The stages of the study begin with the making of flat hull ship models of four models of the bow. The ship model was made by using Maxsurf Modeler. Furthermore, the model was analyzed numerically by using Maxsurf Resistance to reveal the resistance experienced, the power needed, and the waveform that occurs due to the movement of each model.

2.1 Parameters Setup

The ship as the object of this research is a small boat for fishermen used in a lake environment. Data on the main size of the ship used are as follows:

Table 1. Main Dimension of the ship

Variable	Description	Dimension
L_{OA}	Length Overall	5 m
L_{Wl}	Length Waterline	4.1 m
B	Beam	1.4 m
H	Depth	0.75 m
T	Draft	0.36m
Δ_A	Displacement	0.6217 m^3

The shape of the mid-ship from the flat hull ship is the hull type of the bottom bumper. Akatsuki bottom is a type of ship hull that the shaped is almost like the letter "U", but each curve forms an angle and flat at the bottom [21].

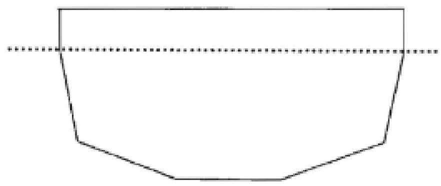

Fig. 1. "Akatsuki" type of hull bottom

The variable parameters used in this study are variations of the bow. There are four types of flat hull ship to design on the types of the bow. The four types of the bow are the Raked Bow, the Maier Form, the Raked Bow II and the Plumb Bow. The basic forms of the four types of directions are presented in Figure 2.

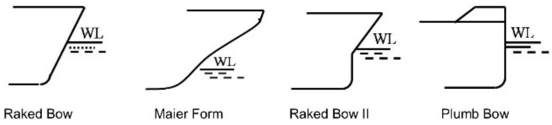

Fig. 2. Types of the bow

2.2 Ship Models and Similarity of the bow

To achieve the objectives of this study, the design of the flat plate ship bow which has low resistance is obtained by comparing four types of bows using numerical analysis. The first model is the flat hull ship using the Raked bow (Fig. 3). The existing ships are mostly designed by using the Raked bow, such as the supply ships, the oil ships, the warships, the merchant ships, etc. [22]. The second model is the flat hull ship using the Maier Form (Fig. 4). The Maier Form began to be used in the 1930s which was able to reduce frictional resistance [23]. The third model is the flat hull ship using the Raked Bow II type (Fig. 5) and the fourth model is the flat hull ship using the Plumb Bow (Fig. 6). The four models have 5m of length, 1.4m of the beam, 0.75m of depth and 0.36m of the draft. In this study, it is assumed that the four ship models have behavior in terms of heave and pitch at the lake.

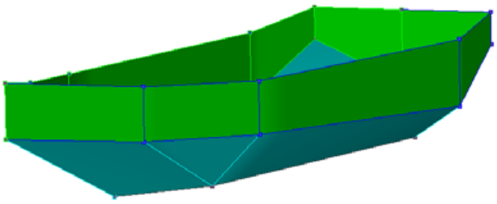

Fig. 3. The design of flat hull ship using the Raked Bow

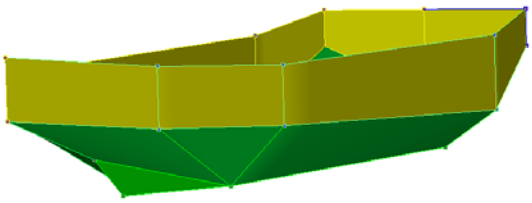

Fig. 4. The design of flat hull ship using Maier From

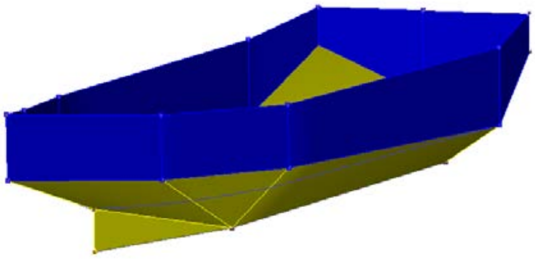

Fig. 5. The design of flat hull ship using the Raked Bow II

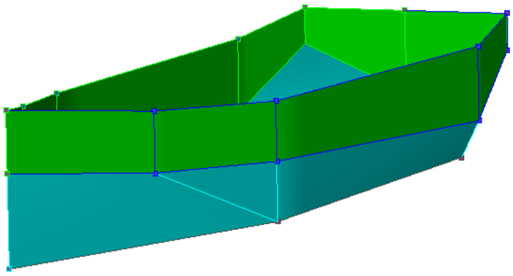

Fig. 6. The design of flat hull ship using the Plumb Bow

3. RESULT AND DISCUSSIONS

The resistance of the ship was tested by using Maxsurf Resistance with the Holtorp method and speed range 0 to 6 knots. The simulation test results on ship speed and resistance experienced by ships are shown in figure 7.

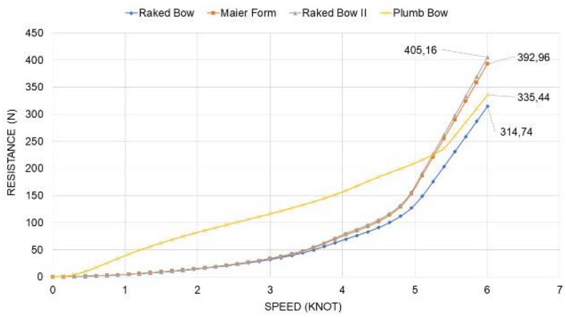

Fig. 7. The graph of the resistance on all four types of the bow of the flat hull ship

The graph in Figure 7 shows at a speed of 6 knots (service speed), the flat hull ship using the type of Raked Bow has the lowest resistance of 314.74 N; the second lowest type of bow is the type of Plumb Bow with the resistance of the ship about 335.44 N; for the type of the Maier Form, the resistance of the ship is 392.46 N; and the type of Raked Bow II has the highest resistance of 405.16.

Based on the results of tests in figure 7, the resistance experienced by ships in three types of bow such as the Raked Bow, the Maier Form and the Raked Bow II is relatively the same in speed range 0 to 3.5 knots. The difference in resistance is experienced by the ship along with the increasing ship speed. For the flat hull ship using the Plumb Bow, the resistance is experienced differently by ships as shown in the graph in figure 7. However, in speed service (6 knots), the resistance experienced by the shipping number two is the lowest of the four types of bow designed.

Differences in resistance experienced by ships are caused by the use of the bow, where there is a difference of the ship's direction with water in moving the water along with the movement of the ship. At the front of the ship (bow), there is a high-pressure area, so that wave makes resistance occur [24]. The wave types that occur in the four types of the bow are presented in Figure 8 and the shapes of the wave patterns when the ship moves are presented in Figure 9-12.

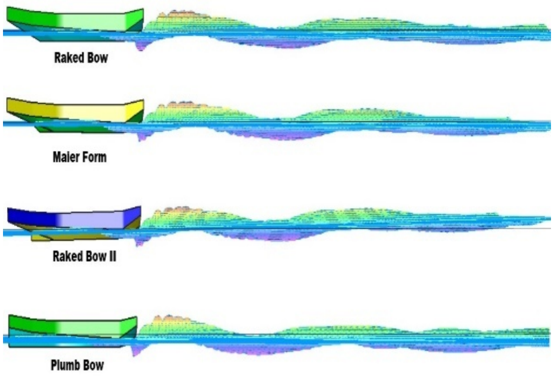

Fig. 8. The waves occurring in the four types of the bow (side view)

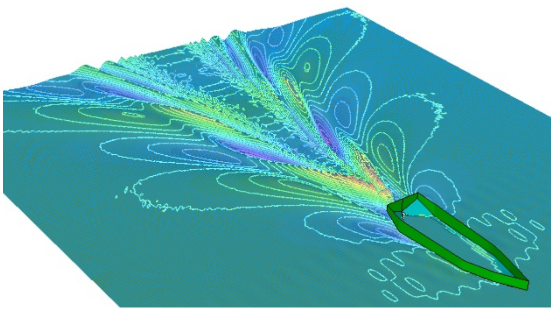

Fig. 9. The wave form simulation result occurring in the flat hull ship using Raked Bow

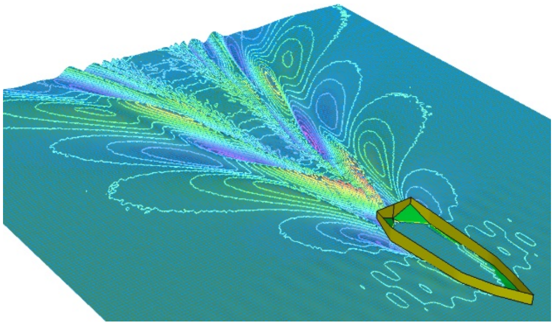

Fig. 10. The waveform simulation results occurring in the flat hull ship using the Maier Form

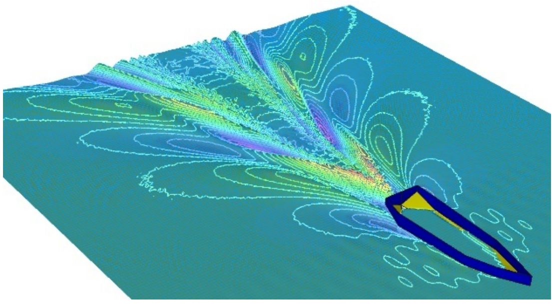

Fig. 11. The waveform simulation results occuring in the flat hull ship using the Raked Bow II

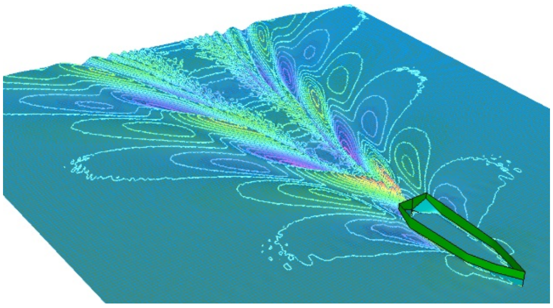

Fig. 12. The waveform simulation results occuring in the flat hull ship using the Plumb bow

Figure 8 shows the waveforms that occured when the ship moves. The ships using Raked Bow type shows the small amount of water wave and low wave height. The ships using the Maier form type, more wave occured and it was higher than the Raked bow. The ships using Raked Bow II type, there is a more and higher wave. On ships using the Plumb Bow type, the shapes, lots, and wave heights are almost the same as the Raked bow type. The results of the resistance testing and the motion test of the ship in a simulation reveal that the higher the resistance experienced by the ship, the more and higher the wave that occurs. This indicates that the shape of the ship's bow affects the waves produced when the ship moves.

The shape of the bow must be well designed so that the fluid force that opposes the movement of the ship is not so high. On ships using the type of the Raked Bow, the shape of the bow is slanted so that it does not become a cross-section for fluid flow when the ship moves. This makes the resistance experienced by ships smaller than the other models. On a boat using the Maier Form, there are bumps on the underside of the bow. Even though the bumps on the bottom are slanted but it becomes a cross-section when the fluid flow moves against the direction of movement of the ship. This is in-line with the ship using the Raked Bow II. The lower protrusion on the bow is made upright so that there is a large influence in causing the high resistance experienced by the ship because it becomes a vertical cross-section when the fluid flow moves horizontally against the direction of the ship's movement. On a ship using the type of the plumb bow, the fluid flow that moves against the direction of the ship is split vertically by the bow and there is no protrusion on the bow that becomes a cross-section when the ship moves.

The resistance experienced by the ship affects the power needed to move the ship. Computer testing using Maxsurf Resistance has produced a graph of speed compared to power. The test results are shown in Figure 13.

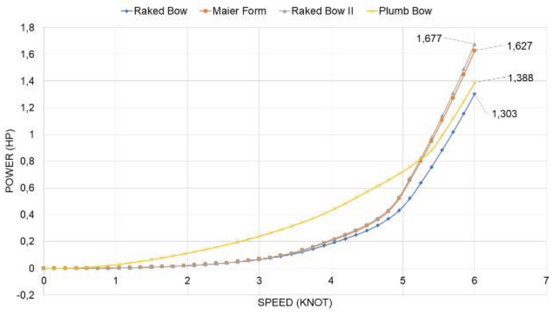

Fig. 13. The graph of the power on all four types bow on the flat hull ship

The results of the tests in Figure 13 shows that the power data need to move the ship. The ship using the type of the Raked bow is the lowest ship that requires power to move with an official speed of 1.303 hp. The second lowest ship is a ship using a type of plumb bow hull. For ships using the Maier Form power, the speed needs at the service speed are 1.627 hp. The ship with the type of the raked bow II is the tallest ship requiring power to drive at the service speed of 1.667 hp. The results of this test indicate that the higher the resistance is experienced by the ship, the higher the power is needed to move the ship.

4. CONCLUSION

The weakness of flat hull ship is the high resistance which must be the primary concern for ship designers. Research using computers to analyze ship designs is very helpful, easy and save time. The results show the flat hull ship using the Raked Bow hull type given the lowest resistance and power needed by the ship to drive. From the simulation results, there are differences wave occurs when the ship moves. Ships with the lowest resistance produce a wave that is relatively low in terms of number and wave height. The higher resistance is experienced by the ship makes the higher and more wave occurs. The lowest power needed by the ship to drive at service speed is a flat hull ship using the type of raked bow and the highest requires power to drive is a flat hull ship with using the type of Raked Bow II.

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