The Study of Shape Flat Hull Ship Toward Resistance

Rahmat Azis Nabawi , Syahril Syahril , Refdinal Refdinal

Manufacturing Laboratory, Universitas Negeri Padang, Padang, Indonesia

***Abstract* – Flat hull ships are increasingly being used in Indonesia for fishing boats, passenger ships and tourist boats. However, this sort of ship has a shortcoming in terms of the enormous resistance compared to streamlined hull vessels, therefore it is necessary to study the hull design of the flat hull ship. In addition, the purpose of this research was to study the effect of the shape and arrangement of the flat plates that form the hull of the ship on the resistance. The research method was the comparator ship method in which the design of the ship models with a flat plate hull was compared to the resistance experienced with a ship with a streamlined hull form (comparator ship). Hence, to reveal the resistance experienced by each ship model, this research used the Maxsurf Resistance Software. The results of the study found that the more similar the hull plate arrangement of a flat hull ship with a comparator ship, the closer the resistance being experienced. The unevenness of the flat hull ship causes energy losses that make the ship have high resistance.**

***Keywords* – Flat Hull Ship, Marine Engineering, Naval Architecture, CFD**

1. Introduction

Flat hull ships have begun to be developed and produced in Indonesia, it is used for fishing boats, passenger ships and tourist boats.

DOI: 10.18421/TEM114-30
https://doi.org/10.18421/TEM114-30

Corresponding author: Rahmat Azis Nabawi,
Manufacturing Laboratory, Universitas Negeri Padang, Padang, Indonesia.
Email: raazna@ft.unp.ac.id

Received: 17 August 2022.
Revised: 24 September 2022.
Accepted: 27 September 2022.
Published: 25 November 2022.

This occurs as the shipbuilding does not require the sophisticated technology equipment and the manufacturing process is relatively effortless and the raw materials can be obtained from local products (no need for imported steel). However, this flat hull ship has higher resistance than ships with streamlined hulls [1],[2],[3],[4]. As a matter of fact, the amount of resistance experienced by a ship while sailing will affect the ship's speed and fuel consumption [5],[6],[7],[8]. Fuel efficiency and energy conservation are the crucial issues in the shipping industry [9],[10].

The results of the study was the ships with Raked bow had the lowest resistance [11]. Additionally, optimizing the reduction of resistance experienced by flat hull ships can be conducted by modifying the shape of the hull used. The shape of the hull affects the resistance experienced by the ship [1]. Modifying the shape of the hull to reduce the resistance the ship experiences is common in ship design science [11]. This research is aimed at examining the effect of the shape of the plate arrangement that forms a flat hull ship in terms of the resistance experienced by the ship and will also discuss the effect of the shape of the hull on the waves that occur when the ship is moving (wave-making system energies).

2. Method

The research method used in this study was a comparator ship, where the ship models which had been modified to become a flat hull ship were compared to the comparator ships [1]. As a matter of fact, the comparator ship in this study was a ship with a size of 3 GT in which this sort of ships was widely used as fishing boats and tourist boats in Indonesia. In addition, the design of flat hull ship models referred to the comparator ship. The parameters being referred as the comparator ship or the control variable consist of the main dimensions such as hull type, bow type and transom type. The independent variables in this study were flat hull ship models with two types of hull skin forming plates and the dependent variable in this study was the resistance experienced by ships. Thus, the research framework was shown in Figure 1.

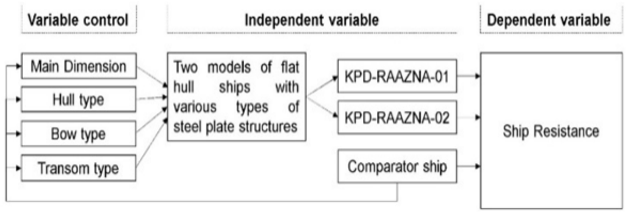


Figure 1. Research Framework

Resistance Analysis Using Computerized Simulation

The use of computers to analyze ship performance has been commonly operated. The development of computer technology has succeeded to cause the test results becoming more accurate in predicting ship designs [12]. Moreover, the analysis of ship performance using computer simulations can reduce testing costs and shortens the time in analyzing ship designs [13]. In fact, the ship prediction using computers has been proven as an accurate method in predicting ship design results [14]. To reveal the resistance experienced by each ship model, the study was conducted using Maxsurf Resistance.

Maxsurf Resistance software is a computer software that is widely used to analyze ship performance [15]. Maxsurf Resistance has been used to calculate the resistance of a trimaran model ship moving on a calm and free water surface [16]. Maxsurf Resistance to investigate the effect of the bulbous bow shape in terms of wave making resistance on Large Container Carriers [17]. The research that had been conducted showed that the resistance curve experienced by the test vessel is relatively the same from the test results by using Maxsurf, Xflow and Daisumi Mihiro's empirical equation [18]. Meanwhile, the Holtrop method was used to express the resistance experienced by ships and uses the 19th International Towing Tank Conference (ITTC) formula which was set on Maxsurf Resistance. The use of the Holtrop method was chosen because it included other factors that affect ship resistance [19].

Table 1. Main Dimensions of the Ship

Length of All	10	m
Length Water Line	9.3	m
Beam	1.6	m
Breadth at The Waterline	1.5	m
Depth	1	m
Draugth	0.55	m

The comparator ship model was drawn according to the shape of the hull of a fishing boat with a size of 3 GT which was commonly used by Indonesian fishermen (See figure 1). In line with the research method used, the difference from the flat hull ship models was the flat plate arrangement that shaped the hull of the ship. Moreover, the RAAZNA-001 model was made to closely resemble the shape of the comparator ship hull in which it would cut more hull forming plates. The RAAZNA-002 model was made with fewer plates than the RAAZNA-001 hull, so the hull was less similar than the comparator ship hull.

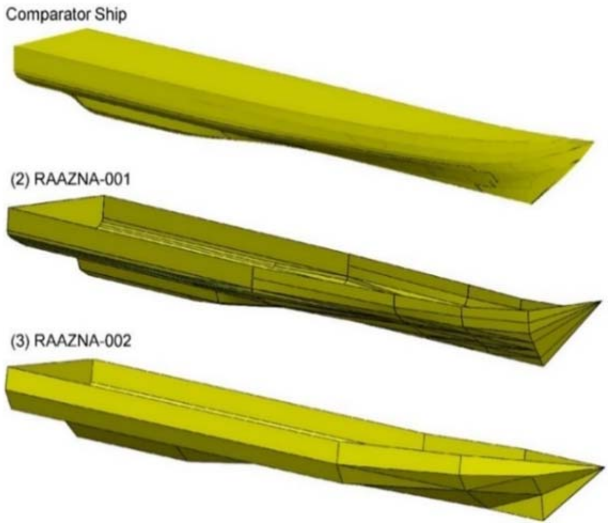


Figure 2. Ship Model

3. Results and Discussion

The analysis of testing and comparison toward the resistance experienced by each ship model with the Maxsurf Resistance software using the Holtrop (monohull) method, whose formula has been modified for computer analysis [20] and the ship speed range from 0 - 10 Knots is shown in Figure 3.

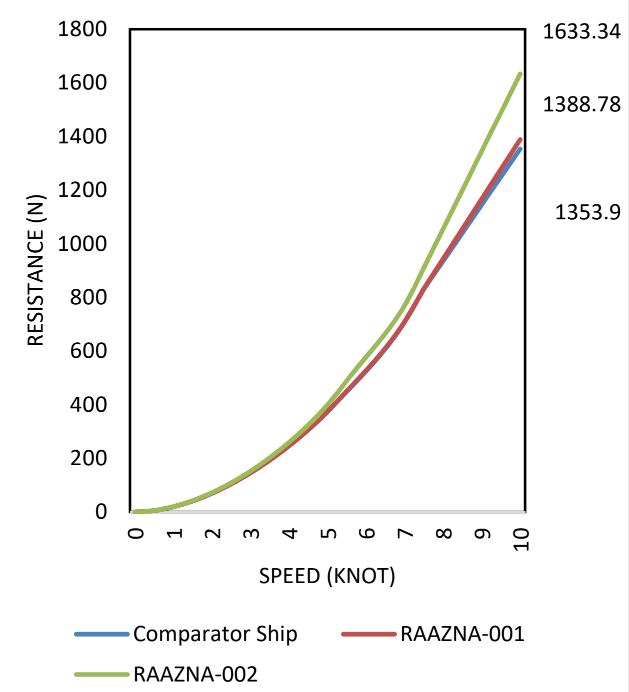
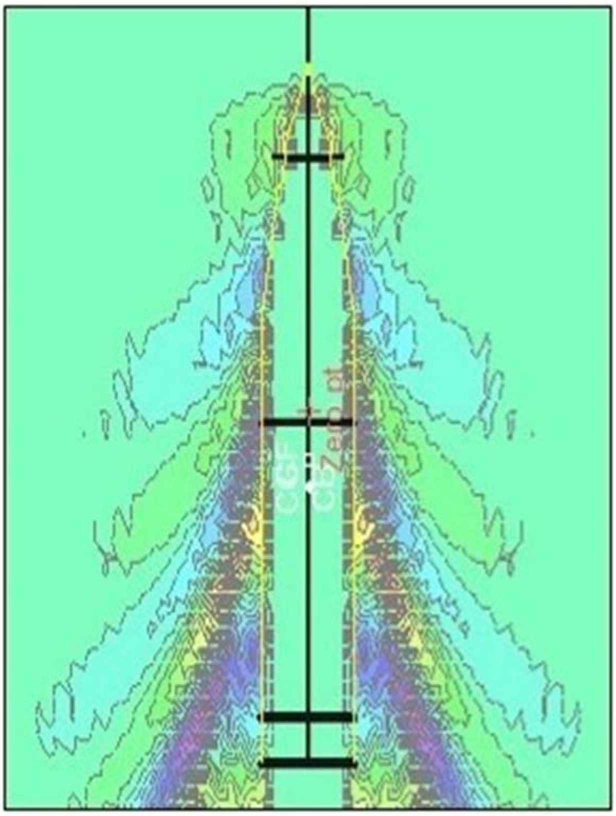


Figure 3. The comparison Chart of Resistance and Speed of the Four Ship Models

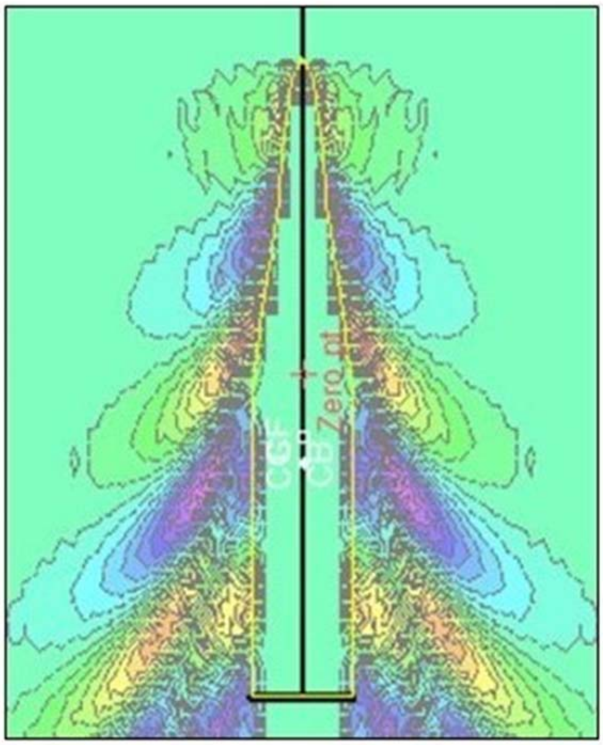
The testing conducted using Maxsurf Resistance produced the resistance data experienced by each ship model. In addition, when the speed range was about 0.25-2.75 Knot, the comparator ship and RAAZNA-001 models underwent the same resistance. In the speed range of 3 - 10 knots, there was a difference in the resistance, where the RAAZNA-001 model went through a larger resistance than the comparison ship. Furthermore, when the ship's speed reached 10 Knots, the resistance underwent by the RAAZNA-001 model was 1388.78 N or 2.57% greater than the comparison ship which only experienced resistance of 1353.9 N. Moreover, RAAZNA-002 model experiencing resistance was 1633.34 N or 20.63% greater than the comparison ship.

To reveal the reason why a difference existed in the resistance from some of these models, it can be seen from the waves that occurred when the ship was moving. Moving ship will cause disturbance on the fluid surface where the pressure variations that arise were demonstrated as changes on the height surface of the fluid [1]. In fact, testing with Maxsurft Resistance also produced a wave phenomenon that happened when the ship was moving forward. The results of the wave simulation that took place when the ship was moving is presented in Figure 4 – 6.



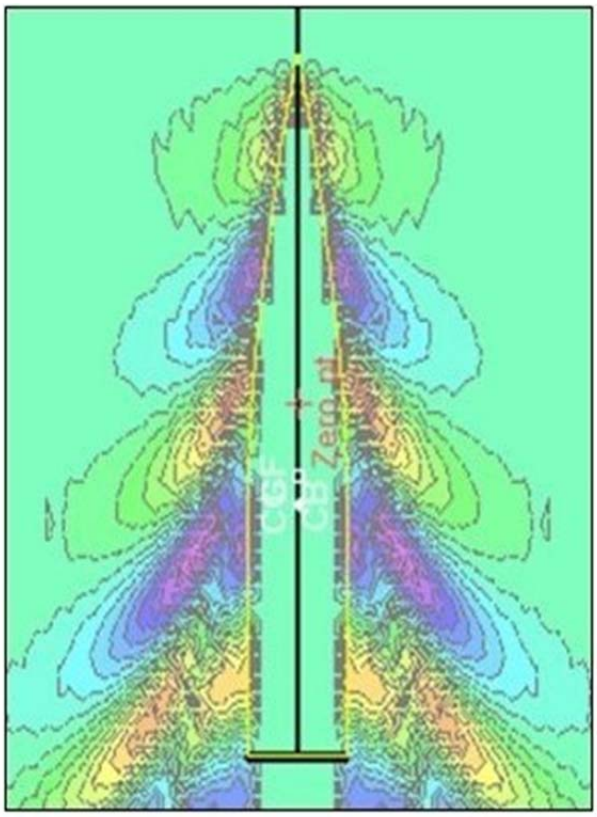
comparator ship

Figure 4. Free surface wave Pattern Maxsurf at a speed of 4,875 kn in the comparator ship



RAAZNA-001

Figure 5. Free surface wave Pattern Maxsurf at a speed of 4,875 kn in the RAAZNA-001



RAAZNA-002

Figure 6. Free surface wave Pattern Maxsurf at a speed of 4,875 kn in the RAAZNA-002

As a matter of fact, the comparator ship model with the RAAZNA-001 model possessed almost the similar divergent wave pattern, yet there were differences in the waves that arose on the bow of the ship. In the bow of the RAAZNA-001 model, turbulence occurred in the fluid, while in the comparator ship model the waves occurred in an oval pattern. In addition, the reason why this turbulence occurred is an interesting question. Judging from the RAAZNA-001 hull, the ship was made by arranging flat plates (not bent), which indicated that there was roughness on the hull surface. The hull roughness also increased the coefficient of friction which resulted on the rise of the resistance experienced by the ship.

The RAAZNA-002 model went through a bigger wave than the comparison model and the RAAZNA-001 flat hull ship model. Moreover, the fronts of the two models formed a fault when the flow followed the fault where the flow velocity occurred but after passing the fault, the flow rate decreased. In accordance with the Bernoulli equation, the difference in flow velocity after passing through the fault caused a pressure difference resulting in a pressure drop which increased the ship's resistance [21]. The results of this study are in line with the research of the 750 DWT pioneering ship modification model using a flat plate that had resistance was a model that had a hull shape resembling a real ship (streamline) [22], [23].

Water was a fluid which contained viscosity when it met the hull of a moving ship, which triggered an inertial forces, meaning that water particles could not traverse the shape of the ship's hull as a whole. Additionally, the separated water particles formed a water vortex (wake) and the broken shape of the flat hull ship increased the eddy which indicated an energy loss and it created the resistance toward the ship.

4. Conclusion

Based on the results of testing and comparing the resistance experienced by each ship model with the Maxsurf Resistance Software using the Holtrop method and a speed range of 0 - 10 knots, the RAAZNA-001 model had a resistance approaching the comparator ship (streamlined hull ship). From the wave phenomenon that occurred in each model, it was concluded that flat plate ships had faults which led to energy losses and this caused resistance to the ship. From the research results, it can also be concluded that the closer the flat hull ship to the streamlined hull form the ship, the smaller the resistance experienced by the ship. However, when the shape of the flat hull ship approached the comparison ship, the number of plates that made up the hull of the ship increased. This fact also needed to be considered as it led to the rise of production costs at the plate cutting stage and an increase in the length of the weld joint. The number and length of welded joints also caused many parts of the hull to experience residual stress (lack of weld joints). Therefore, further research and development on the flat hull ship model is needed to be conducted.

Acknowledgements

The authors would like to thank Lembaga Penelitian dan Pengabdian Masyarakat Universitas Negeri Padang for funding this work.

References

[1]. Harvald, S. A. (1983). Resistance And Propulsion Of Ships. *Ocean Engineering, A Wiley Series*. John Wiley & Sons.

[2]. Putra, G. L., Wibowo, H. T., & Agusta, F. (2017). Stability analysis of semi-trimaran flat hull ship for a sea transportation model. *Communications in Science and Technology*, *2*(2), 42-46. https://doi.org/10.21924/cst.2.2.2017.52

[3]. Nabawi, R. A., Syahril, S., & Salmat, S. (2020). Stability study of flat hull ship for fishing tourism. *Teknomekanik*, *3*(2), 80-85. https://doi.org/10.24036/teknomekanik.v3i2.9272

[4]. Nabawi, R. A. (2021). Study Reduction of Resistance on The Flat Hull Ship of The Semi-Trimaran Model: Hull Vane Vs Stern Foil. *CFD Letters*, *13*(12), 32-44. https://doi.org/10.37934/cfdl.13.12.3244

[5]. Demirel, Y. K., Turan, O., & Incecik, A. (2017). Predicting the effect of biofouling on ship resistance using CFD. *Applied ocean research*, *62*, 100-118. https://doi.org/10.1016/j.apor.2016.12.003

[6]. Liu, S., & Papanikolaou, A. (2016). Fast approach to the estimation of the added resistance of ships in head waves. *Ocean Engineering*, *112*, 211-225. https://doi.org/10.1016/j.oceaneng.2015.12.022

[7]. Zhang, S., Tezdogan, T., Zhang, B., & Lin, L. (2021). Research on the hull form optimization using the surrogate models. *Engineering Applications of Computational Fluid Mechanics*, *15*(1), 747-761. https://doi.org/10.1080/19942060.2021.1915875

[8]. Salmat, S., Zulhendrik, A., Iski, M. I., Adli, A., & Nasty, A. Z. (2020). Design of Hybrid Hull Ship by B-NINE TEAM to The National Unmanned Fast Boat Contest 2019. *Teknomekanik*, *3*(1), 17-21. https://doi.org/10.24036/TM.V3I1.5772

[9]. Ramadhan, O., Syahril, S., Nurdin, H., & Purwantono, P. (2019). Design of Catamaran Ship Using Solar Power. *Teknomekanik*, *2*(1), 7-13. https://doi.org/10.24036/TM.V2I1.2472

[10]. Syahril, S., & Nabawi, R. A. (2019). Numerical Investigation of the effect on Four Bow Designs Flat Hull Ship. *International Journal of Geomate (Geotechnique, Construction Materials and Environment)*, *17*(62), 231-236. https://doi.org/10.21660/2019.62.95333

[11]. Zhang, B. J., & Miao, A. Q. (2015). The Design of a Hull form with the Minimum Total Resistance. *Journal of Marine Science and Technology*, *23*(5), 591-597. https://doi.org/10.6119/JMST-014-0605-1

[12]. Li, S. Z., Zhao, F., & Ni, Q. J. (2014). Bow and stern shape integrated optimization for a full ship by a simulation-based design technique. *Journal of Ship Research*, *58*(02), 83-96. https://doi.org/10.5957/JSR.2014.58.2.83

[13]. Trisyaldi, A., Purwantono, P., Waskito, W., & Primawati, P. (2019). Study of Ship Design Maninjau Lake Tourism by Using Catamaran Hull Type and Fiberglass Material. *Teknomekanik*, *2*(1), 24-28. https://doi.org/10.24036/TM.V2I2.3072

[14]. Terziev, M., Tezdogan, T., Oguz, E., Gourlay, T., Demirel, Y. K., & Incecik, A. (2018). Numerical investigation of the behaviour and performance of ships advancing through restricted shallow waters. *Journal of Fluids and Structures*, *76*, 185-215. https://doi.org/10.1016/J.JFLUIDSTRUCTS.2017.10.003

[15]. *MAXSURF. (2022). Naval Architecture Software*. Retrive from: https://maxsurf.net/ [accessed: 10 June 2022].

[16]. Hafez, K. A., & El-Kot, A. A. (2012). Comparative investigation of the stagger variation influence on the hydrodynamic interference of high speed trimaran. *Alexandria Engineering Journal*, *51*(3), 153-169. https://doi.org/10.1016/J.AEJ.2012.02.002

[17]. Nuruddin, H., Mustaffa Kamal, I., Mansor, M. N., & Hafidz, N. M. (2017). Investigation on the effect of bulbous bow shape to the wave-making resistance of an ultra large container carrier (ULCC). *ARPN J Eng Appl Sci*, *12*, 1254-1259. Retrieved from: www.arpnjournals.com [accessed: 15 June 2022].

[18]. Pan, W., Chaohe, C., & Xiao, Z. (2018, July). Comparative analysis on the methods of preliminarily estimating resistance of yachts. In *IOP Conference Series: Materials Science and Engineering* (Vol. 383, No. 1, p. 012052). IOP Publishing. Retrieved from: https://doi.org/10.1088/1757-899X/383/1/012052 [accessed: 10 June 2022].

[19]. Holtrop, J. (1984). A statistical re-analysis of resistance and propulsion data. *International shipbuilding progress*, *31*(363), 272-276.

[20]. Recommendations, I. T. T. C. (2011). *ITTC-Recommended procedures and guidelines, practical guidelines for ship CFD applications* (Vol. 3). 7.5-03-02.

[21]. Budiyanto, M. A., Tresno, H., & Fattah, M. (2017). Perbandingan nilai hambatan kapal antara hasil simulasi dengan eksperimen pada kapal pelat datar semi-trimaran. *Prosiding SNTTM XVI*, 168-171.

[22]. Afriansyah, N., Adietya, B. A., & Rindo, G. (2018). Studi Desain Analisa Perbandingan Performance Kapal Perintis 750 DWT dengan Variasi Hull Menggunakan Pelat Datar. *Jurnal Teknik Perkapalan*, *6*(1), 160–167.

[23]. Afriansyah, N., Adietya, B. A., & Rindo, G. (2018). Studi Desain Analisa Perbandingan Performance Kapal Perintis 750 DWT dengan Variasi Hull Menggunakan Pelat Datar. *Jurnal Teknik Perkapalan*, *6*(1), 160–167. Retrieved from: https://ejournal3.undip.ac.id/index.php/naval/article/view/19933/18837 [accessed: 18 June 2022].