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Numerical Analysis of The Effect of Chine Variation on The Design of The Senopati Catamaran Fishing Boat on Resistance Based on Maxsurf Resistance Software

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Abstract

The majority of fishermen in Indonesia still rely on traditional boats that have been built and passed down through generations. These fishermen tend to focus primarily on maximizing their catch, often overlooking other important aspects such as hydrodynamic resistance. Beyond the fishing gear used, one of the key factors influencing the effectiveness of a fishing vessel is its hull design. This study aims to analyze the resistance characteristics of a catamaran-type fishing vessel designed by the Senopati Team. The analysis was conducted using Maxsurf Resistance software with speed variations ranging from 1 to 15 knots. To determine the optimal resistance performance, chine variations were introduced to the hull design, including both single and double chine configurations. Each variation applied chine widths of 5%, 6%, and 7% of the vessel's beam, with chine heights of 1.1 meters and 1.4 meters. The analysis results indicate that resistance increases with vessel speed. However, an increase in chine width generally leads to a reduction in resistance. The most optimal hull configuration was identified as the single chine with 7% width and 1.4 meters height. These findings suggest that the incorporation of chine variations, whether single or double, can effectively reduce the resistance experienced by the vessel compared to a bare hull configuration.

1 Introduction

Indonesia is the largest archipelagic country with 17,508 islands and a coastline stretching 81,000 km. This makes Indonesia rich in abundant marine resources, with fisheries being one of the most promising potentials. It is estimated that Indonesia has 6,000 fish species, with only 3,000 identified so far [1]. With such abundant marine potential, the maritime sector should be able to become an economic pillar for Indonesia. However, Indonesia's marine potential has not been utilized optimally. So far, the maritime sector has received less serious attention compared to the terrestrial sector [2].

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Fiqri Fadillah Fahmi, et al.

The vastness of Indonesia's marine territory results in diverse sea conditions. Differences in climate, weather, and seasons significantly influence sea conditions in each region. This leads to fishermen not being able to maximize their catch every month, while their livelihood heavily depends on the fish caught at sea [3]. The majority of Indonesian fishermen still rely on traditional boats that have been built and passed down through generations to catch fish [4]. These fishermen only think about how to get as many catches as possible without considering other aspects such as resistance. In fact, besides the fishing gear used, one of the key factors determining the effectiveness of a fishing vessel is its design [5]. The majority of fishing vessel designs in Indonesia still use the monohull type.

This type of

vessel has a very large hull, resulting in high resistance, which makes monohull fishing vessel designs considered less efficient. [6] To overcome this, research was conducted on another hull type, namely the catamaran. This type was chosen because it has a wider deck area, which provides better stability, making it feel more comfortable and safer. In addition, the spacious deck area also makes it easier for fishermen to arrange or install the equipment needed for fishing. Besides having a large deck area, catamaran fishing vessels have a slender hull shape, which can reduce wave wash compared to monohulls [7]. This allows the vessel to have higher speeds and lower vessel loads, resulting in lower operational costs. Traditionally, ship resistance analysis can be performed using experimental methods, such as towing tank tests using scaled-down ship models. However, the limitations of this experimental testing include the rarity of towing tank facilities, high costs, long durations, and applicability only to the specific ship model being tested [8]. With the development of technology in the field of computation, there is a more universal method for predicting resistance values using Maxsurf Resistance [9]. Maxsurf Resistance can predict ship resistance values with high accuracy by conducting studies and analyses on systems that are difficult to perform with experimental methods. Resistance analysis of the ship hull was carried out using Maxsurf Resistance software. The analysis was performed with design variations including bare hull, single chine, and double chine, with chine widths of 5%, 6%, and 7% of the ship's beam, and chine heights of 1.1m and 1.4m. This analysis was then conducted at certain speeds.

2 Research Methods

This study uses a quantitative and descriptive approach. The quantitative approach is used to analyze ship resistance using Maxsurf Resistance software [10].

Fiqri Fadillah Fahmi, et al.

Meanwhile, the descriptive approach is used to describe resistance phenomena in more detail [11]. The method used in the analysis is the Holtrop method. The Holtrop method was chosen for its applicability in analyzing cargo vessels such as fishing boats, cargo ships, container ships, and frigates [12]. The research sample used is the catamaran hull of the Senopati Team's fishing vessel, varied with the addition of single chine and double chine, with chine widths of 5%, 6%, and 7% of the ship's beam, and chine heights of 1.1m and 1.4m.

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4 Result and Discussion

At this stage, the research results focus on the resistance values generated by each model analyzed using Maxsurf Resistance software. Then, the results are validated by comparing the numerical analysis results from Maxsurf Resistance with manual calculations. In addition, to strengthen the research results, the researchers also compared the method used, the Holtrop method, with experimental methods conducted by other researchers [13].

1. Analysis of Barehull Resistance Value

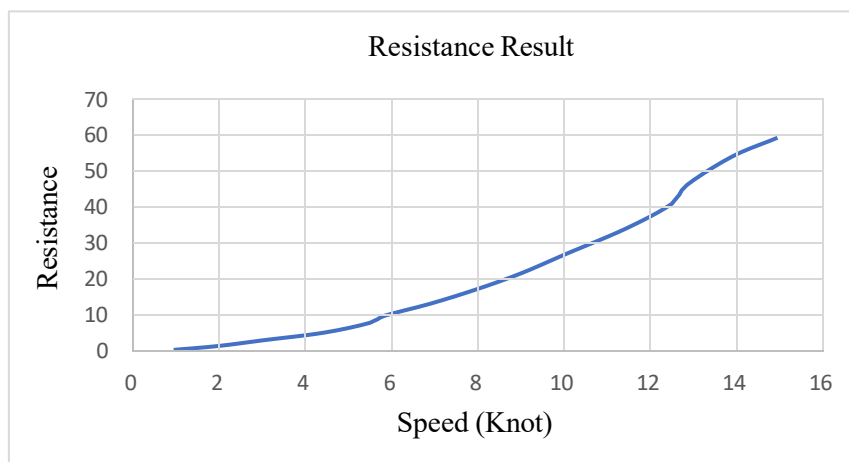


Figure 1. Barehull analysis result

Fiqri Fadillah Fahmi, et al.

Based on Figure 1 it shows that the resistance value will increase with vessel speed. This phenomenon is consistent with hydrodynamic principles, which state that an increase in vessel speed will lead to an increase in resistance due to wave resistance and viscosity effects [14].

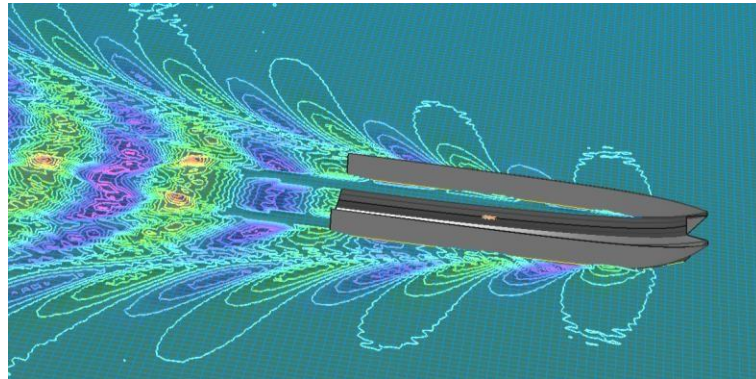


Figure 2. Wave Pattern Barehull

2. Validation of Analysis Results

a. Validation of Maxsurf Resistance with manual calculations

The researcher used a barehull type hull as a sample for comparison with manual calculations.

The formula used to find the resistance is:

$$R_t = 0.5 \times \rho \times C_t \times S \times V_s^2 \quad (1)$$

Manual calculations were performed for speeds ranging from 1 to 15 knots. The results were then compared with the Maxsurf Resistance results as presented in.

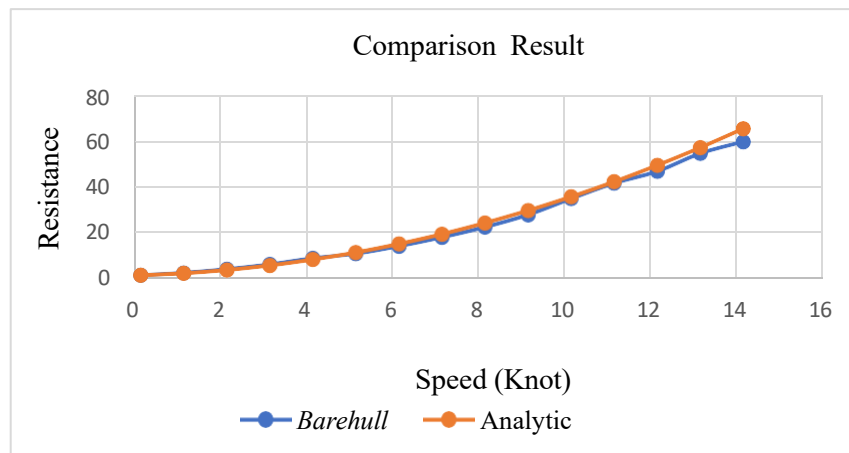


Figure 3. Maxsurf Resistance Validation with manual calculation

Figure 3 shows that the resistance values obtained through Maxsurf Resistance exhibit a similar trend to the manual calculation results at each speed variation. This indicates that Maxsurf Resistance can produce sufficiently accurate and reliable resistance estimations.

Fiqri Fadillah Fahmi, et al.

b. Validation of the Holtrop method with experimental methods

The researcher created a similar design with the dimensions of the vessel used in the experimental method analysis. The purpose of this approach is to measure the validity of the Holtrop method by comparing the numerical simulation results with experimental data from the actual vessel [15].

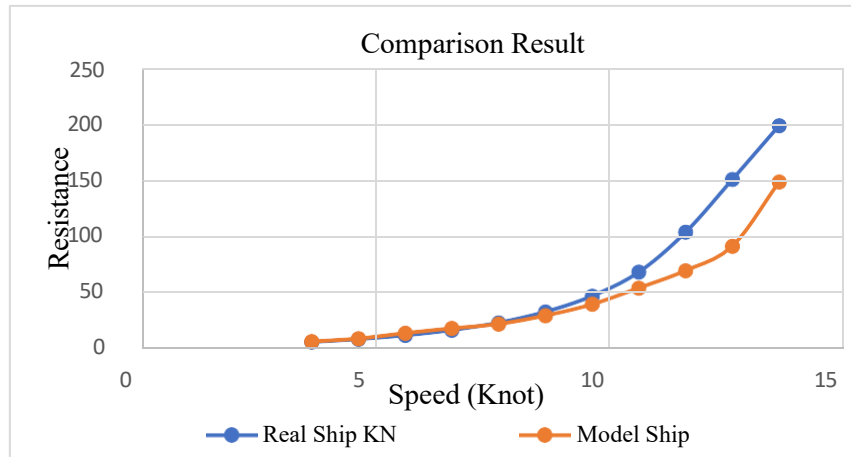


Figure 4. Comparison of the Holtrop method with the experimental method

Based on Figure 4 the graphs show that the resistance values against speed from both methods exhibit a similar pattern, although there are differences at certain speeds. This similarity in trends indicates that the Holtrop method with Maxsurf Resistance can represent the ship's resistance behavior reasonably well, even if not entirely identical to experimental results.

3. Analysis of Single Chine Hull Resistance Value with 1.1m Height

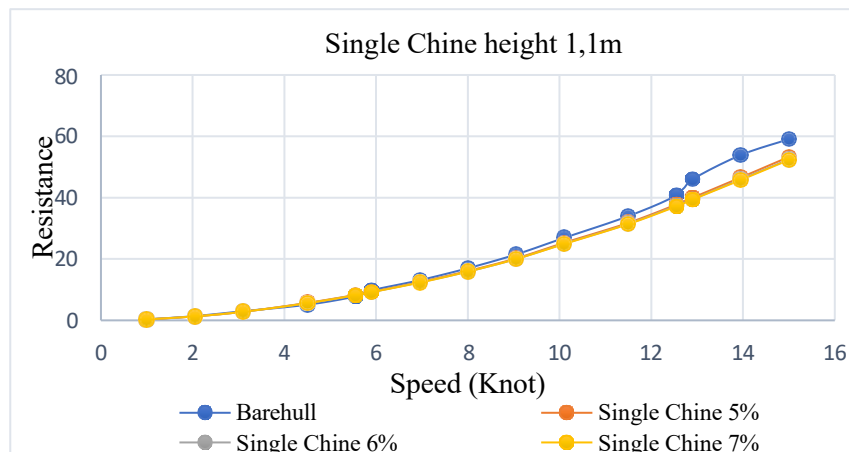


Figure 5. Single chine hull analysis result graph with chine height 1.1m

Figure 5 shows that the higher the vessel speed, the higher the vessel resistance. Conversely, the wider the chine design, the lower the resistance experienced. Furthermore, from the graph above, the chine design with 7% width has a smaller resistance value compared to the 5% and 6% designs.

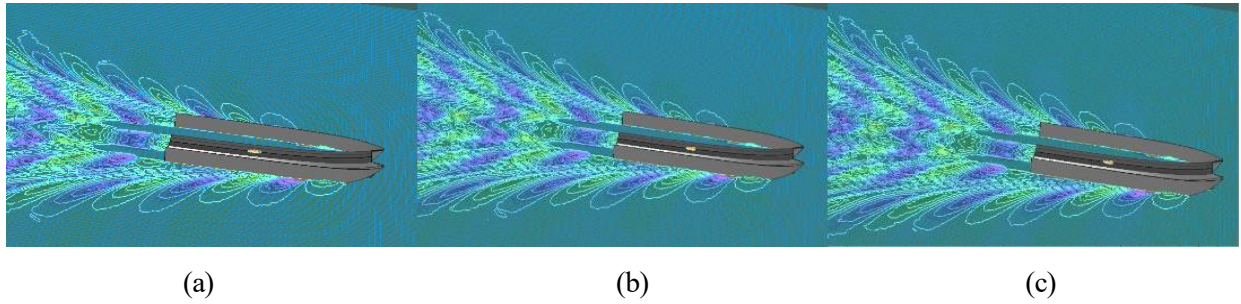


Figure 6. Wave pattern single chine with height 1.1m at width: (a) 5%, (b) 6%, (c) 7%

4. Analysis of Single Chine Hull Resistance Value with 1.4m Height

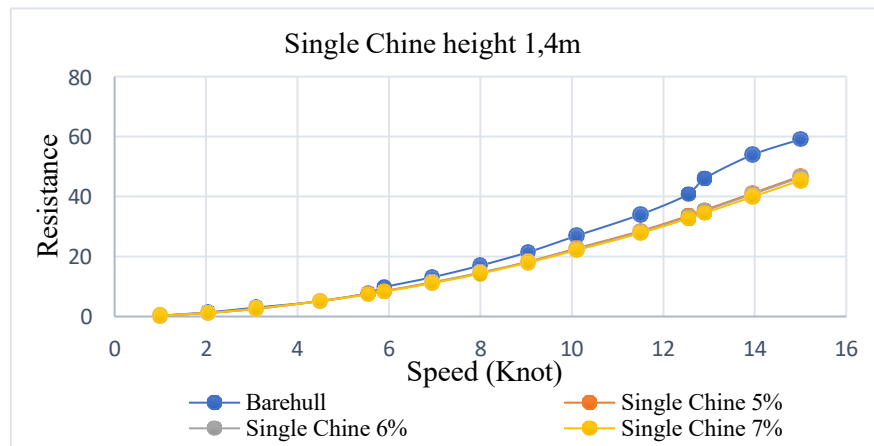


Figure 7. Single chine hull analysis result graph with chine height 1.4m

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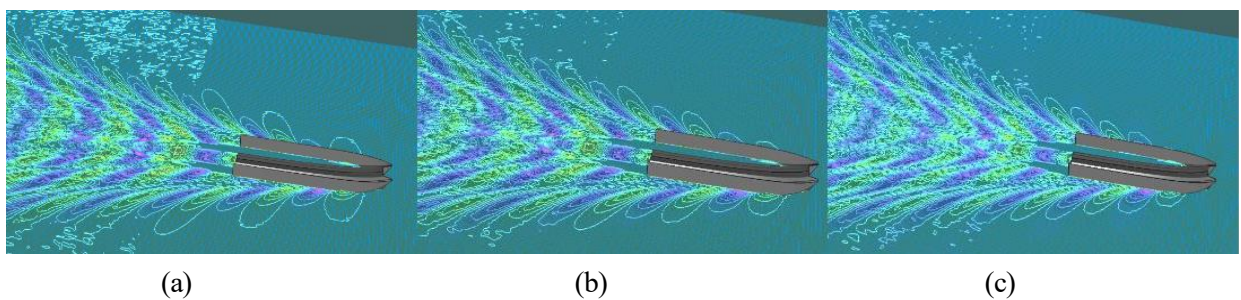


Figure 8. Wave pattern single chine with height 1.4m at width: (a) 5%, (b) 6%, (c) 7%

Fiqri Fadillah Fahmi, et al.

5. Analysis of Double Chine Hull Resistance Value

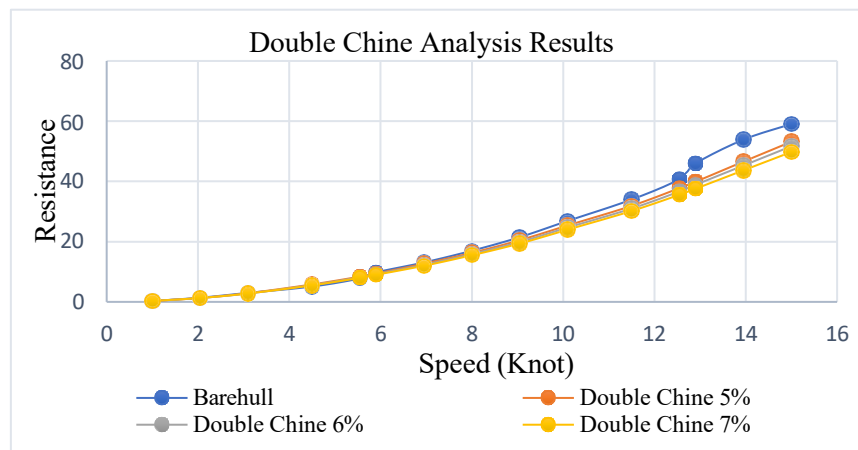


Figure 9. Double chine hull analysis result graph

From Figure 9 above, the double chine design with a 7% width yields the smallest resistance value compared to the 5% and 6% width designs at each speed. The difference in resistance values at each speed is also clearer compared to the single chine with 1.1m height and single chine with 1.4m height. This clarifies that the difference in height and width of the chine significantly affects the resistance experienced by the vessel.

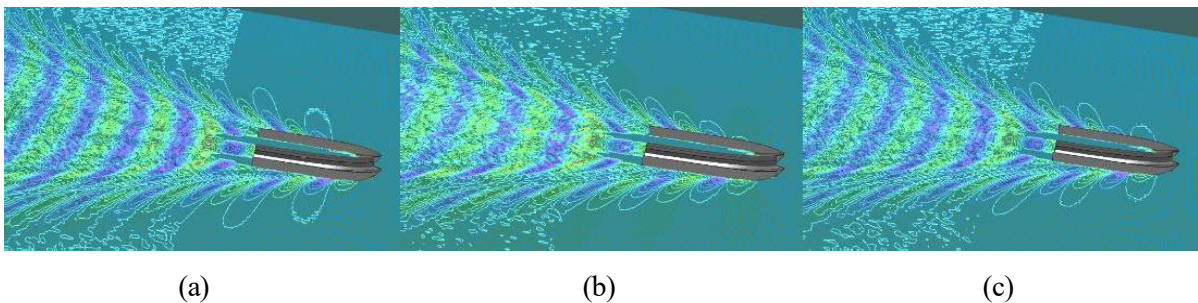


Figure 10. Wave pattern double chine in width: (a) 5%, (b) 6%, (c) 7%

Fahmi, et al.

6. Analysis of All Hull Design Variations

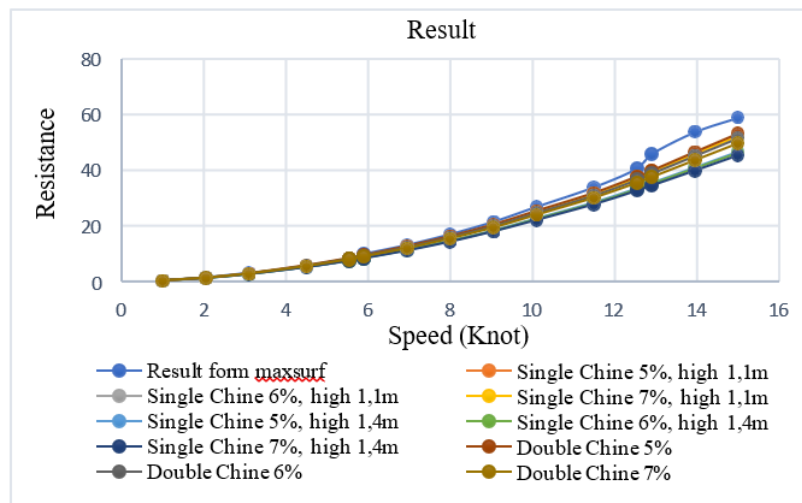


Figure 11. Overall graphic of chine design variations

From Figure 11 it can be seen that the catamaran hull design without chine additions (barehull type) produces the highest resistance value at each speed. This indicates that the hull form without chine additions has less efficient hydrodynamic performance. Conversely, the design with a single chine addition of 1.4m height can produce the lowest resistance compared to other designs.

5 Conclusion

1. The numerical analysis conducted using Maxsurf Resistance software demonstrates that variations in chine geometry have a significant influence on the hydrodynamic resistance performance of the Senopati Team catamaran fishing vessel. Among all tested configurations, the most optimal hull design is the single chine type with a chine width of 7% of the beam and a chine height of 1.4m, yielding the lowest resistance value of 45.4 KN at a speed of 15 knots. In contrast, the bare hull design produces the highest resistance value of 59.1 KN at the same speed.
2. The findings indicate that increasing the chine width tends to reduce total resistance due to improved fluid flow and wave pattern distribution along the hull surface. Moreover, the implementation of both single and double chine configurations provides better hydrodynamic efficiency compared to the bare hull design. These results can serve as a valuable reference in future catamaran fishing vessel design development to enhance fuel efficiency and overall operational performance.

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Fahmi, et al.

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Fahmi, et al.

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