International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN (Online): 2350-0557, Volume-11, Issue-5, October 2024
https://doi.org/10.55524/ijirem.2024.11.5.8
Article ID IJIR3023, Pages 59-65
www.ijirem.org

Study on the Development of Trimaran Traditional Fishing Vessel with a Review of Resistance and Effective Power

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Received: 4 September 2024 Revised: 17 September 2024 Accepted: 2 October 2024

ABSTRACT- An important aspect of trimaran ship research is to obtain an optimal model through the analysis of resistance and power requirements. Trimaran ships have the advantage of a wide deck surface and crew members can move freely. In this study, the monohull and trimaran ships were calculated using computational fluid dynamics (CFD) approach. This study explores the optimal model for a fishing boat trimaran with a smaller power requirement than that of monohulls. The computational fluid dynamics (CFD) approach was used to calculate the resistance and power requirements of the ship. The resistance of the trimaran hull affects the performance of the ship, and the selection of the right hull minimises its interaction with the fluid. The study found that trimarans with S/L = 0.2 and 0.3 reduced the resistance by 33.42% and 68.94%, respectively. This study aims to improve the performance and catch efficiency of the traditional Indonesian fishing industry by selecting an appropriate trimaran hull. The selection of an appropriate trimaran hull can optimally affect the performance of a ship and result in abundant catches.

KEYWORDS: Fishing Vessel, Monohull, Trimaran, Resistance, EHP

I. INTRODUCTION

The level of utilisation of fish resources in public waters has only reached 13.4 tons so therefore, the opportunities available are still quite large. The volume of fisheries production in Maluku Province in 2002, the volume from 247,987.4 tons and in 2003 it increased to 250,859.8 tons or an increase of 1.15%. In 2004, it continued to increase to 377,508.3 tons or an increase of 33.55%. The value of production increased from Rp 633,474,933 in 2002 to Rp 1,204,512,559 in 2004, an increase of 47.41%. Thus, fishery production in Maluku until 2004 reached only ± 28.94% of the available sustainable potential.

The results of World Wide Fund (WWF) research, an international non-governmental organisation that deals with issues concerning conservation, research and environmental restoration. Observation results indicate that in the Maluku Islands, water has become a very abundant fish resource because coral reefs are well maintained there [1]. In general, Maluku has become the "headquarters" of the largest fish in the world, but unfortunately, it cannot be managed properly so that the fish in Maluku waters have been stolen and destroyed by foreign fishermen's habitat.

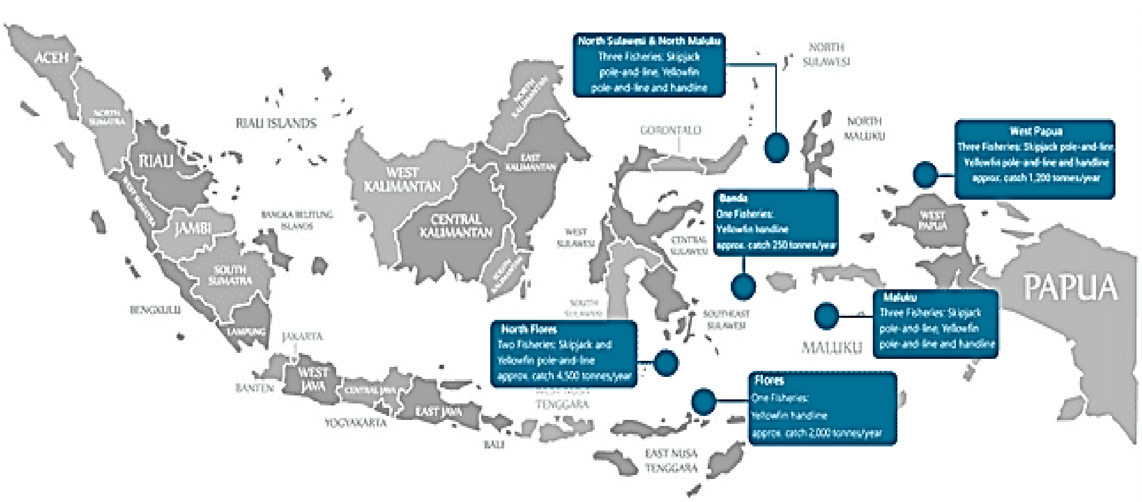


Figure 1: Tuna Fisheries Progressing in Indonesi

Traditional fishermen (Figure 2) engage in small-scale subsistence and commercial fishing, generally carried out by beach dwellers and certain ethnic groups using traditional fishing and boat methods. Nearly all ships with decks are machined, and only a third of deckless boats have engines, mostly external engines that are separate from the hull. Many traditional fishing boats are still used in developing countries with long productive coastlines. Indonesia is reported to have approximately 700 thousand fishing boats, with one-quarter of them in canoes and half with no engines.

Fishing vessels must be developed to achieve more effective operations. One alternative is to use a triple hull (trimaran). The choice of trimaran hull is urgent because it has a broad deck surface and good stability [2]. The wide deck surface allows the crew to move freely. There are 3 important aspects have been investigated in research studies to obtain an optimal model through resistance analysis and fuel use.

Figure 2: Traditional Fishing Vessel

Trimaran hull design is essential for predicting the magnitude of resistance and the need for engine power in trimaran vessels. In this study, the trimaran ship resistance calculation will be performed using a computational fluids dynamic approach to obtain the character of the resistance and continue to calculate the amount of engine power needed (Effective Horse Power / EHP)

II. TRIMARAN RESISTANCE

A drag is the resistance of the flow to an object. Drag is a resistance from friction of an object in which resistance can also occur in the pipe wall where fluid flows. Energy must be provided to overcome drag, maintain the relative motion between objects and fluid flow, and prevent the deformation of an object caused by drag.

The shape of the rear stern of a ship in the form of a transom often adds its own resistance which adds to the pressure resistance component and induces drag on the trimaran hull. Wave resistance occurs owing to free-surface gravity waves and viscous stress caused by pressure reduction in the hull of the ship stern owing to the boundary layer. Wave breaking and spraying can significantly contribute to total resistance at high speeds.

Froude [3] first introduced the total resistance of a ship consisting of 2 (two) components: residual resistance and friction resistance. The ship friction resistance is assumed to be the same as the 2-dimensional flat plate resistance which has the same wet surface area and moves in water at the same speed as the speed of the ship, as shown in equation .1.

$$C_T = C_F + C_R \qquad (1)$$

Trimaran ship resistance is more complex than monohull resistance because of the influence of interference and interaction between two hulls. The influence of interference and interaction is very important to be studied carefully both through experiments and CFD simulations; thus, so that later these results can contribute to predicting the resistance components and total resistance of trimaran vessels.

The influence of viscous and wave interference on trimaran vessels is significant. Viscous interference is caused by asymmetric-flow water flow around the hull which affects the boundary layer formation, whereas wave interference is caused by the interaction of the waves generated by each hull.

In this section, the components of the coefficient of interaction of the trimaran ship outline consist of one main hull and two side hulls. The total coefficient of resistance (C_T) is calculated based on equation (2)

$$C_{T(Trim)} = \frac{R_{T(Trim)}}{0.5\rho (WSA) V^2} \qquad (2)$$

For Mainhull

$$C_{T(Main)} = \frac{R_{T(Main)}}{0.5\rho A v^2} \qquad (3)$$

For Sidehull

$$C_{T(Side)} = \frac{R_{T(Side)}}{0.5\rho A v^2} \qquad (4)$$

where ρ is the density of water, v is the velocity of the ship, and A is the wetted surface area. The total resistance obtained by adding interference is expressed as follows:

$$C_{T(Trim)} = C_{T(Main)} + 2C_{T(Side)} + IFCv + IFCw \qquad (5)$$

Where, $IFCv$ is viscous interference, and $IFCw$ is wave interference

The effective power calculation (EHP) is then performed, that is, the amount of power needed to overcome the drag from the hull, so that the ship can move from one place to another at the service speed, using the following formula:

$$EHP = R_T . Vs \qquad (6)$$

III. METHOD

Analysis of ship resistance using traditional fishing boat models and trimaran with the main size as in the table 1 and shown in the figure 3 and figure 4.

Table 1: Principal Dimension

Dimensi	Unit	Monohull	Trimaran	
			S/L=0.2	S/L=0.3
Length (L)	m	18	18	18
Breadth (B)	m	2.22	8.6	10.4
Draugh (D)	m	1.22	0.91	0.91
Heigh (H)	m	2.4	2.4	2.4
Displacement	ton	21.1	21.1	21.1

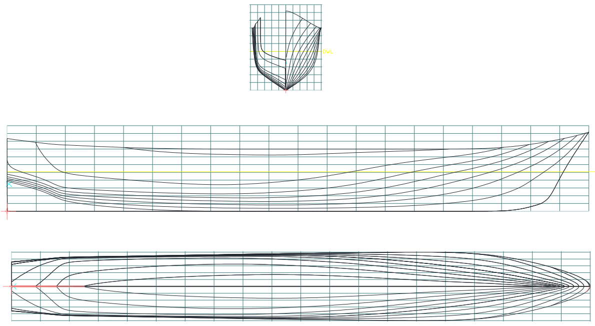


Figure 3: Lines Plan of Monohull

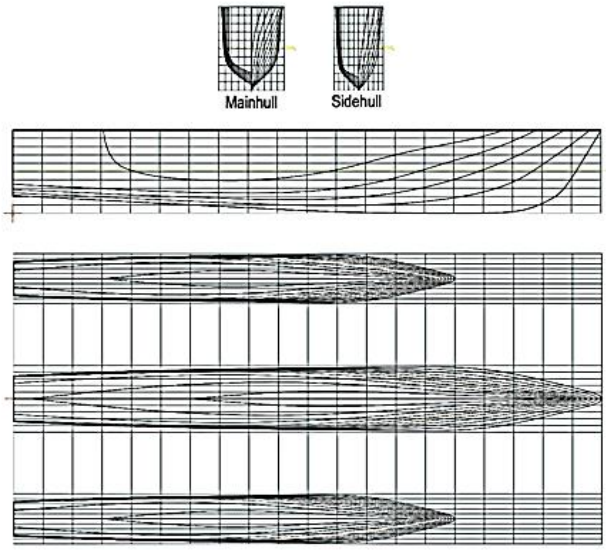


Figure 4: Line Plane of Trimaran

Model making was performed using the Design Modeller tool and defined in accordance with the field data. Defining the model in this case provided the boundary conditions for the model to be simulated. The boundary conditions were the fluid type, fluid density, and flow velocity. The model was defined using the ANSYS CFX software. In this process, the fishing boat model is assumed to be stationary, whereas the fluid is assumed to be moving. Therefore, boundary conditions data such as speed are applied to the fluid domain, as shown in Figure 5 and Table 2 .

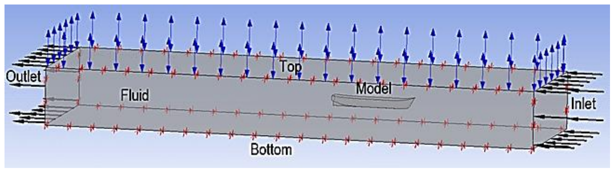


Figure 5: Model Definision

Table 2: Model Definision

Property	Fine Mesh
Grid	Unstructured with inflation mesh
Total Elements	up to 2.2 million
Domain	Air and Water, SST Turbulence [4]
Boundary physics:	
Inlet	Velocity, v = 11 to 17 knot
Outlet	Dowpress
Top	Opening
Bottom	free slip
Wall	symetri
Model	no slip
Solver settings:	
Advection scheme	High Resolution [5]
Convergence criteria	Residuary type: RMS, Target: 0.0001

The number of iterations affects the level of accuracy that can be achieved. The determination of the number of iterations is influenced by the level of accuracy of the model that has been made. The greater the number of grids used in the modelling, the more iterations that need to be performed to calculate the model. The iteration process stopped when it reached a predetermined convergence limit. In this process, the calculation is performed until it reaches the smallest error value or a convergent value is obtained. The convergence criteria used in the iteration process using ANSYS CFX is 10^{-4} [6] shown in Figure 6

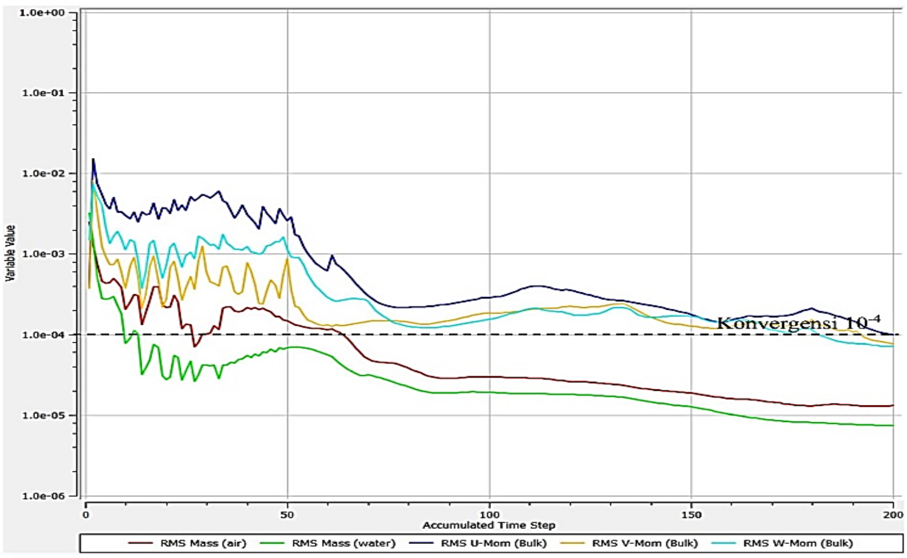


Figure 6: Convergence Criteria

The large number of cells or grids used in the calculation determines the accuracy of the results obtained because the number of cells affects the change in the geometric shape at the time of processing the results. Figure 7 shows the initial computational domain. Grid (mesh) at the front of the hull is up to 2L, at the back of the hull is 5 times the length of the ship, the distance up and down is 1 time the length of the ship and 2L is the distance to the left and right side of the ship. This distance is sufficient to avoid the blockage effect [7][8], which uses the number of elements ranging from 63,519 to 2,123,236 with an unstructured mesh type [9] for the fishing boat model, as presented in figure 8.

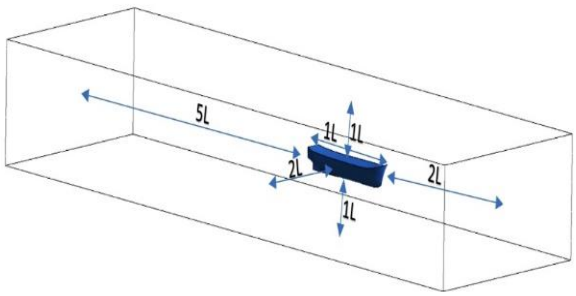


Figure 7: Initial domain computation

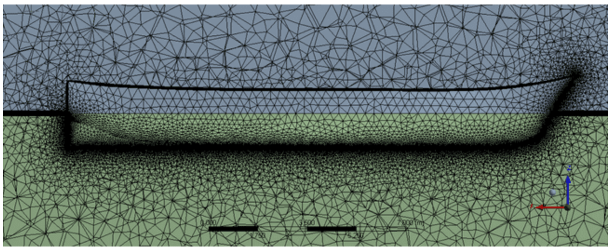


Figure 8: Meshing

The fishing boat model was constructed to meet the independent grid on the number of elements (grid) of 1,100,028 with a drag of 11.30 kN and a barrier gap of 1.74%, as shown in Figure 9.

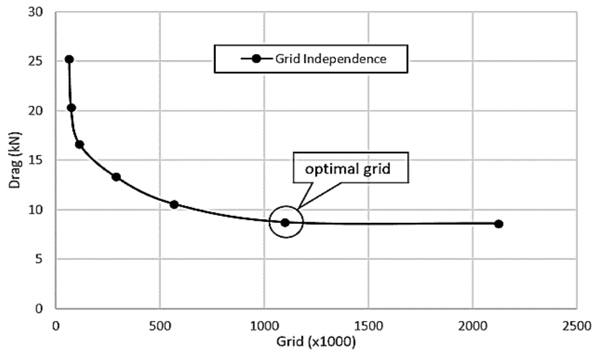


Figure 9 Grid Independence

IV. RESULT AND DISCUSSION

The computational results for the CFD monohull and trimaran hull shapes are presented in Table 3 and Figure 10, respectively. The contribution of viscous resistance is greater than that of total resistance in the shape of a flat hull (L/B >>). Monohull ships have greater resistance than trimaran vessels. This is because the hull is wider than that of the trimaran hull. A wider hull causes the wave to become more dominant. However, viscosity (which is dominated by friction resistance) increases with the length of the hull [10]. With an increase in the length or area of the wet field, surface friction also increased. Generally, the wave resistance decreases with hull length (for the same displacement).

The interaction between the two hulls in the transverse direction (S/L) significantly affected the resistance of the ship. CFD calculations showed that the smaller the distance between the trimaran hulls (S/L), the greater the resistance. This phenomenon arises because of the effects of viscous and wave interactions between the hulls [11]. The resistance of the trimaran hull with S/L = 0.2, the resistance was greater than that of the trimaran hull with S/L = 0.2. This phenomenon occurs because of the increased hull interaction owing to interference between the hulls, which was also revealed by [12]. Stated that the distance of the hull separation between the hull (S/L) is crucial to the occurrence of wave interactions (wave making) which contradict the front (bow) and spread to the back (stern) of the ship, as shown in Figure 11.

Table 3 Resistance and EHP of monohull and trimaran

Velocity	Monohull		Trimaran	
Knot	R_T (kN)	EHP (kW)	R_T (kN)	EHP (kW)
11	8.74	49.42	7.82	44.24
12	11.59	71.48	9.04	55.78
13	13.78	92.04	9.97	66.60
14	15.38	110.65	10.83	77.97
15	16.67	128.52	11.80	90.96
16	17.85	146.83	12.91	106.15
17	19.03	166.28	14.16	123.75

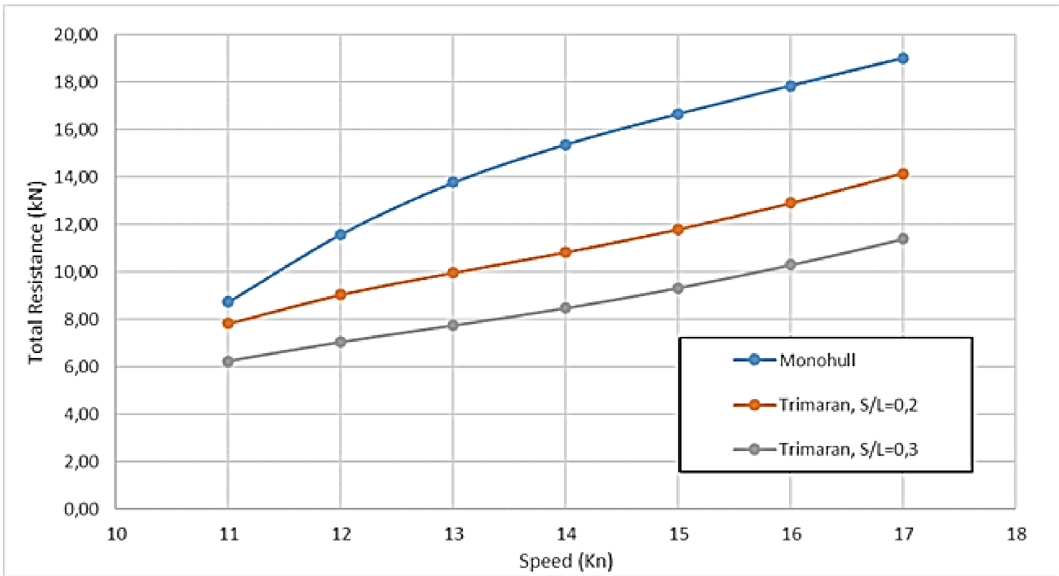


Figure 10 Resistance of monohull and trimaran

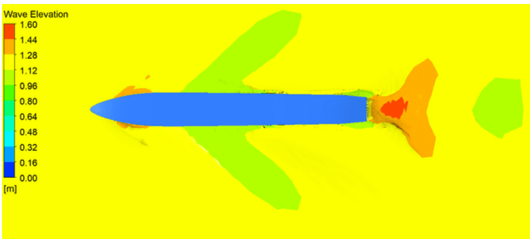
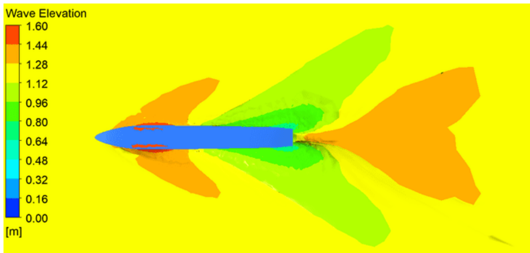
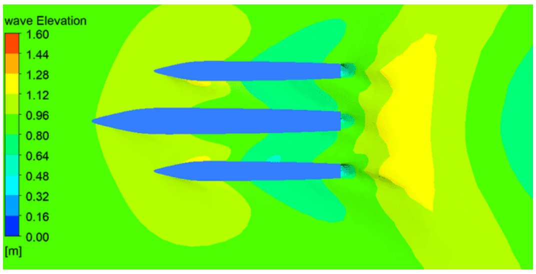
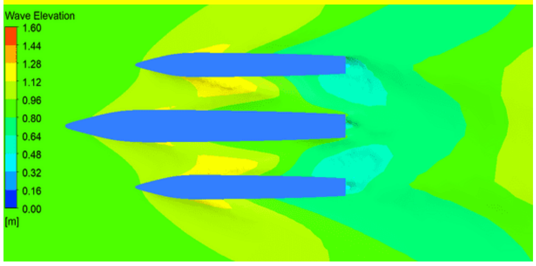
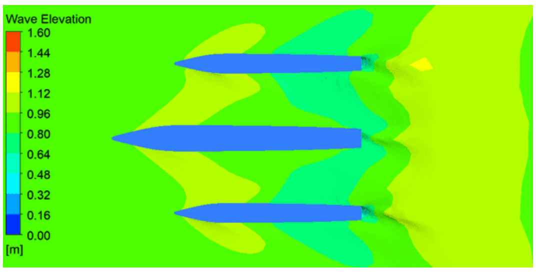
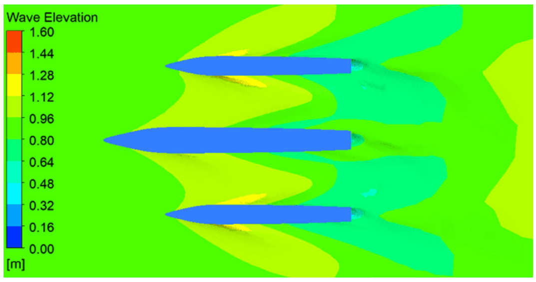
Boat	Velocity (Kn)	
	11	17
Monohull		
Trimaran, S/L = 0.2		
Trimaran, S/L = 0.3		

Figure 11: Wave Elevation

The calculation of the power required in this case, the effective power (EHP), is also affected by the calculation of resistance. As shown in Figure 12, the results of the resistance calculation indicate that monohull ships have greater power requirements than trimaran vessels do. which has an average power requirement of 33.42% greater than that of the trimaran with S/L = 0.2 and 68.94% greater than that of the trimaran with S/L = 0.3. The power requirements for different hull configurations reflect the variations in the resistance observed between the monohull and trimaran designs. This difference in power efficiency can be attributed to the unique hydrodynamic characteristics of trimaran vessels, which benefit from reduced wave-making resistance owing to their multihull structure. The significant reduction in the power requirements for trimarans, particularly those with larger hull separations, suggests potential advantages in fuel efficiency and operational costs for these vessels.

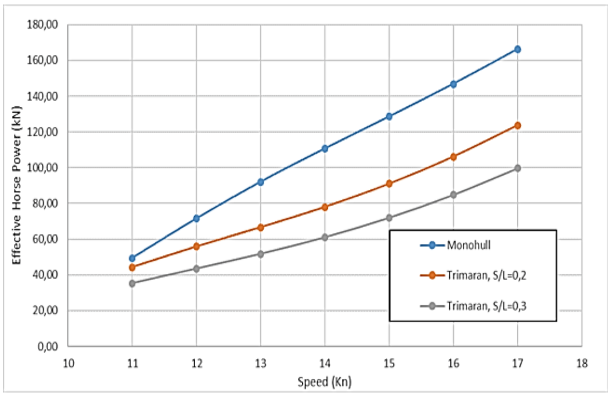


Figure 12 Effective power for monohulll and trimaran

V. CONCLUSION

This study investigates the optimal model of a fishing boat trimaran with a smaller power requirement than that of monohulls. The CFD approach was used to calculate the resistance of the ship and the power requirements. The trimaran hull affects the resistance of the ship, and the correct selection of the hull can minimise the interaction between the hull and fluid. The study found that the trimaran with S/L = 0.2 and 0.3 had a positive effect that could reduce resistance by an average of 33.42% and 68.94%, respectively. Traditional fishing vessels in Indonesia mostly use canoes, and do not have engines. This study used a computational fluid dynamics (CFD) approach to calculate the resistance and power requirements of a trimaran ship.

This study is important because it focused on obtaining an optimal model for fishing boats, specifically trimaran ships, to improve their performance and catch efficiency. This study utilised computational fluid dynamics (CFD) to analyse the resistance and power requirements of both monohull and trimaran hull shapes. By selecting an appropriate trimaran hull, the interaction between the hull and the fluid can be minimised, resulting in a more efficient and sustainable fishing industry.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

ACKNOWLEDGMENT

The authors express their sincere gratitude to Pattimura University for their invaluable support throughout this research, which culminated in its successful completion.

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