Trimaran Fishing Vessel Development: A Review of Vessel Power, Safety and Comfort Needs

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Abstract— *In general, fishing fleets operating in Maluku waters and managed by local entrepreneurs consist of mono hull fishing vessels (such as purse seines, etc.) and trimaran in chart form. These two types of fishing fleets have been known to the people of Maluku for a long time. However, these two types each have their advantages and limitations, for example, mono hull fishing boats have limited deck space and poor transverse stability, especially in bumpy sea conditions in extreme weather. While the trimaran type has better deck space and transverse stability than a mono hull ship, but because it is still in chart form, it has limited space. The shortcomings that exist in these two types of fishing fleets are coupled with the expertise or experience of fishermen which has minimal impact on the decrease in the catch and what is worse can be fatal to accidents and the sinking of ship arma. To increase the catch of fisheries, it is necessary to have a means and a reliable fishing fleet. This study aims to examine the development of trimaran fishing vessels in terms of the study of energy needs, safety and comfort for the captain and crew during fishing operations. The initial stage of this research begins with data analysis and the principal size of mono hull fishing vessels operating in Maluku waters, from this data the hull form of a trimaran vessel is designed with an area similar to or close to the area of a monohull fishing vessel operating in Maluku waters using maxsurf, then analyzed the calculation of obstacles. ship and stability to assess the energy needs and safety and comfort of the ship during fishing operations. This research is focused on analyzing the energy requirements, safety and comfort of the trimaran fishing vessel. The final result of this research is expected to be used as an alternative fishing boat to increase the fish catch of fishermen which will have an impact on the income and welfare of fishermen.*

Keywords— Trimaran Fishing Vessel, Resistance, Power, Safety, Comfort.

I. INTRODUCTION

As a province where 92% of its total area is water, the marine and fisheries sector in Maluku Province is the main source of economic growth in the region. Capture fisheries potential in Maluku is recorded at 1.72 million per year. This has prompted the Indonesian government to designate Maluku as the “National Fish Barn.” In a global context, Maluku is an important part of the world's marine biodiversity, considering that this province has 76% of the world's coral species and 37% of the world's coral fish species.

Overfishing is one of the main threats to Maluku's fishery sector which includes the exploitation of shrimp and big-eye tuna, snapper, grouper, flying fish and albakora tuna. The lack of data availability, for example data related to small pelagic fish and large pelagic fish as well as migratory species as well as information on the value and status of coral reefs, seagrass beds and estuary (estuary) ecosystems in Maluku Province is another challenge in fisheries management efforts in Maluku Province. Management of marine conservation areas that are not yet optimal adds to the long list of threats to Maluku's fishery sector. The development of coastal areas that are not environmentally friendly as well as the pollution resulting from the development of public waters needs to be managed through good water zoning planning. Law enforcement efforts are needed to tackle the rampant illegal, unregulated and unreported fishing practices (Illegal, Unregulated, and Unreported / IUU Fishing), shark fishing, destructive fishing practices, wildlife crime, and the lack of capacity of relevant stakeholders.

Fishermen need to have a good boat to be able to catch fish optimally. Fishing boats operating in Maluku waters often experience accidents at sea during fishing operations caused by extreme weather factors, overloading and human error. One way to improve the stability of fishing boats is by changing the shape of the monohull hull to a trimaran. This is because the form of monohull ships that are often found in Maluku waters has several shortcomings in relation to ship stability, as well as limited loading space. The advantages of the trimaran are that it has better stability, longer cruising range, and has smaller ship resistance and friction compared to the monohull hull. Therefore, as an effort to minimize ship accidents, it can be done by implementing the use of the trimaran ship type as an alternative in the procurement and addition of fishing vessels in Maluku. Trimaran ship is a development of a ship model with a multi hull system. Trimaran ships have several advantages compared to monohull ships, for example, on the size of the ship with the same width, the trimaran ship's friction resistance is smaller, so that it has the thrust with the same speed is greater. The deck area of a trimaran ship is wider than a ship with a monohull hull type. Submerged volume and relatively smaller wet area, better stability because it has multiple hulls.

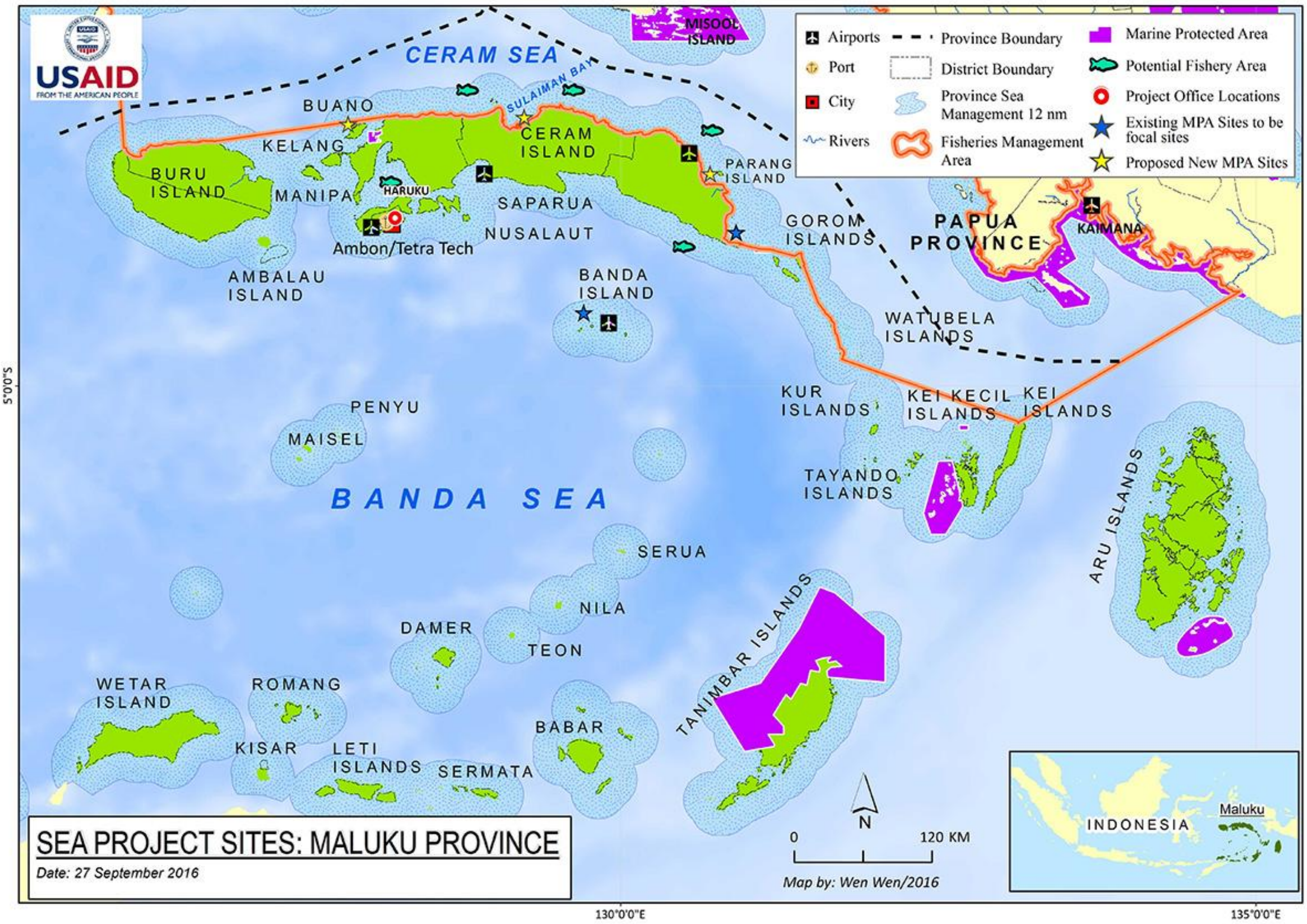


FIGURE 1: Maluku Province

The utilization of the installed production capacity of the shipyard industry is now in the range of 50%-60% and to reach a utilization rate of 80% still takes a long time. If the government shows its side, domestic production capacity will increase. Currently, the capacity of building new ships in Indonesia is around 900,000 deadweight tonnage (DWT) ships per year. Meanwhile, the capacity for docking repairs throughout the year is 12 million DWT.

So far, the project for the fisheries sector tends to be small and there is no significant growth. For national needs, Iperindo also admits that it does not know how much fishing vessels need to explore the archipelago at this time. If you trace the projection in 2025, IPERINDO hopes that the shipping industry in the country will be able to build and repair ships with a capacity of 300,000 DWT.

The development of Trimaran fishing vessels has never been carried out by domestic or foreign agencies. Selection of Hull Trimaran is very important because it has a large deck surface and also has good stability. The large deck surface allows crew members to move freely. The Trimaran Fishing Ship is one form of UNPATTI's Leading Strategic Plan to become a national scientific and technological reference center in the field of Shipping and Fisheries.

The purpose of this study was to obtain the shape of the trimaran fishing boat hull. This research is focused on the study of the development of trimaran fishing vessels in terms of energy requirements, safety and comfort of ships during fishing operations. The problems formulated are: Analysis of the development of trimaran fishing vessels in terms of the aspects of energy needs, safety and comfort of the captain and crew. The overall objective of this research is to minimize fishing boat accidents during operation at fishing ground and reduce the Power

From the study conducted can be obtained an effective and power-efficient trimaran fish vessel model. The results of the technology are expected to be well utilized to improve optimal catches and meet environmental safety criteria and obtain abundant catches.

II. METHOD

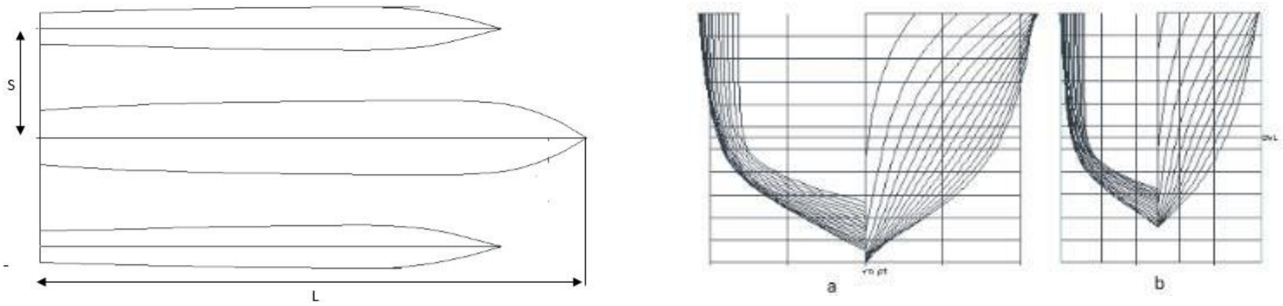


FIGURE 2: Trimaran Configuration, S/L=0.2

In the simulation, the amount of resistance components that act on the trimaran hull will be known. Simulation of free-surface modeling (on water and air media) is used to calculate the total resistance on the hull. The wall for the fluid domain in free slip conditions, namely the shear stress on the wall is zero and the velocity near the wall does not experience a slowdown due to the effect of wall friction. In this simulation, the model is created in a no-slip condition (i.e. friction occurs on the model surface). Meanwhile, to calculate the viscous resistance, the hull is immersed (in the water medium) until it is full of water by assuming the top boundary condition is a solid wall and free slip. Then the wave resistance can be calculated from the difference in the value of total resistance and viscous resistance.

The CFD program consists of 4 main elements:

1. ICEM, which is a geometry and meshing design.
2. CFX-pre, is the boundary condition and specific parameter.
3. Solver is an iterative process.
4. CFX-post is a process of analysis.

In the validation process, there are several important parameters that are considered, namely grid (mesh), convergence, and data results experiment.

2.1 Convergence

At this stage, the iteration process of calculations will always be controlled by a controlling equation. If the calculation result does not match the specified error rate, the computation will continue. The following are some RMS charts that show the convergence of the iteration process, as shown in Fig 3.

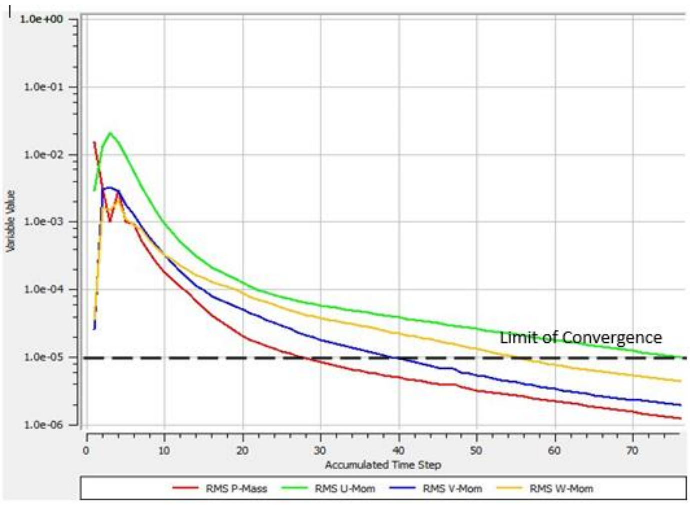
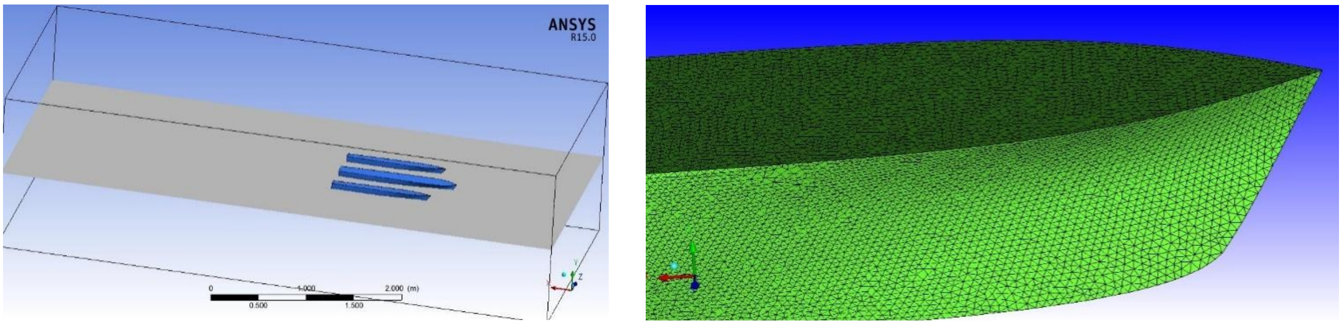


FIGURE 3: Convergence

The root-mean square (RMS) criterion used to check the convergence of the free surface simulation is the residual target value (variable value) reaching 10-5. The target criteria (variable value) are widely applied in computational engineering, as recommended in the ANSYS ICEM manual (2007) and Dinham et al (2008).

2.2 Grid Independence

The large number of cells or grids used in the calculation will determine the accuracy of the results obtained because the number of cells affects the change in geometric shape during result processing. Figure 4 shows the initial computational domain. The boundary at the front of the hull is up to 1.5 times the length of the hull model, at the back the hull is 4 times the length of the hull. Then sideways are 1.5 times the length of the model and the distance is above 2.5 times the length of the model and under 2 times the length of the hull model. This distance is sufficient to avoid the blockage effect (Utama, 1999; Ahmed and Soares, 2009). The computation for the mesh used (multiphase flow calculations) consisted of 1,582,580 mesh elements.



(a) Numerical Domain **(b) Meshing Model**

FIGURE 4: Numerical Model Trimaran

The quality or number of mesh grids is fundamental to convergence and accuracy of CFD simulation / computation. Grid quality and value are discussed in detail by Thompson et al (1999) and Deng et al (2010). The number of mesh elements, 1582,580 for the trimaran hull is quite optimal and accurate, where the number of elements used in the computation shows that it is grid independence as shown in Figure 4. Resistance values for the number of mesh elements (grid) 1,582,580 and 2,875,830 are constant and the same. So it can be said that the selected 1,582,580 mesh numbers in CFD computation have met a fairly good level of accuracy.

III. RESULT AND DISCUSSION

3.1 Resistance and Power

The trimaran drag component coefficient is symmetrical in the transverse hull distance configuration (S/L). For the hull trimaran configuration S / L = 0.2, presented sequentially in Figure which shows that the viscous resistance is greater (dominant) than the wave resistance at Fr <0.27. This is because the hull distance is close enough so that the fluid between the hulls hitting the ship's hull will be reflected to other hulls that are in deep flow. The magnitude of the difference in the viscous coefficient of the ship is shown in Table 1.

The viscous resistance coefficient is very dominant at Fr <0.22 then at S / L> 0.22 The wave resistance coefficient starts to increase, but the viscous resistance coefficient is more dominant at S / L <0.27. This is shown in table 1. Figures 5 show that viscous interference is more dominant than resistance interference.

TABLE 1
RESISTANCE COEFFICIENT TRIMARAN VESSEL

Fr	Coefficient Total (C_T)	Coefficient Vicous(C_V)	Coefficient Wave (C_W)
	(10^{-3})		
0.15	4.491	4.201	0.29
0.17	4.848	4.11	0.738
0.19	5.258	4.008	1.251
0.21	5.965	3.908	2.057
0.23	6.295	3.851	2.444
0.25	6.443	3.806	2.637
0.27	6.653	3.795	2.857

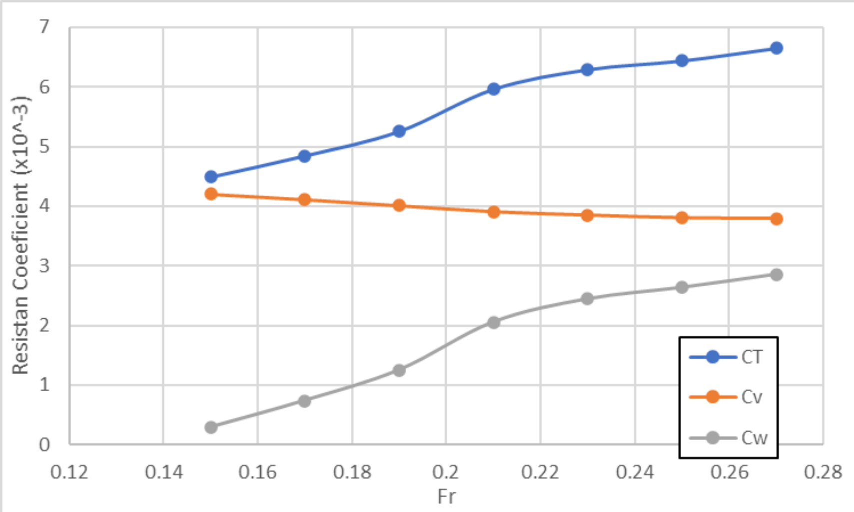
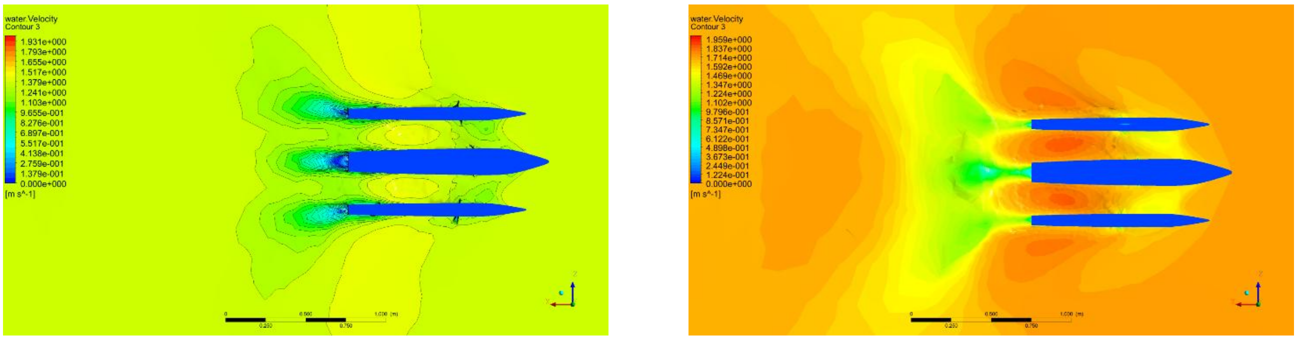


FIGURE 5: Resistance Coefficient Trimaran Vessel



(a) (b)

FIGURE 6: Trimaran Vessel, (a) Fr=0.21, (b) Fr=0.27

The Engine Effective Power (EHP) calculation also shows the same trend, namely, trimaran vessels require the least power among other comparison vessels. This is shown in Figure 7. Where, the Trimaran ship at a speed of 12 knots requires a power of 608.08 kW, while the catamaran requires 629.16 kW power and the monohull ship requires 665.43 kW power. This shows the trimaran ship has the advantage of using less engine power. The shape of the flat hull or thin ship hull (L/B >>), the contribution of the resistance is greater than the wave resistance to the total resistance. Viscous resistance (which is dominated by friction resistance) increases with increasing hull length, Tuck and Lazauskas (1996). With the increase in the length or area of the wet area, the surface friction force will also increase. As for the wave resistance, in general, it becomes smaller as the length of the hull increases (for a fixed displacement).

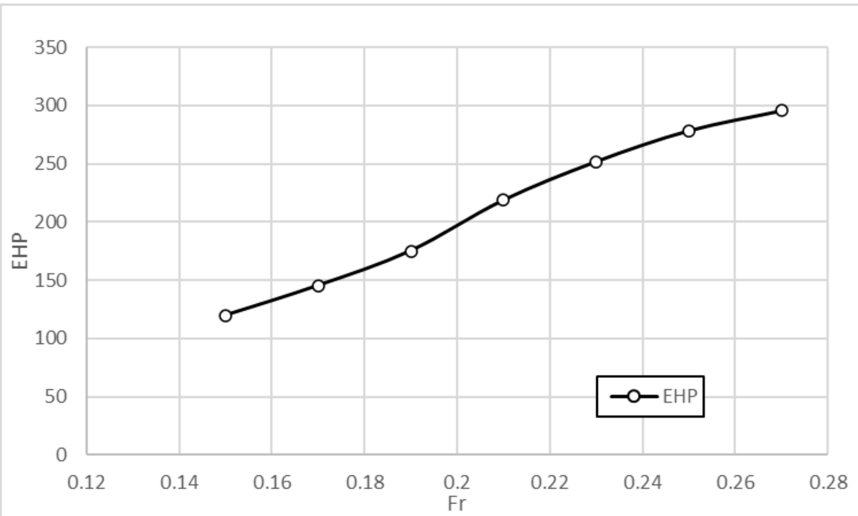
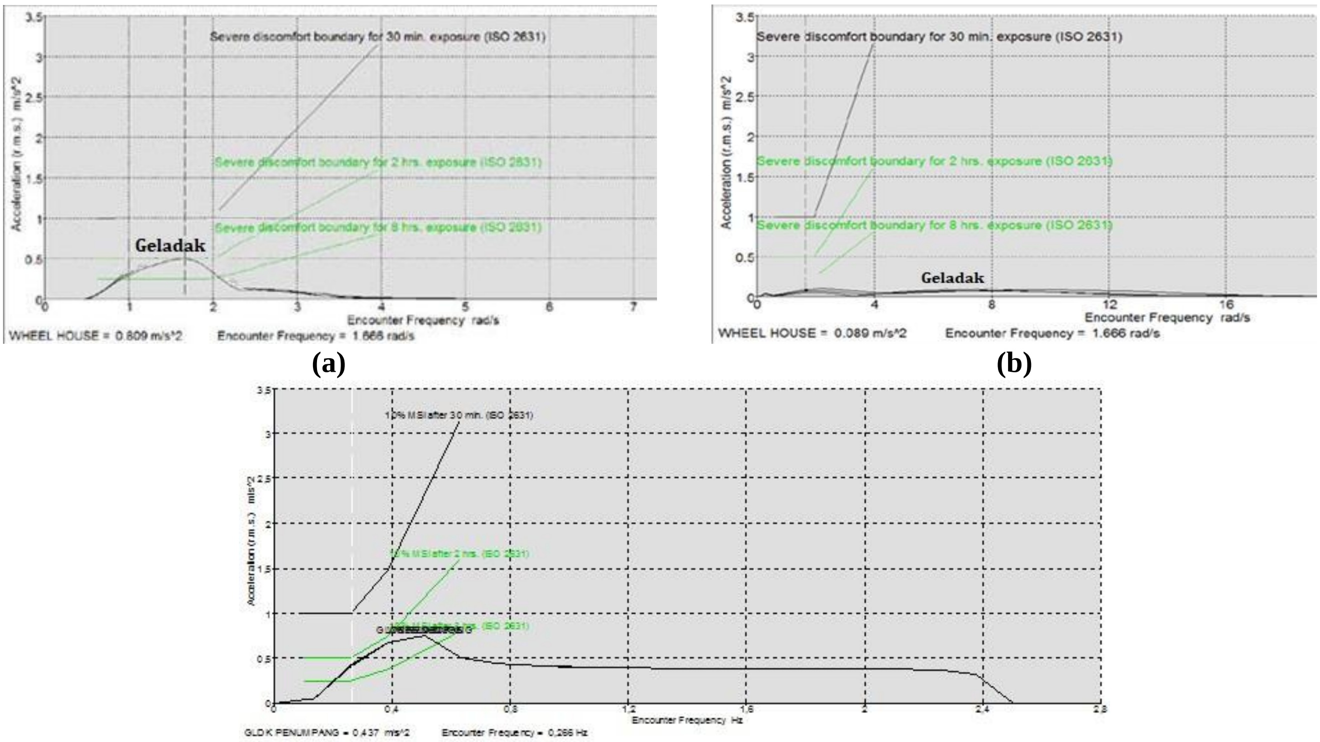


FIGURE 7: Effective Horsepower

3.2 Comfort and Safety

Ship comfort is indicated by the MSI measurement indication (Motion Sickness Index) which is determined by the remote location on the deck. Meanwhile, for the wave data and wave direction that has been calculated above.

In heading seas, MSI occurs in 10% of decks after 2 hours, on vehicle decks and decks. Where at that time the amount of encounter frequency was 1.666 Hz, and the vertical acceleration value was 0.503 m/s^2 on the crew deck. When the ship follows the waves, the ship is very stable, and it is predicted that no crew will experience seasickness. In the condition of the ship against the waves from the direction of 45 degrees, at the three measurement locations 10% of the crew will experience seasickness after 8 hours of voyage. And the highest cases are encountered frequencies of 0.508 Hz and vertical accelerations of 0.750 m/s^2.



(a) (b)

(c)

FIGURE 8: MSI ships Trimaran S/L = 0.2, (a) Heading Seas (180^0), (b) Following Seas (0^0), (c) Quartering Seas (45^0)

According to the book Ship Stability for Mates and Masters, the period of shaking can be calculated by the formula:

$$T = \frac{2\pi CB}{\sqrt{gGM}} \quad (1)$$

Where :

T = Period

C = 0.373+0.023(B/D)-0.043(LPP/100)

= 0.373+0.023(10.4/2.85)-0.043(46/100)

=0.437

B = Breadh

GM = Metacenter Point

The formula for moment of ship:

Ship Momment = Displacement x GM (2)

= 10.5 s

The shaking period for trimaran ships according to the International Maritime Organization (IMO) regulation is around 10 - 14.5 seconds, and the Trimaran IKan Ship has a shaking period of about 10.5 seconds so it still meets the IMO requirements.

IV. CONCLUSION

From the simulation results of the calculation of the Trimaran ship, several results can be concluded as follows.

1. Hull interference occurs as a visible change in speed between the flow velocity between the trimaran hull and those outside the hull.
2. The Trimaran ship has the highest vertical acceleration response when the ship is moving against the direction of the waves (heading seas), where at a ship speed of 15 knots, a wave height of 2.5 meters and an average wave period of 7.2 seconds causing vertical acceleration of 0.806 m/s^2 respectively and 0.503 m/s^2 on deck.
3. Shaking period of a trimaran is an average of 10.5 seconds, but on a trimaran that meets the IMO standard and is declared not good.

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