Defining Ship Principal Dimensions Using Comparison Method

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Abstrak

Dalam proses mencari ukuran utama kapal terdapat berbagai metode yang dapat digunakan. Dalam studi kali ini akan digunakan Metode Perbandingan (Comparison method)) untuk mendapatkan ukuran utama kapal dan didapatkan ukuran utama kapal yakni, panjang (L) = 20.152 meter, lebar (B) = 5.5 meter, tinggi (H) = 2.939 meter, sarat (T) = 1.5129 meter, kecepatan servis (Vs) = 20 knots. Tahanan kapal sebesar 152.6 kN pada kecepatan servis (Vs) = 20 knots dan dapat diatasi dengan daya sebesar 2426.31 HP. Daya yang diambil untuk memenuhi kebutuhan tersebut adalah sebesar 2600 HP yang disuplai oleh 2 mesin tempel (outboard engine) dengan daya masing-masing 1300 HP.

Kata Kunci: *Metode Pembanding, Ukuran utama, Software Maxsurf*

Abstract

In the process of finding the principal dimension of the ship there are various methods that can be used. In this study, the Comparison method will be used to obtain the main size of the ship and the main dimensions of the ship are obtained, namely, length (L) = 20,152 meters, beam (B) = 5.5 meters, depth (H) = 2,939 meters, draft (T) = 1.5129 meters, service speed (Vs) = 20 knots. The ship's resistance is 152.6 kN at service speed (Vs) = 20 knots and it can be overcome with a power of 2426.31 HP. The power taken to meet these needs is 2500 HP supplied by 2 outboard engines with a power of 1300 HP each.

Keywords*: Comparison Method, Principal Dimension, Maxsurf Software*

1. Introduction

The ship design process is an analysis process that is repeated to obtain optimal results. Therefore, to get optimal design results and as expected, it cannot be done in one trial (one time). In designing a ship several methods can be used, including the following: (1) Comparison Method, (2) Statistical Method, (3) Trial and error/Literation method, and (4) A complex solution method.

In this study, the comparison method is used to obtain the principal dimension of the ship with the help of regression analysis. This method is simple to use and does not take a long time. After that, the calculation and drawing of the line plan, the calculation of the ship's stability and resistance are carried out. Maxsurf software is used to perform these calculations

Previous research from the proceedings [1] carried out the Geosim Procedure method to determine the main size of tourism ships in the Raja Ampat Region. In addition to the principal dimension, the calculation of the line plan, stability and ship resistance is carried out by numerical studies. [2] to design a tourist boat in the tourist area of Bali from a technical and economic point of view. The ship designed is a speed boat with a speed of 19 knots. Statistical methods are used to determine the principal dimension of the ship. The use of maxsurf software to calculate ship resistance, stability and seakeeping is carried out for fast ships with variations in deadrise [3][4]. Comparing the results of the calculation of ship resistance using Maxsurf Resistance with manual calculations has been carried out with a comparison result of 0.1% [5]. Based on that research, the principal dimension of the ship was calculated using the comparison method and to calculate the line plan, ship resistance and stability using Maxsurf Software.

Lines Plan is a sectional and cross-sectional image of the ship projected onto the diametral plane, the waterline plane, and the center plane of the ship. The line plan drawing becomes the main guide or the basis for the planner to carry out a complete ship design, starting from calculating the ship's characteristics, determining the division of space on the ship, determining the loading capacity of the ship, the main motor power needed to be able to move the ship according to the desired speed, as well as calculating and checking the ship's maneuverability in its voyage.

The ship's resistance at a given speed is the fluid force acting on the ship in such a way that it opposes the motion of the ship. The resistance is equal to the component of the fluid force acting parallel to the axis of motion of the ship.

The total resistance, given the notation RT, can be broken down into several different force components that are caused by a variety of causes and interact with each other in very complex ways.

2. Method

2.1. Principal Dimensions

In the process of finding the main size of the ship according to the plan, one of the methods that can be used is to use the main size data from the comparison ship, which will then be carried out linear regression analysis to find the main size of the ship. The process of compiling and determining the main size of the ship is done by making a graph with the axis (X) as the number of passengers and the axis (Y) as the main size of the ship.

The author takes samples of fast passenger ships as many as 10 comparison ships that can represent these statistical data, namely L (Length), B (Beam), H (Depth), T (Draft), Vs (Service Speed), is a function of the number of passengers. By using linear regression, the main size of the ship can be found from the planned number of passengers.

Table 1. Comparison Vessel Data

No	Ship Name	L	B	H	T	Vs	BHP	Number of Passengers
1	Jawa Boat	17.25	5.36	2.05	0.9	28	1360	50
2	Natuna Ekspres	12.07	5.46	1.75	0.5	25	920	25
3	Gili Iyang	11.97	5.41	1.86	1.1	14	300	65
4	Trisna	15.79	6.36	2.03	1.2	17	600	73
5	Arjuna	14.3	6	2.25	1.33	25	860	95
6	Gerbang Samudra	12.8	6.2	2.73	1.4	22	620	98
7	Putri Sri Tanjung	16.6	6.5	2.28	1.35	22	620	80
8	Rajawali Nusantara	13.85	5.3	1.77	1.05	20	400	74
9	Satria Nusantara	9	3.7	0.67	0.4	25.5	200	13
10	Bahari	14.5	5.36	1.75	1.25	28	1160	55

After obtaining the principal dimensions, we can calculate the ship's loading capacity using the formula (1).

$$DWT = P_B(1 + R \times V_S^3 / 10^6) \tag{1}$$

2.2. Lines Plan

In this study, the ship model was created using the Maxsurf software. The principal dimension of the ship is obtained from 10 comparison ship data and a regression analysis is carried out between the principal dimension of the ship and the number of passengers. The selected hull shape is based on the existing hull shape in the sample design provided by the program. The ship's principal dimension that has been determined is inputted into the Surface menu, Surface Size. Figure 1 shows the main ship size input process

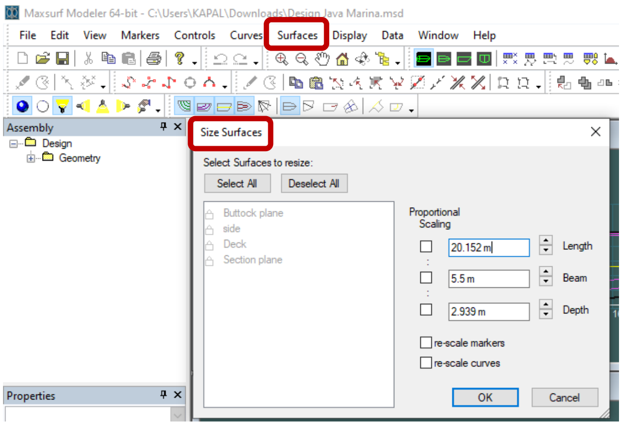

Figure 1. Input the principal dimension of the ship on the surface menu

2.3. Resistance

In this study, the calculation of ship resistance is assisted by using the Maxsurf software. The Wyman calculation method is used to calculate the ship's resistance. This choice was made because this method is suitable for speed boats with a planning hull model. In addition, the hull used is of a normal shape so that it fits the Wyman method [6].

2.4. Stability

Ship stability is calculated using maxsurf software and calculated for several conditions (load case), namely: (1) Empty State, (2) Load 100% Consumable 90%, and (3) Load 0% Consumable 90%. Stability criteria used are IMO criteria for all types of ships [7].

Table 2. Empty State

No	Item Name	Quantity	Unit Mass [tone]	Total Mass [tone]	Unit Volume [m^3]	Total Volume [m^3]	Long. Arm [m]	Trans. Arm [m]	Vert. Arm
1	Lightship	1	81.242	81.242			8.753	0	1.774
2	Passenger	0	0	0			8.753	0	1.774
3	Fuel	0%	8	0	8.471	0	13.3	0	1
4	Total Load case			81.242	8.471	0	8.753	0	1.774
5	FS correction								0
6	VCG fluid								1.774

Table 3. Load 100% Consumable 90%

No	Item Name	Quantity	Unit Mass [tone]	Total Mass [tone]	Unit Volume [m^3]	Total Volume [m^3]	Long. Arm [m]	Trans. Arm [m]	Vert. Arm
1	Lightship	1	81.242	81.242			8.753	0	1.774
2	Passenger	100	0.07	7			8.753	0	1.774

No	Item Name	Quantity	Unit Mass [tone]	Total Mass [tone]	Unit Volume [m^3]	Total Volume [m^3]	Long. Arm [m]	Trans. Arm [m]	Vert. Arm
3	Fuel	90%	8	7.2	8.471	7.624	13.3	0	1
4	Total Load case			95.442	8.471	7.624	8.753	0	1.774
5	FS correction								0.041
6	VCG fluid								1.798

Table 4. Load 0% Consumable 90%

No	Item Name	Quantity	Unit Mass [tone]	Total Mass [tone]	Unit Volume [m^3]	Total Volume [m^3]	Long. Arm [m]	Trans. Arm [m]	Vert. Arm
1	Lightship	1	81.242	81.242			8.753	0	1.774
2	Passenger	0	0.07	0			8.753	0	1.774
3	Fuel	90%	8	7.2	8.471	7.624	13.3	0	1.55
4	Total Load case			88.442	8.471	7.624	9.123	0	1.756
5	FS correction								0.044
6	VCG fluid								1.8

3. Results and Discussion

From the graph in Figure 2, the author gets the formula for the equation of the line, namely $y = 0.0431x + 11.134$, with $R^2 = 0.2329$. The value of R^2 is used to predict how much influence the independent variable (x) has in this case the number of passengers on the dependent variable (y) in this case the length of the ship. This R^2 value shows a less strong relationship between the x and y variables because the value of 0.2329 is closer to 0. The writer replaces the variable x with the planned number of passengers.

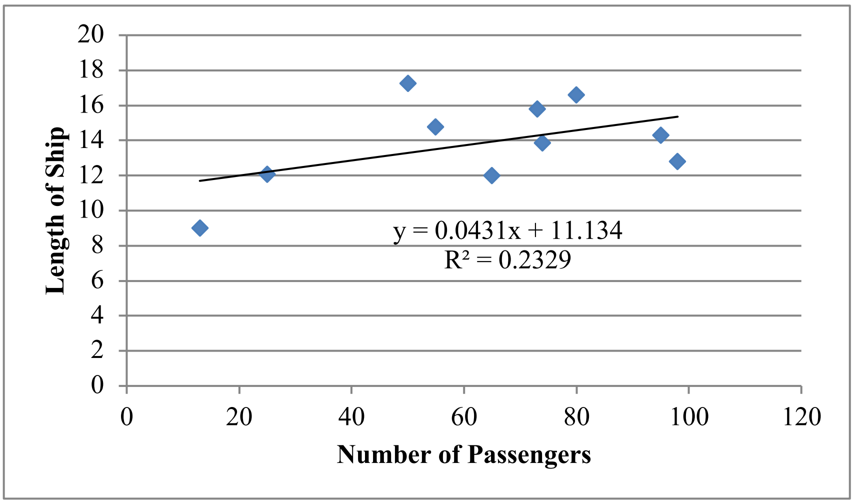

Figure 2. Graph of the relationship between the number of passengers and the length of the ship (L)

From the graph in Figure 3, the author gets the formula for the equation of the line, namely $y = 0.0228x + 4.1324$, with $R^2 = 0.6263$. This R^2 value shows a strong relationship between the x and y variables because the value is closer to 1. The writer replaces the variable x with the planned number of passengers.

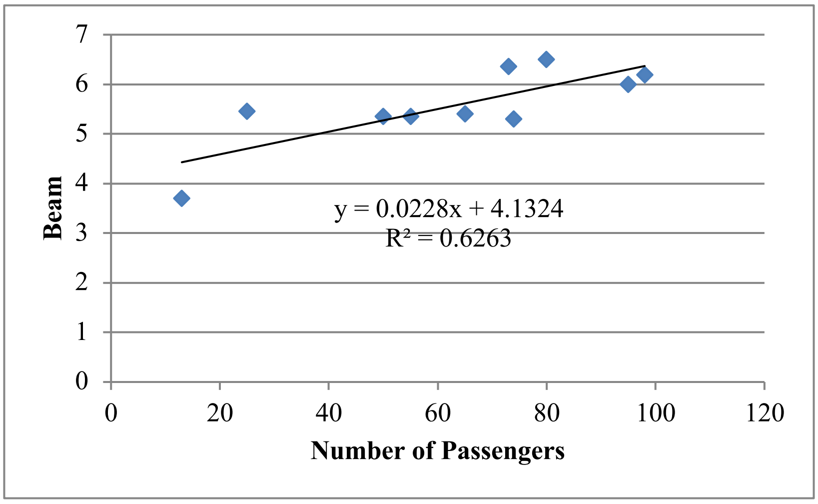

Figure 3. Graph of the relationship between the number of passengers and the beam of the ship (B)

From the graph in Figure 4, the author gets the formula for the equation of the line, namely y = 0.0163x + 0.8916, with R^2 = 0.7158. This R^2 value shows a strong relationship between the x and y variables because the value is closer to 1. The writer replaces the variable x with the planned number of passengers.

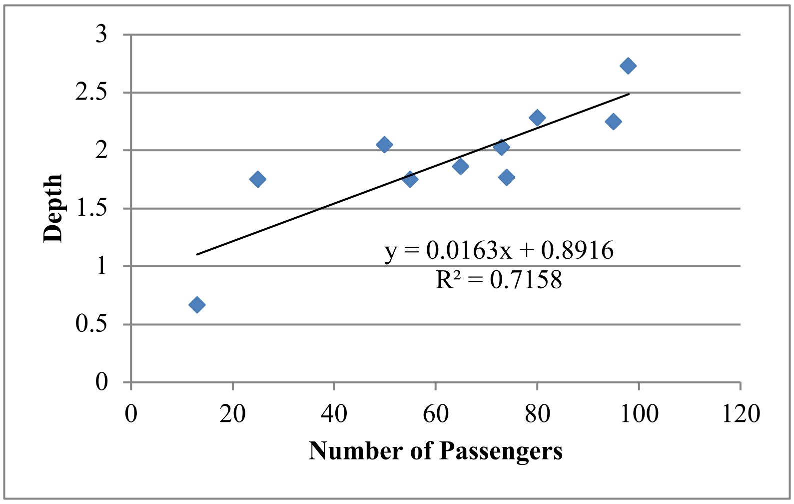

Figure 4. Graph of the relationship between the number of passengers and the depth of the ship (H)

From the graph in Figure 5, the author gets the formula for the equation of the line, namely y = 0.0118x + 0.3091, with R^2 = 0.8708. This R^2 value shows a strong relationship between the x and y variables because the value is closer to 1. The writer replaces the variable x with the planned number of passengers.

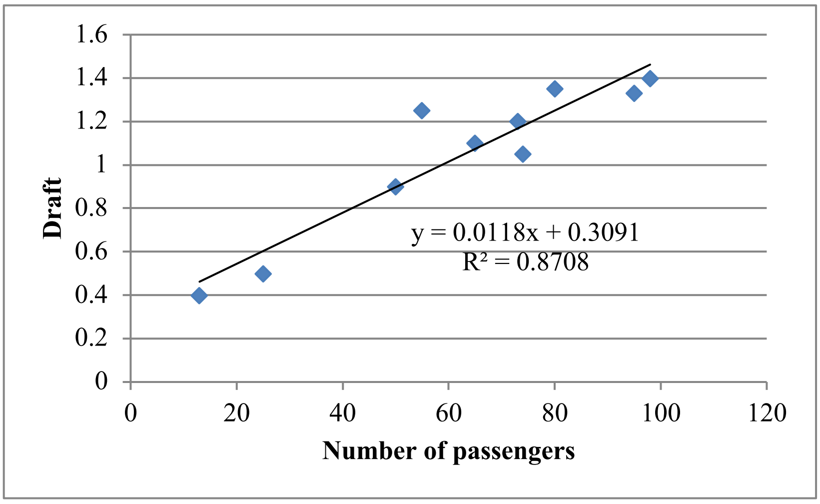

Figure 5. The graph of the relationship between the number of passengers and the ship's draft (T)

From the graph in Figure 6, the author gets the formula for the equation of the line, namely y = -0.0585x + 26,321, with $R^2 = 0.1242$. This R^2 value shows a less strong relationship between the x and y variables because the value of 0.1242 is closer to 0. The writer replaces the variable x with the planned number of passengers.

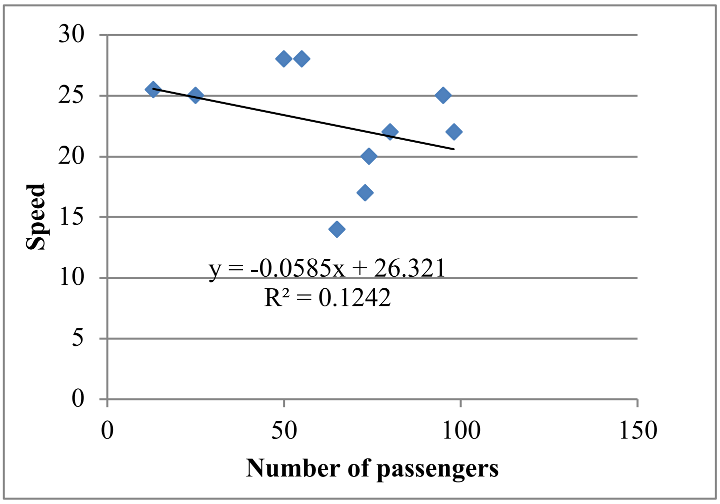

Figure 6. Graph of the relationship between the number of passengers and the service speed of the ship (Vs)

From the linear regression calculation above, it is obtained that the main size of the fast passenger ship planned in Table 5.

Tabel 5. Principal Dimensions

No	Item	Value	Units
1	Ship Name	Java Marine Pratama	
2	Length (L)	20.152	M
3	Breadth (B)	5.5	M
4	Height (H)	2.939	M
5	Draft (T)	1.513	M
6	Velocity of Service (Vs)	20	Knots
		10.288	m/s

3.1. Lines Plan

The ship model was created using Maxsurf software. The resulting ship hull model is as followson Figure 7, Figure 8 and Figure 9.

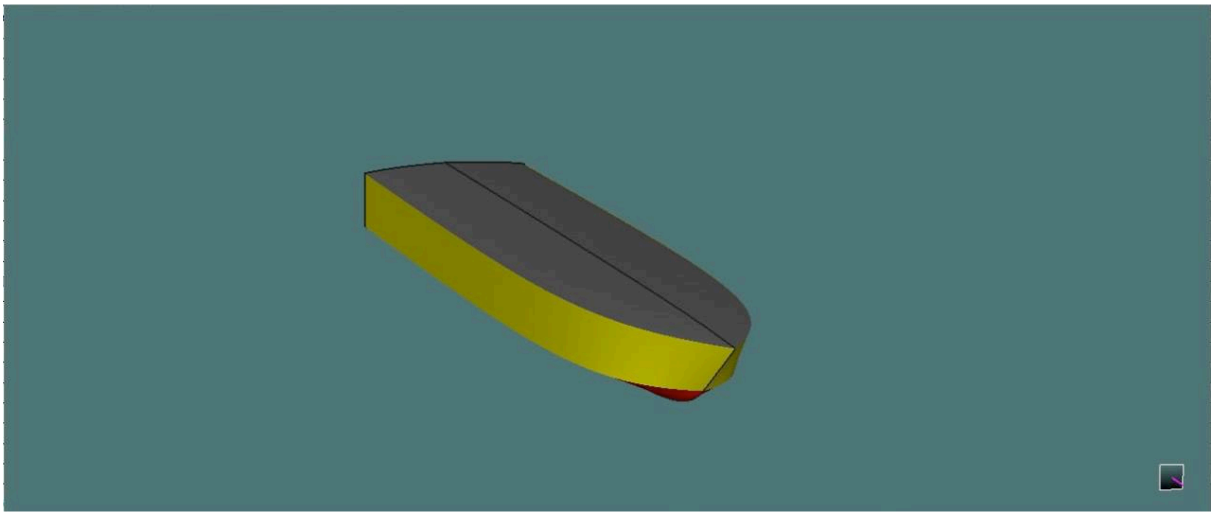

Figure 7. Perspective View of Hull Model

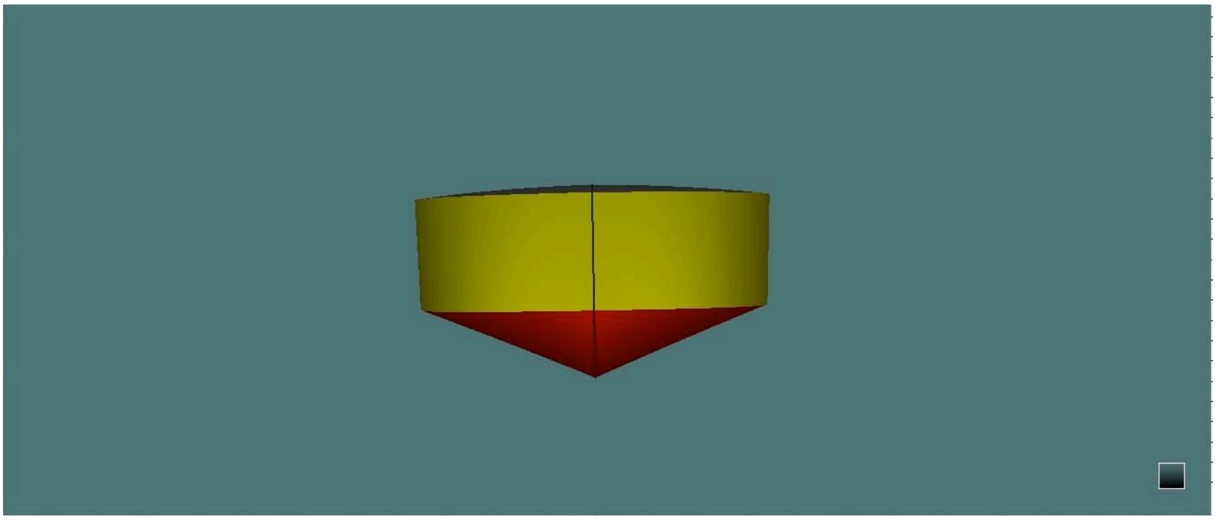

Figure 8. Body View of Hull Model

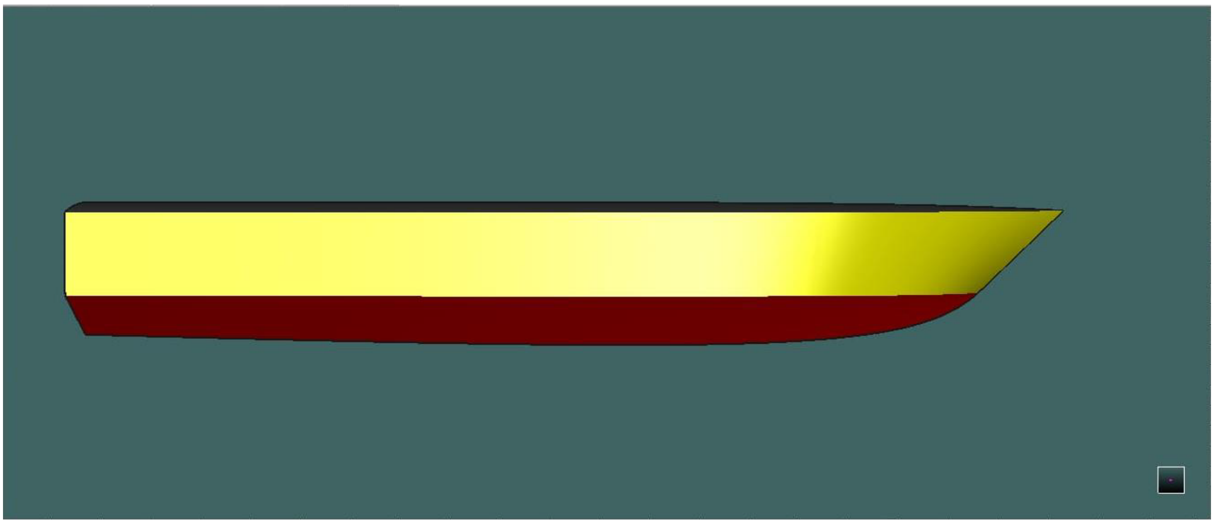

Figure 9. Profile View of Hull Model

3.2. Stability

The calculation results can be seen Table 6 and Figure 10 for below.

Table 6. Stability Calculation Results Criteria for Empty State

No	Criteria	Status
1	Area 0° to 30°	Pass
2	Area 0° to 30°	Pass
3	Area 0° to 30°	Pass
4	Max GZ at 30 or greater	Pass
5	Angle of Maximum GZ	Pass
6	Initial GMt	Pass

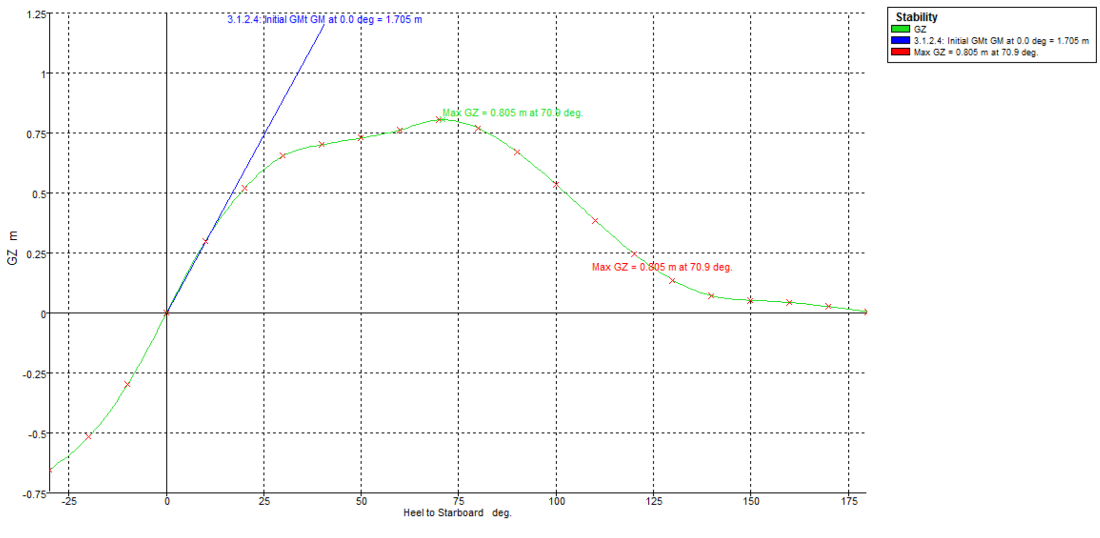

Figure 10. Graph of Stability Calculation Results for Empty State

Table 7. Stability Calculation Results Criteria for Load 100% Consumable 90%

No	Criteria	Status
1	Area 0° to 30°	Pass
2	Area 0° to 30°	Pass
3	Area 0° to 30°	Pass
4	Max GZ at 30 or greater	Pass
5	Angle of Maximum GZ	Pass
6	Initial GMt	Pass

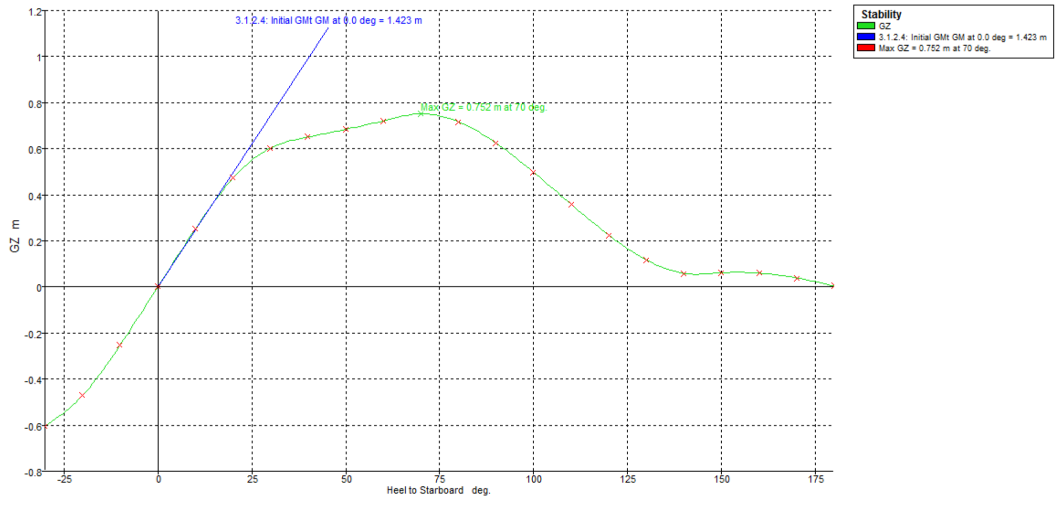

Figure 11. Graph of Stability Calculation Results for Load 100% Consumable 90%

Table 8. Stability Calculation Results Criteria for Load 0% Consumable 90%

No	Criteria	Status
1	Area 0° to 30°	Pass
2	Area 0° to 30°	Pass
3	Area 0° to 30°	Pass
4	Max GZ at 30 or greater	Pass
5	Angle of Maximum GZ	Pass
6	Initial GMt	Pass

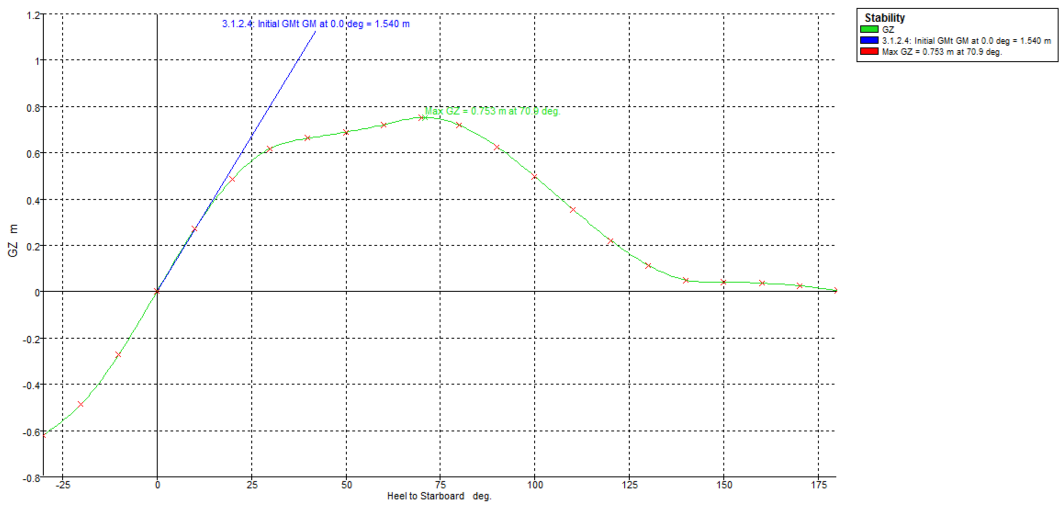

Figure 12. Graph of Stability Calculation Results for Load 0% Consumable 90%

Based on the calculation of stability with the three shipping conditions above, it is concluded that all stability criteria have been met according to IMO. So it can be concluded that the selection of this basic size is correct in terms of ship stability.

3.3. Resistance

The calculation of resistance and engine power is obtained from ship model simulation using the maxsurf model with a test speed of 20 knots, the method used is Wyman and the efficiency is 90% [8]. Table 9 is simulation results.

Table 9. The results of the calculation of Resistance with Maxsurf

No	Speed [knots]	Froude No. LWL	Wyman Resist. [kN]	Wyman Power [HP]
1	0	0	0	0
2	1	0.038	0.5	0.407
3	2	0.076	2.1	3.256
4	3	0.113	4.8	10.988
5	4	0.151	8.5	26.045
6	5	0.189	13.3	50.868
7	6	0.227	19.1	87.9
8	7	0.265	26	139.582
9	8	0.303	34	208.356
10	9	0.34	43	296.663
11	10	0.378	53.1	406.946
12	11	0.416	64.2	541.645
13	12	0.454	76.4	703.202
14	13	0.492	89.7	894.059
15	14	0.529	104.1	1116.659
16	15	0.567	119.5	1373.441
17	16	0.605	133.3	1635.405
18	17	0.643	140.2	1826.915
19	18	0.681	146.6	2023.07
20	19	0.719	152.6	2223.101
21	20	0.756	158.3	2426.31

Based on the simulation results at Maxsurf, with a service speed of 20 knots, the required power is 2426.31 HP. The power taken to meet these needs is 2600 HP supplied by 2 outboard engines with a power of 1300 HP each and a weight of 970 Kg each (2 x 970 = 1940 Kg).

4. Conclusion

The main dimensions of the ship are obtained, namely, length (L) = 20,152 meters, width (B) = 5.5 meters, height (H) = 2,939 meters, draft (T) = 1,5129 meters, service speed (Vs) = 20 knots. The ship's resistance is 152.6 kN at service speed (Vs) = 20 knots. It can be overcome with a power of 2426.31 HP. The power taken to meet these needs is 2600 HP supplied by 2 outboard engines with a power of 1300 HP each.

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