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Purse Seine Vessel Design under 100 GT Based on the Characteristics of South Sulawesi Waters in Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The waters of the Makassar Strait of South Sulawesi, where various Purse Seine vessels operate, have characteristics of very high biodiversity, the strength of very strong ocean currents, and the temperature and cultural characteristics of Bugisness and Makassar fishermen. It is necessary to design a purse seine ship that perfectly matches the designs of traditional ships operating in South Sulawesi waters so far. This research aims to create a purse seine vessel design under 100GT with International Maritime Organization standards that match the characteristics of the Makassar Strait. The Design Implementation Method is carried out by considering the length, width, height, shape of the ship's body, the volume of loading space, and construction weight by analyzing the main dimension ratio, hydrostatic parameter analysis and purse seine ship stability analysis. The design results were carried out using a length of 24 meters, width of 4.4 meters, and height of 1.9 meters. The shape of the purse seine vessel body is V-bottom shape, and the middle part towards the stern is U-V flat bottom. The tamping capacity of the first, Second and Third loading room size Volume is

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29.48, 26.87 and 15.98 tons, respectively, and The Stowage factor fish is 0.5 tons/m. Ship stability or KG value to three conditions, namely the state of the ship heading to the fishing ground has a KG/VCG fluid value of 1.25 m, this value meets the IMO recommended standards, the second condition is the ship conducting fishing operations, the KG/VCG fluid value in the second condition is 1.22, and the third condition is the condition of the ship heading back to the fishing base, the KG/VCG value of 1.25 meters. The VCG/KG value of the three conditions has met the minimum value issued by IMO. The shape of the ship's body at the bow forms a "V-bottom" model, and at midship to stern has two forms of the ship's body, namely, a Round bottom and U-V flat bottom following the characteristics of South Sulawesi Waters.

Keywords: Purse seine; vessel design; vessel stability; VCG Fluid; South Sulawesi.

1. INTRODUCTION

Makassar Strait is a waterway in South Sulawesi located between Sulawesi Island and Kalimantan Island, which is famous for its natural wealth and special characteristics. The waters of the Makassar Strait have high biodiversity. More than 1,000 species of fish are found in this area, including sharks, rays, tuna and snapper. In addition, this area is also home to various species of marine mammals, such as dolphins, whales, and dugongs [1].

South Sulawesi waters in the Makassar Strait have very strong "ocean currents", especially around the Makassar Strait and the Sulawesi Sea. These currents are caused by temperature and pressure differences in the region and can reach speeds of up to 3-4 knots. The water temperature in the Makassar Strait is relatively warm, with an average temperature of around 28-30°C throughout the year. This warm water temperature is an important factor in maintaining biodiversity in the area. In addition to rich biodiversity, the waters of South Sulawesi also have unique cultural diversity. Various ethnic groups, such as Bugis, Makassar and Banjar, with different customs and cultures, inhabit the area.

Statistical data states that the value of South Sulawesi fisheries production reached around 5.63 trillion rupiahs or around 6.12% of the total national fisheries production. So, it can be concluded that fisheries play an important role in South Sulawesi's economy. South Sulawesi has marine waters with a coastal length of about 2,500 km and the potential for large capture fisheries resources with the potential for various types of fish with high economic value. The potential of South Sulawesi fisheries for a fishing area 12 miles from the coast is 620,480 tons/year and 80,072 tons/year for the exclusive economic zone (EEZ), a fishing area 12-200 miles from the coast. This marine fisheries potential has only been utilized by about 56%, namely 14,468 tons annually [2]. Potential Capture Fisheries in South Sulawesi are fish species: Skipjack and Tuna: 30,989 tons, Shrimp: 3,139 tons, Tuna: 9,969 tons, Seaweed: 1,490 tons, and other Marine Fisheries: 201,586 tons [2] Based on these data, the utilization of capture fisheries resources in South Sulawesi waters is still small, this may be due to the provision of fishing vessels is still small.

Purse seine vessels are one type of fishing vessel South Sulawesi fishermen use. In general, the model and shape of purse seine vessels in Indonesia are almost the same, with only the difference in the hull model, this is related to the characteristics of the waters that will be used as fishing grounds, and shipbuilders can influence the ship model because the shipbuilding is without prior design. Purse seine shipbuilding in South Sulawesi is still very simple in that shipbuilding is without design. Purse seine shipbuilding is generally carried out in people's shipyards with the shipbuilding process carried out by hereditary habits without any shipbuilding calculations so that the resulting ship is not guaranteed safety because the resulting ship has not been thoroughly tested for stability before the ship is declared seaworthy, besides that there are several weaknesses possessed by purse seine vessels made in people's shipyards, namely the problem of hull shapes that are not smooth, prone to leaks, improper specifications of driving machines, and binding techniques for each weak construction joint. As a result of some of these weaknesses, fishermen are more wasteful in operating their vessels, and insurance does not want to accept these vessels, so the guarantee of fishermen's sustainability is very low [3].

Fishing boats have characteristics/features that can distinguish them from other ships according to [4], namely ship speed. The speed required by the fishing boat is adjusted to the fishing needs. Manoeuvrability (manoeuvre ability) Special movements carried out properly during operation, such as good steerability, turning circle radius, and propulsion (propulsive engine), can easily move forward and backwards. Seaworthiness (Seaworthiness) Seaworthiness is used in fishing operations and is sufficiently resistant to resist wind and wave forces, high stability and sufficient buoyancy are needed to ensure safety in shipping. The scope of the fish voyage area is determined by the movement of fish groups, regions, fish seasons, and migrations. Construction must be strong because fishing operations will face changing natural conditions, and ship construction must withstand the load of engine vibrations that arise, then the driving engine. The fishing boat requires a large enough driving engine power, while the engine volume is not too large with small vibrations and Fish storage and processing facilities. Generally, fish ships are equipped with facilities such as a cool room, freezing room, and processing machine. In addition, the volume and capacity of fishing equipment must be considered. To design a purse seine vessel must meet common needs such as Vessels are designed using efficient labour following the fishing operation system, Purse seine vessels are designed for fishing in bad weather as well as calm day and night, Vessels are designed with safety in mind for fishermen who make the catch, Setting and hauling can be done in a short time and with attention to fishing gear breaks, Purse seine vessels must be effective in day and night operations [4].

The main dimensions of the ship according to standard [5] consist of, The length of the ship (Length/L) consists of Total length or LOA (Length Over All) is the horizontal distance of the ship measured from the top point of the bow height to the trailing point of the stern. This total length is the largest length of a ship and is measured parallel to the ship's keel; Distance along the vertical line or LPP / LBP (Length Perpendicular / Length Between Perpendicular) is the horizontal distance calculated from the vertical bow line to the stern, upright line. What is meant by the perpendicular line (Fore Perpendicular) is an imaginary line that lies perpendicular to the intersection between Lwl and the ship's body at the bow. Meanwhile, what is meant by the stern vertical line (After Perpendicular) is an imaginary line located on the stern of the ship's body or behind the steering shaft (for ships that have a steering shaft) (Fig. 1).

The length of the water line or LWL (Length of Water Line) is the horizontal distance on the ship calculated from the point of intersection between the water line (water line) with the bow height to the point of intersection between the water line and the stern height The width of the ship (Breadth / B) is generally divided into 2 types, namely the largest width or Bmax (Breadth maximum), the horizontal distance at the largest width of the ship, calculated from one of the outer sides (sheer) one to the other side (sheer) opposite (Fig. 1).

The success of the fishing business is largely determined by the technical feasibility of the vessel used as one of the most important ship factors of the fishing unit component, therefore proper ship planning is a ship that can provide comfort and safety with both during the voyage and the fishing process takes place is the most important step in the purse seine fishing business. Based on the output plan that will be produced, it is very important to research planning to manufacture purse seine vessels following IMO standards because until now, research on purse seine design of 100 GT scale down has not been found. The research will present a Purse seine vessel design adapted to the shipping area, fishing gear, and the habits of fishermen when operating fishing gear and can provide increased efficiency and effectiveness in purse seine shipbuilding and fishing gear operation in South Sulawesi waters.

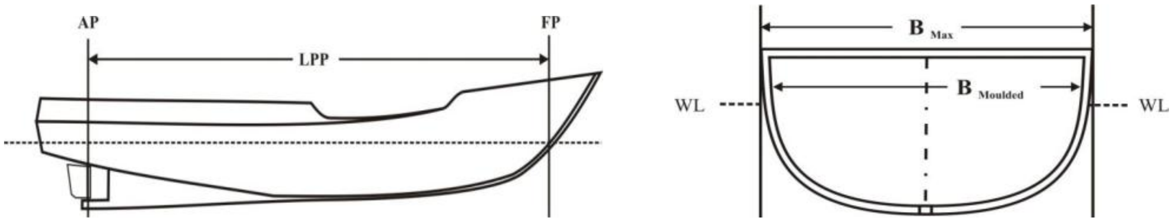

Fig. 1. Length Perpendicular (LPP) (left) and Ship Breadth (B) (right)

2. MATERIALS AND METHODS

This research was conducted for 2 years at the Navigation Workshop of the Maritime Technology Department of the Pangkep State Polytechnic of Agriculture and the Shipping Workshop of Hasanudin University Makassar, South Sulawesi. Utilizing purse seine vessels undergoing repairs at the Makassar shipyard, the research began by analyzing the main dimensions, hydrostatic parameters, and stability of purse seine vessels. The approach used in the research is the approach to the characteristics of the Makassar Strait waters, the approach to fishing gear and fishing aids, and the habits of fishermen in the operation of fishing gear. The second phase is made laboratory-scale purse seine shipbuilding. The shipbuilding is based on the ship design made in the first year of research through software. The purpose of laboratory-scale shipbuilding is to test the ship's stability based on the waters' characteristics and fishing gear. The first step is to measure the main dimensions of the purse seine vessel used as a sample. The results of these measurements are processed and analyzed to determine whether the ship's main dimensions and hydrostatic parameters follow the International Maritime Organization (IMO) standard [5]. The second step is if the main dimensions of the ship do not comply with the IMO standard, then the purse seine ship redesign is carried out in Maxsurf software which is adjusted to the IMO standard and takes into account the characteristics of the waters and fishing gear and their aids, propulsion engines and ship stability.

3. RESULTS AND DISCUSSION

3.1 Main Size of Purse Seine Vessel and Main Dimension Ratio of Vessel

The main size of purse seine vessels in South Sulawesi and operating in South Sulawesi waters are generally dimensioned as in Table 1. Test results of stability, ship resistance, and engine power to be used on purse seine vessels measuring 25 meters in length, so that of the 10 samples selected, 1 sample will be used as a role model for purse seine vessels in South Sulawesi waters. The sample ship used as a role model is KMN-Minasate'ne.

The purse seine vessels in Table 1, built-in community shipyards, may not be built with as strong and high-quality materials as large shipyards. This may cause the vessels to be less resistant to adverse weather conditions and subject to faster wear. Design and construction may not be designed and constructed with the same precision as vessels built in large shipyards. This may result in vessels not performing optimally and experiencing structural problems [6].

3.2 Ship Stability, Endurance, and Design Strength Tests

3.2.1 Lines plane kapal purse seine

Kmn-minasete'ne ship is a purse seine ship operating in south Sulawesi waters. The ship operates for 6-10 days per trip, so a model suitable for its designation is needed, while the model is depicted in the kmn line plan. minasete'ne, the line plans are from the results of the model redesign to get a stability value that follows the standards used. The results of redesigning the lines plans of the kmn minasatene ship can be seen in Fig. 2.

Based on the line plan, it can be concluded that, in general, purse seine in south Sulawesi has a v-bottom body shape at the bow. The midship to stern section has a ship's body shape: round bottom and u-v flat bottom. This follows the characteristics of purse seine vessels, which must have very high speed and very good stableness so that the v-bottom body shape of the midship to stern section has a ship's body shape, namely uv flat bottom, which matches the characteristics of purse seine vessels. The shipbuilding design in Fig. 3 consists of midship images, profile construction, bulkheads, the general arrangement of purse seine vessels, and the purse seine vessel redesign profile in Fig. 4.

General Arrangement is an image of a ship. The general arrangement is made to make it easier to see and know the layout of each room on the ship. To optimize the operation of 30 GT fishing boats in Sulawesi waters, the ships produced must be adapted to local designs without ignoring the necessary design standards. The required design standards are: line plan drawings, hydrostatic and stability calculations, power calculation engine calculations and appropriate space arrangements [4] Commonly used designs of traditional fishing boats in the south Sulawesi region such as in Barru regency South Sulawesi province in Indonesia [7]. To improve design optimization according to water characteristics, it is important to select the appropriate power profile and environmental conditions in design testing [8].

Table 1. Main size data of purse seine vessels operating in South Sulawesi waters

No	Nama Kapal	L (m)	B (m)	H (m)	T (m)	L/B	B/H	T/B	T/H	L/H
1	KMS. Matoanging	22.70	4.76	1.70	1.22	4.77	2.80	0.26	0.72	13.35
2	KM. Ical 02	23.59	5.15	1.50	1.13	4.58	3.43	0.22	0.75	15.73
3	KM. Bintang Timur	15.60	3.62	1.44	1.04	4.31	2.51	0.29	0.72	10.83
4	KM. Harapan Baru	16.12	4.24	1.23	0.90	3.80	3.45	0.21	0.73	13.11
5	KMS. Garuda Jaya	17.42	4.17	1.19	0.86	4.18	3.50	0.21	0.72	14.64
6	KMN. Minasate'ne	24,00	4,4	1.9	1.25	5.45	2.31	0.28	0.66	15.87
7	KMN. Samudra	18.50	3.95	1.30	0.75	4.68	3.04	0.19	0.58	14.23
8	KM. Arta Jaya	17.86	4.10	1.45	1.20	4.36	2.83	0.29	0.83	12.32
9	KM. Jaya Laut	16.70	4.55	1.50	1.35	3.67	3.03	0.30	0.90	11.13
10	KM. Rosa Wijaya	15.95	3.80	1.05	1.05	4.20	3.62	0.28	1.00	15.19

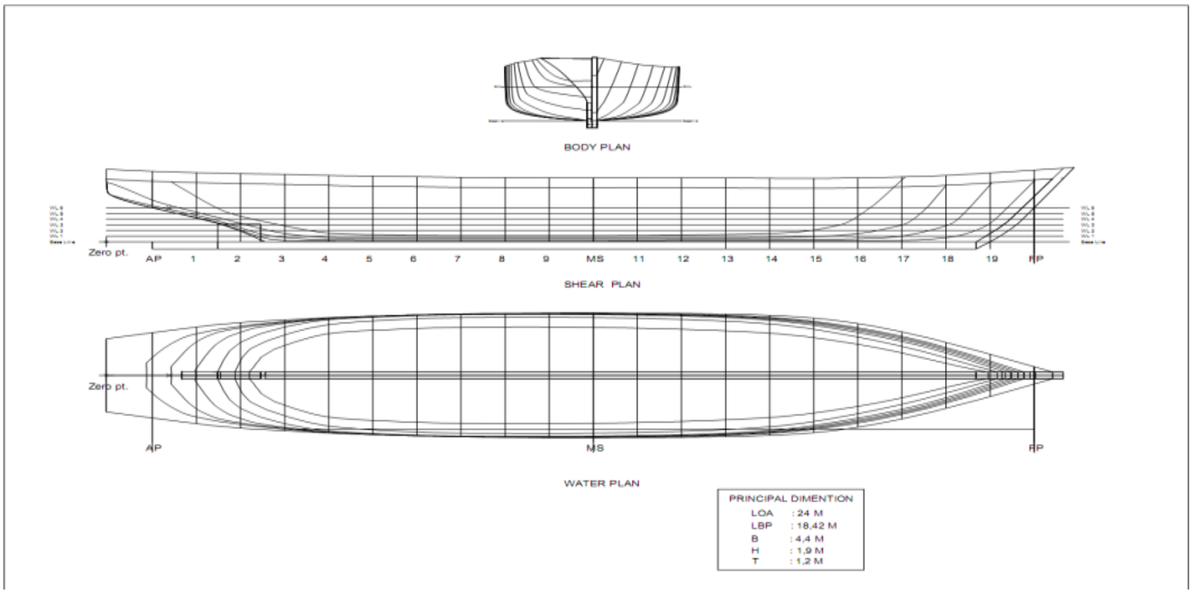

Fig. 2. The redesign of the lines plans of the kmn-minasatene

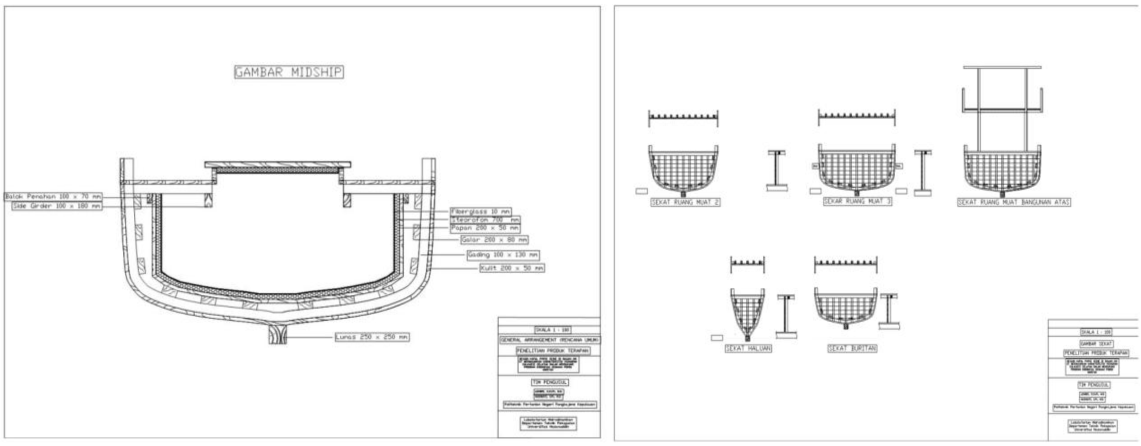

Fig. 3. Mindship (midship to stern) and ship bulkheads

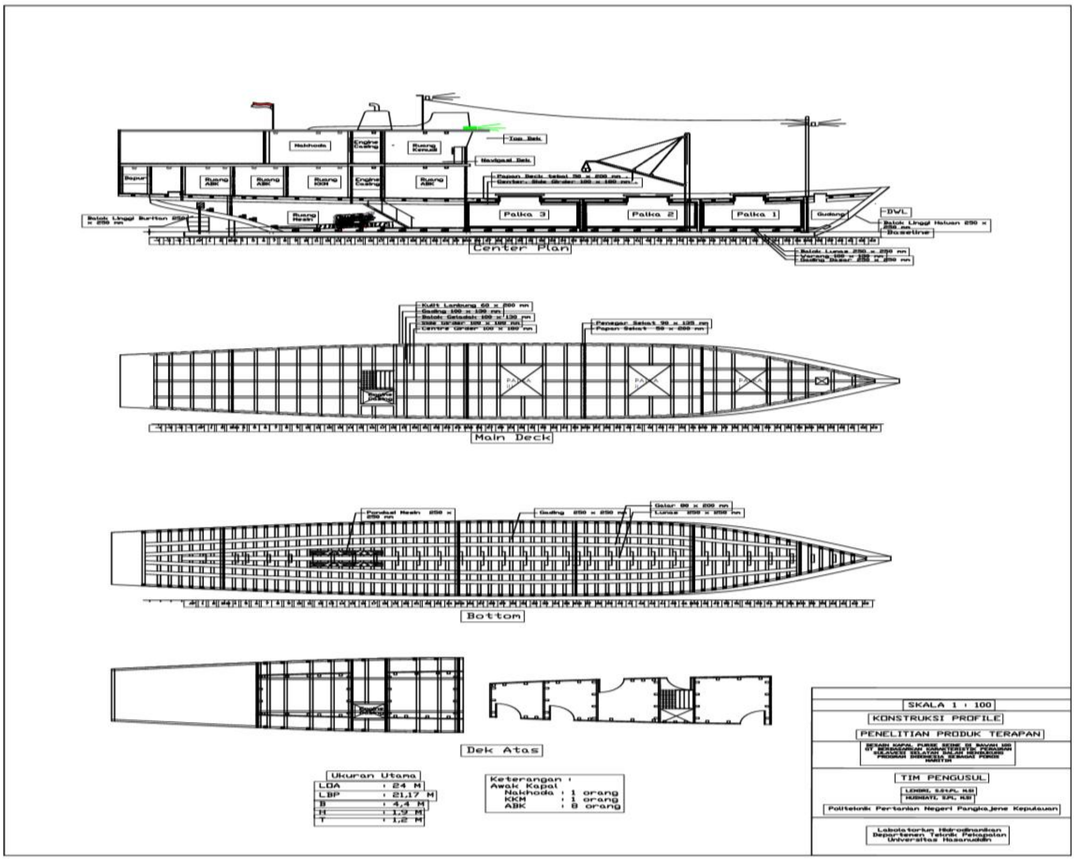

Fig. 4. Purse seine vessel redesign profile

Table 2. Calculation of ship stability value when heading to the fishing ground

No	Item Name	Quantity	Unit Mass Tonne	Total mass tonne	Vert.Arm tonne.m
1	Construction Wight	1	27.7	27.7	1.726
2	Line Holler	1	0.05	0.05	1.9
3	Winch Pure	1	0.09	0.09	1.9
4	Crane Purse (Power Block)	1	1.1	1.1	1.95
5	Anchor	1	0.086	0.086	1.3
6	Riggings	1	0.015	0.015	0.5
7	Main Machine	1	0.329	0.329	0.75
8	Generator	1	0.25	0.25	0.6
9	Fuel Pump	1	0.04	0.04	0.63
10	Engine Cooling Pump	1	0.04	0.04	0.67
11	Propeller Shaft	1	0.08	0.08	0.24
12	Propeller	1	0.09	0.09	0.78
13	Gear Box	1	0.04	0.04	0.63
14	Steering Sistem	1	0.1	0.1	0.68
15	Nets	1	2	2	0.87
16	Fuel 100%	1	1.5	1.5	0.77
17	Fresh Water 100%	1	1	1	0.72
18	Ship Crew & Debriefing	1	0.85	0.85	1.8
19	Ice Cube	1	19.761	19.761	0.65
Total Loadcase				55.121	1.251
VCG fluid					1.251

Table 3. Calculation of KG value under the condition that the ship is in fishing operation

No	Item Name	Quantity	Unit Mass	Total mass	Vert.Arm
			Tonne	**tonne**	**tonne.m**
1	Construction Weight	1	27.7	27.7	1.726
2	Line Holler	1	0.05	0.05	1.9
3	Winch Pure	1	0.09	0.09	1.9
4	Crane Purse (Power Blok)	1	1.1	1.1	1.95
5	Anchorar	1	0.086	0.086	1.3
6	Riggings	1	0.015	0.015	0.5
7	Main Machine	1	0.329	0.329	0.75
8	Genset	1	0.25	0.25	0.6
9	Generator	1	0.04	0.04	0.63
10	Fuel Pump	1	0.04	0.04	0.67
11	Engine Cooling Pump	1	0.08	0.08	0.24
12	Propeller Shaft	1	0.09	0.09	0.78
13	Propeller	1	0.04	0.04	0.63
14	Steering Sistem	1	0.1	0.1	0.68
15	Nets	1	2	2	0.87
16	Fuel 70%	1	1.05	1.05	0.54
17	Fresh Water 70 %	1	0.7	0.7	0.56
18	Ship Crew & Debriefing 70%	1	0.8	0.8	1.8
19	Fish 50% + Ice 90%	1	27.66	27.66	0.75
	Total Loadcase			62.22	1.219
VCG fluid					1.219

Table 4. Calculation of KG value in the condition of the ship heading back to the fishing base

No	Item Name	Quantity	Unit Mass	Total mass	Vert.Arm
			Tonne	**tonne**	**tonne.m**
1	Construction Weight	1	27.7	27.7	1.726
2	Line Holler	1	0.05	0.05	1.9
3	Winch Pure	1	0.09	0.09	1.9
4	Crane Purse (Power Blok)	1	1.1	1.1	1.95
5	Anchorar	1	0.086	0.086	1.3
6	Riggings	1	0.015	0.015	0.5
7	Main Machine	1	0.329	0.329	0.75
8	Genset	1	0.25	0.25	0.6
9	Generator	1	0.04	0.04	0.63
10	Fuel Pump	1	0.04	0.04	0.67
11	Engine Cooling Pump	1	0.08	0.08	0.24
12	Propeller Shaft	1	0.09	0.09	0.78
13	Propeller	1	0.04	0.04	0.63
14	Steering Sistem	1	0.1	0.1	0.68
15	Nets	1	2	2	0.87
16	Fuel 45%	1	0.65	0.65	0.34
17	Fresh Water 30 %	1	0.3	0.3	0.25
18	Ship Crew & Debriefing 70%	1	0.8	0.8	1.8
19	Fish 100% + Ice 50%	1	29.642	29.642	0.83
Total Loadcase				63.402	1,247
VCG fluid					1,247

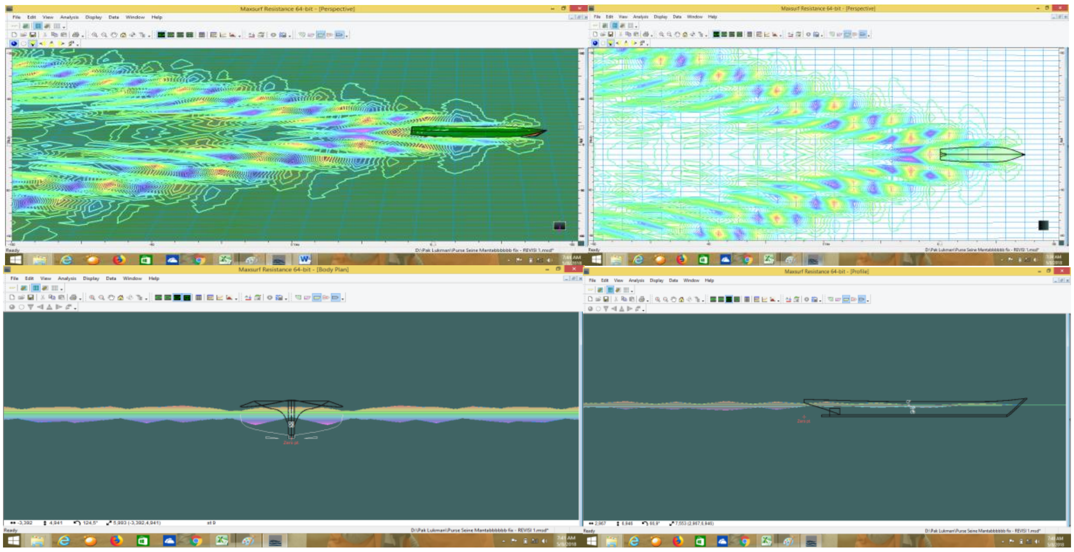

Fig. 5. 3-dimensional view (top-left) and top view (top-right) Front view (bottom-left) and Side view (bottom-right)

3.2.2 Stability test

Based on the line plan above, the stability test is carried out as a ship stability testing program to measure the purse seine ship stability value. In this study, 3 conditions are calculated for stability: stability when heading to the fishing ground, when operating on the fishing ground, and when returning to the fishing base [9].

The condition of the ship heading to the fishing ground, fuel, fresh water, crew supplies, and ice is still 100%, with a fluid VCG value of 1.25 (Table 2), and The condition of the vessel when conducting fishing operations at the fishing ground includes 70% fuel, 70% crew equipment, 50% fish load and 90% ice loading. The second condition has a VCG fluid value of 1.22 (Table 3).

Vessel condition heading to fishing base, fuel condition 45%, fresh water 30%, fish cargo 100%, ice 50%. In the third condition, the fluid VCG value is 1.25 (Table 4).

3.2.3 Wave profile analysis

A ship's wave profile refers to the characteristics of the waves generated by a ship as it moves over the water's surface. A ship's wave profile can be influenced by various factors, such as ship speed, size and shape, and water surface conditions [10]. the results of the analysis of the wave profile that occurred at a speed of 10 knots (the maximum speed of a purse seine vessel measuring 30-50 GT is 10 knots) so that engine power of 256.559 hp is obtained, not much different from the speed measurement results obtained in the study [11,12]. the wave profile shows good wave stability from the appearance of the wave profile (Fig. 5), a picture that shows stability on the trip.

4. CONCLUSION

The design results show that the shape of the ship's body at the bow forms the letter/model "V-bottom", and at midship to stern has a ship's body, namely, U-V flat bottom. KG/VCG values in all three conditions Heading to the fishing ground, conducting fishing operations, and conditions returning to the fishing base have KG/VCG following IMO standards, and the maximum speed of purse seine vessels measuring 30-50 GT is 10 knots. So the Engine Power of 256,559 HP is obtained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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