

Design of Multi-Purpose Waste Management Ship for Indonesian Waters (Case Study: Barito River)

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Abstract

The number of activities from human activities not infrequently make material in the form of residues which continuously and will make piles in nature, residues or residues from human activities, namely waste, industry, or remnants of natural processes in the form of solids or liquids. Organic and inorganic that can be decomposed and cannot be decomposed also can no longer be used and disposed of in the environment. The Barito River is the largest and longest river in South Kalimantan, whose springs originate from the interior of Central Kalimantan and empties into South Kalimantan, namely the Java Sea. The Barito River has a status of heavily polluted Water Quality Index (IKA). From the above problems, it is necessary for ships that can overcome and reduce solid or liquid waste; therefore, to design a multipurpose catamaran waste management ship that can solve the above problems, with equipment for handling waste, oil spill waste, and waste. Sedimentation. To design the ship, this Final Project uses a linear regression method with a size of L = 20 m, B = 8.25 m, H = 3.8 m, T = 1.3 m, and the number of crew members is 5 people. This ship uses 16 solar panels, with 4 charge controller units, 2 battery units, and 2 inverter units to support the ship's electricity. The analysis of resistance analysis was obtained using the Holtrop method of 3.9 kN. This ship stability method uses criteria that refer to IMO A.749 (18) Code On Intact Stability Chapter 3 Design Criteria Applicable To All Ships, with the results fulfilling the requirements.

Key words : Catamaran Ship, Pollution Reduction, Ship Design, Ship Waste Management, Solar Energy, Solar Panel,

1. Introduction

Numerous huge marine oil spills have occurred thus far, and each one has had disastrous effects on the marine and coastal ecosystem as well as the nearby fishing and tourist businesses. Every day there is a greater chance of an oil spill. The risk cannot be greatly decreased, not even with the adoption of double-hull tankers (Clauss et al., 2022). Human health, marine life, natural resources, and the country's economy are all seriously harmed by oil spills. Every national government takes action to stop oil spills and remove them if they become a hazard. For the containment and control of an oil spill, there are better options. Quick to react and with good organization (Manivel & Sivakumar, 2020). The risk of accidents of light duty and over tankers (with or without spillage) grew from 0.025 to 0.066 between 2008 and 2017, nearly tripling. Thus, it is anticipated that there would progressively be an increase in the danger of

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oil spills carried to Indonesia by ships (Zhang, 2021). These 44 cases can be divided into six categories, based on the cause of the accident:

- Ship to ship collisions 22 (50.0%)
- Ship grounding 17 (38.6%)
- Onshore storage tanks ruptured 2 (4.5%)
- Ship collision with wharf 1 (2.3%)
- Incorrect loading and unloading operations 1 (2.3%)
- The ship sank while on the way 1 (2.3%)

Ship-to-ship collisions or ship aground incidents, which frequently involve a human aspect, are to blame for the majority of significant oil spills (Shirai, 2005). The production of diverse machinery and equipment is accelerating as technology nowadays. Modern engineering and equipment design that can withstand a variety of weather and sea conditions. Oil spill response plans will also be improved by the utilization of local chemical and oil laboratories. The behavior of oil spills is influenced by ocean conditions, which also affect how well countermeasures work. Oil's chemical and physical characteristics gradually alter when it is spilt on water.

Pollution of the marine environment is an event that can cause harm to the marine tourism sector, the fisheries sector, the agriculture and livestock sector, the bird life sector, and the marine animal sector. Marine pollution by tankers can be in the form of oil spills (oil spills) due to accidents, leaks and tanker washing water (ballast). Marine pollution from oil spills is responsible for 12% of the total marine pollution, but marine pollution from ship spills attracts high public attention due to the consequences of oil spills by ships, which are generally caused by ship accidents. Pollution originating from the sea can be grouped into two, namely pollution originating from ships (vessel-sourced) and pollution originating from offshore oil exploitation activities (off-shore drilling). Oil spills (Oil Spill) are one of the marine pollution incidents that can result from the results of tanker operations (ballast water), repair and maintenance of ships (docking), mid-ocean loading and unloading terminals, bilge water (water, oil and lubricant drains), scrapping ships, and what often happens is tanker accidents/collisions. In addition to having a bad taste and smell, spilled oil harms the ecosystem by polluting the air, water, and nearby plants and animals (Manivel & Sivakumar, 2020).

The operational range of current oil skimming vessels is restricted to waves having a wavelength of 25 m and a wave height of 1 m. Beyond these sea conditions, it is impossible to ensure safe oil recovery operations since the accompanying motion, structural strains, and loads might seriously harm the ship and its subsystems (Klaus and Kuhnlein, 1992). Additionally, the skimming system's effectiveness rapidly declines since less oil is skimmed as a result of the breaking waves' process of mixing oil, water, and air with air. A considerable wave height of 1.5 meters, which obviously surpassed the oil fleet's working restrictions, was the most likely sea state in the North Sea. The capabilities of current oil skimming systems must be enhanced to function safely and effectively in more challenging circumstances in order to fulfill the high transit requirements, operational conditions, and viability (Clauss et al., 2022).

Due to the rapidly expanding marine oil spill accident, there are already significant regions of contamination in the relevant sea area when the oil leak is properly controlled, making the process of cleaning up the oil spill challenging and inefficient. This class of engineering ships can be built to respond quickly to unexpected oil spills at sea, to block when pollution has not yet spread widely, and to efficiently tackle the Pollution barrier area, which will enormously prevent or minimize harmful emissions due to oil spill accidents and save on maintenance costs. These problems include the rapid spread of marine oil spills, huge pollution, and difficulty in cleaning up (Zhang, 2021). The cost of oil spills has been the subject of several studies. According to (Yamada,2009) has a recent review of the area. Operating expenses for oil spill cleaning, however, which are mentioned as one of the top cost categories in relation to the overall cost of oil spills, do not yet receive the credit they merit. For instance, see (Liu, 2066 and Wirtz, 2009). The reader is referred to (Psarros et al., 2011) for a more in-depth explanation. In addition, the majority of the current models are based on historical data from previous oil spills gathered from IOPCF statistics, which are passive by definition.

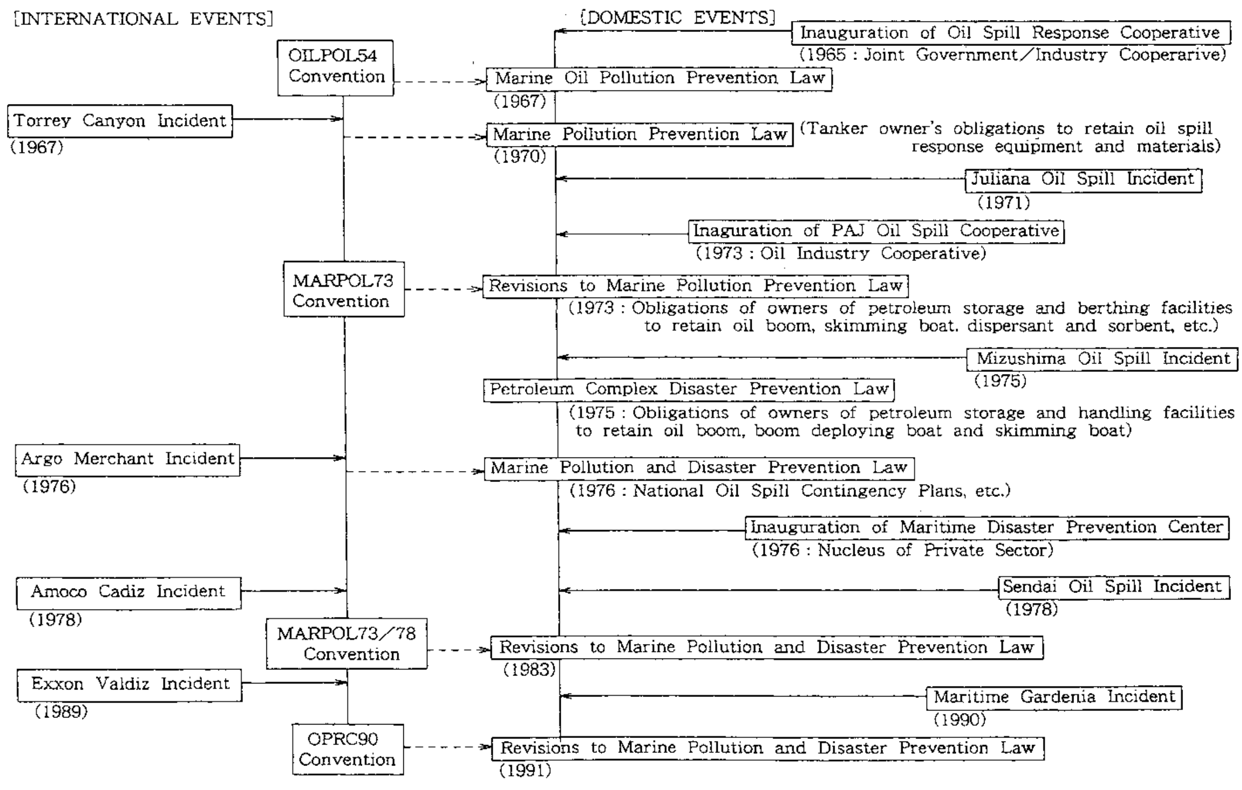

Fig. 1 Historical review of oil spill related events.

It is therefore extremely dubious to use such models for extrapolation outside of this range because they are constructed using data on spill sizes that fall within a certain range, typically with modest median values for spills (Kontovas et al., 2010). Only two models allow for cost assessment of oil spill cleanup in the scientific literature. One has been put up by (Etkin - Etkin, 1999 and 2000) and is deterministic but permits a rather open interpretation of the cost element in question. (Shahriari and Frost, 2008) have put out another deterministic paradigm that leaves no space for interpretation. In terms of the expenses associated with a worldwide oil leak, both models' projections are accurate, but none has a very high spatial precision. As a result, because local circumstances are not adequately reflected, the model cannot be used for thorough risk management or to optimize the oil combat fleet. Additionally, because of the special characteristics of the examined sea region, which the International Maritime Organization (IMO) has designated as a Specially Sensitive Ocean Area (PSSA), oil might quickly reach the coast with disastrous results, for instance (Lecklin et al, 2011). In other words, it is very hard to stop an oil leak from reaching the coast once it happens at sea (see Hietala and (Lampela, 2009 and Aps et al. 2007). The coastline is scattered with tiny islands, which makes it difficult for the cleaning boats to sail in certain areas even if the depth of the sea would permit, which makes the cleanup operation much more difficult.

Other element that sets the HELCOM agreement apart from other marine areas is that it forbids the use of chemical dispersants or in situ burning as oil fight methods, and cleaning is mostly done mechanically (HELCOM, 2012). All of this illustrates the intricacy of the topic and the limits of the cleaning cost estimating methods that are currently available. The source of each expenditure, which together make up the entire operational cost of oil spill cleanup, should thus be considered. According to research by (Richards, 1972) the impurity combination in the oil-water mixture has to be separated before the waste particles are separated from the water using a conveyor. These conveyors are also employed to remove floating and decayed items from mixes. By rotating the drum clockwise, oil is absorbed by the drum and subsequently removed by a scrapper that is mounted next to the drum, according to research by

(Kaylor et al, 1993). Finally, the collected oil enters the separate oil tank from the skimmer. Belt oil skimmers' environmental factors and known characteristics were researched by (Walczyk et al., 2044) Belt speed and wave height are examples of environmental parameters. The belt material must be changed for each type of application based on the oil combined with water in order to determine the current oil concentration in the combination and the rate of oil removal in the mixture. Conveyor systems for moving items from one location to another have been examined by (Hammond et al., 2011), including surface conveyors that carry a number of significant flight members along specified trajectories. The conveyor surface may move freely along the rollers positioned on and off the conveyor loop for a range of applications thanks to the pivoting flight section.

(Patel et al, 2015) In this essay, we investigate oil skimmers' design enhancements and various skimmer design characteristics, after which we discuss the findings. Shaft size, rope type, scrapper design, system placement speed, and scrapper material are some of the modified design elements. Because of this design element, the oil skimmer's efficiency has been somewhat increased. It has also been possible to examine various degreasing system types and identify them from one another using certain metrics. (Patil et al., 207) have indicated that the separation of oils is based on surface tension, specific gravity, and viscosity. Limitations of each approach must be addressed. He observed how oil skimmers operated in a variety of belt locations, including the slanted, vertical, and horizontal axes of the oil tank.

The majority of solid oil booms are currently set up by tugboats for anti-proliferation management of maritime oil spill pollution, and oil spill recovery ships are subsequently dispatched out to conduct recovery operations. However, the response time to accidents is lengthy, only one engineering device serves more than one purpose, and cooperation effectiveness is poor. Pollutant diffusion is a problem that cannot be solved fast and efficiently. Additionally, the solid oil explosion won't just obstruct the ship's path; it will also disturb marine life's usual activities, and the layout range is constrained. Consequently, an oil spill recovery and rescue ship showed up.

2. Methodology
2.1 Spiral Design

The process of making a ship design is an iterative process, which must go through every stage that must be met to get a good and optimal ship design. This design is described in the spiral design (the spiral design). The spiral design divides the entire process into four stages, namely concept design, preliminary design, contract design, and detail design (Watson, 1998)

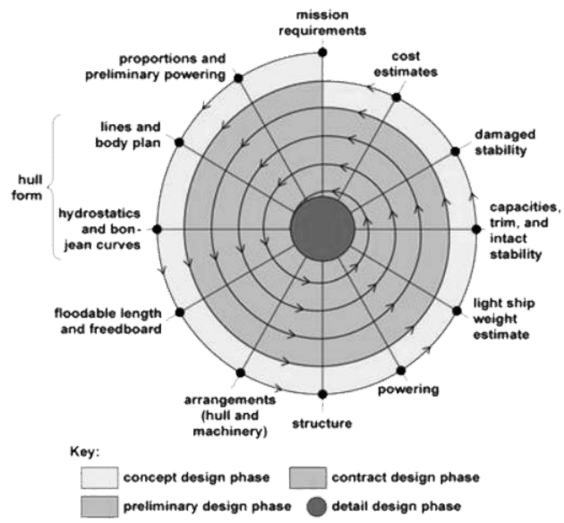

Fig. 2 Spiral Design.

2.1.1 Concept design

Concept design or ship design concept is an advanced stage after the Owner's requirement. The concept of ship design is the task or mission of the designer to define an object to meet mission requirements and comply with existing constraints or problems. Concepts can be made using approach formulas, curves, or experience to make initial estimates that aim to get estimates of construction costs, ship machinery costs, and ship equipment and supplies costs. These design concept stage results are generally drawings or sketches, either partially or wholly.

2.1.2 Preliminary design

The second stage in the design process is the preliminary design. Preliminary design is a further technical endeavour that will detail the design concept. Concerning the spiral diagram, this preliminary design is the second iteration or can be said to be the second path on the spiral diagram. What is meant by detail includes features that have a significant impact on the ship, including the initial approach to the costs that will be required. Examples of adding details are the calculation of the ship's longitudinal strength, the development of the midship section of the ship, a more accurate calculation of the weight and centre of gravity of the ship, draft, stability, and others.

2.1.3 Contract design

The contract design stage is an advanced stage after preliminary design, namely, developing ship design in a more detailed form that allows shipbuilders to understand the ship to be built and accurately estimate all shipbuilding costs. The primary purpose of the design contract is to create a document that describes the ship to be built. Furthermore, the document will base the contract or development agreement between the shipowner and the shipyard.

2.1.4 Detail design

Detail design is the last stage of the ship design process. At this stage, the results from the previous stages are developed into a more detailed working drawing as a whole. This stage includes all the plans and calculations needed for the ship's construction and operation process. The bulk of this work is the production of working drawings required for the production process.

2.2 Linear Regression

The method used in linear regression is the Least Squares Method. This method aims to make the errors that occur as small as possible, as shown below. The trick is to square the error (D^2), where;

$$D^2 = \left(y1 - f(x1)\right)^2 + \left(y2 - f(x2)\right)^2 + \left(yn - f(xn)\right)^2 \quad (1)$$

From the regression form :

$$Y = a + bx \quad (2)$$

a and b must be made such that for D^2 to be a minimum, so that:

$$\partial D^2/\partial a = 0 \quad (3)$$

$$\partial D^2/\partial b = 0 \quad (4)$$

$$b = \frac{n\sum xiyi - \sum xi \sum xi}{n\sum xi^2 - (\sum xi)^2} \quad (5)$$

$$a = y - bx \quad (6)$$

After obtaining a and b, enter them into the regression equation y = a + bx. To predict whether the regression line that we have made already has the slightest possible error, it is necessary to calculate the correlation coefficient (r). The correlation coefficient has a value from 0 - 1. The closer the value to 1, the better r. The formula for calculating r is:

$$r = \sqrt{\frac{Dt^2 - D}{Dt^2}} \quad (7)$$

Where :

$$Dt^2 = \sum_{i=1}^{n}(yi - y)^2 \quad (8)$$

$$D^2 = \sum_{i=1}^{n}(yi - a - bxi)^2 \quad (9)$$

2.3 Ships stability

To calculate the ship's stability was designed using the A.N-Krylov method to obtain relevant results using the standards provided by IMO. On a ship, whether in an upright position or tilted to an angle, two forces act: The ship's weight (W) and the buoyant force (Fb) are equal but act in opposite directions. The weight of the ship is the gravitational force measured in Newtons. The buoyant force, also measured in Newtons, is also called the displacement (force). For the displacement (mass) of the ship, measured in tons, the symbol Δ is used. For the underwater volume of the hull, called the volumetric displacement, the symbol ∇ is used. (A.N-Krylov)

$$F_B = g\Delta = \rho g\nabla \quad (10)$$

The initial metacentric height equals the difference between the metacentric radii and the distance between the centre of buoyancy (B) and gravity G.

$$GM_0 = BM_0 - GB \quad (11)$$

The transverse metacentre radius at each inclination is also called the metacentre difference.

$$r_\varphi = B_\varphi M_\varphi = \frac{dI_{WL}}{d\nabla} \quad (12)$$

The transverse metacentric radius for the upright position is:

$$r_0 = BM_0 = \frac{I_{WL}}{\nabla} \quad (13)$$

Where: Iwl = moment of inertia of the waterplane.

The relationship between the two equations is:

$$r_\varphi = r_0 + \nabla \frac{dr_0}{d\nabla} \quad (14)$$

The static stability arm can be calculated using the following equation:

$$GZ = y_{B\varphi} \cos\varphi + (z_{B\varphi} - Z_B) sin\varphi - GBsin\varphi \quad (15)$$

Where : $y_{B\varphi}, z_{B\varphi}$ are the coordinates of the centre of buoyancy.

The equation $BN = y_{B\varphi} \cos\varphi + (z_{B\varphi} - Z_B) sin\varphi$ is called the righting arm of form, and BC = BG sinφ is called the righting arm of weight. The formula can also calculate GZ:

$$GZ = y_{B\varphi} \cos\varphi + Z_{B\varphi} - KGsin\varphi \quad (16)$$

The relationship between GZ and the inclined angle is assumed to be directly proportional for a slight inclination angle. Then the erection moment can be calculated by:

$$M_R = g\Delta\, GM_0\varphi \quad (17)$$

The above formula is called the metacentre formula of stability. For all angles of inclination, the erection moment can be calculated by:

$$M_R = g\Delta\, GZ \quad (18)$$

The curve of the straightening arm must match the appropriate characteristics. An example of the GZ value at the slope angle GZ20^0, GZ30^0, GZ40^0, GZ ^{0}m must match the slope angle m. The difference between the straightening arm and the angle of inclination is called the generalized metacentre height:

$$h_\varphi = \frac{d(GZ)}{d\varphi} = B_\varphi M - y_{B\varphi} sin\varphi + Z_{B\varphi} cos\varphi - KGcos \quad (19)$$

Geometrically, this is equal to the distance between the metacentre M and the projection of G in the direction of the buoyant force, Z

$$E_R = \int_0^\varphi M_R\, d\varphi = g\Delta \int_0^\varphi GZ d\varphi \quad (20)$$

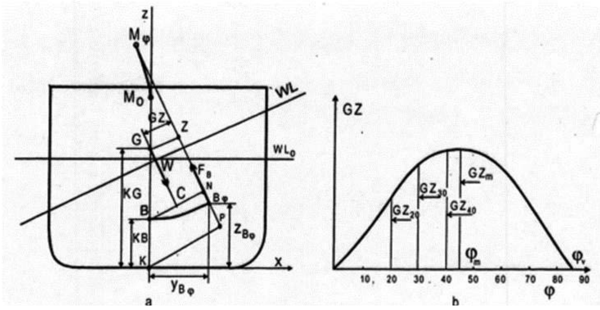

Fig. 3 GZ Curve.

2.3 Ships resistance

To find out the total resistance of the designed ship, this study uses the Insel & Molland method and the slender body in the maxsurf program which then the results obtained will be compared. Manual calculations by using the following formula:

The total resistance of the ship for each catamaran hull:

$$C_{total} = (1+\beta k) \times Cf + \tau \times Cw \quad (21)$$

Where :

C_F = Friction Resistance

$1 + \beta k$ = Catamaran viscous resistance interference

τ = Catamaran wave resistance interference

C_W = wave resistance

For Catamaran Viscous Resistance Interference :

$$1+\beta k = [\beta \times (1+k)] - \beta + 1 \quad (22)$$

To calculate the total resistance of the catamaran used the following formula:

$$Rt = 0{,}5\ x\ \rho\ x\ 2\ x\ WSA\ x\ V^2 x\ Ctot \quad (23)$$

2.4 Number of solar panels

To calculate the need for how many solar panels are used on board, the calculation below is used:

$$Number\ of\ Panel = \frac{total\ electricity\ needs\ on\ the\ ship(wh)}{Solar\ panel\ power\ peak\ (w)\ x\ sun\ exposure\ time\ (h)} \quad (24)$$

The duration of solar radiation is estimated to be five h. The amount of power produced by all solar panels in 1 h is :

Number $Solar\ Panel$ (Pieces) × $Power$ Peak $Solar\ Panel$ (W) = ... (Wh) (25)

The amount of power generated by all the solar panels in 5 hours is:

Amount of Power 1 h × Duration of irradiation for five h = ... (Wh) (26)

2.5 The energy produced by solar panels

Solar PV (Photovoltaic) energy is defined as solar energy generated by Solar PV modules.

$$Epv(t) = \frac{Ppv}{1000}.\eta s.\eta c.x1.\frac{Irr(t)}{Gstc}; t = 0,1,2,\dots 24 \quad (27)$$

PPV is the Solar PV module's peak wattage in watts; Irr is solar radiation in kW/m2, and GSTC is radiation at standard test conditions equal to 1 kW/m2. ηs is the efficiency of the Solar PV system which is the energy loss due to converters, cables, temperature, etc. ηc is the charging efficiency which is the energy loss due to the process of charging Solar PV energy to the battery, and x1 is the number of Solar PV modules.

2.6 Number of battery

To calculate the need for how many batteries are used onboard, the calculation below is used:

$$Number\ of\ Battery = \frac{total\ electricity\ needs\ on\ the\ ship(kW)}{Battery\ Capacity\ (kW)} \quad (28)$$

2.6 Battery Energi

Other factors that affect battery capacity, such as temperature, charging current, or discharging, are not considered.

$$Ebatt = \frac{Vbatt.Cbatt.x2}{1000.\eta d} \quad (29)$$

Where Vbatt is the nominal battery voltage in volts and Cbatt is the battery capacity in Ampere-hours, ηd is the battery discharging efficiency representing energy loss during the energy discharge process, and x2 is the number of batteries.

3. Data

3.1 Research data location

The Barito River or the Dusun River (or also called the Banjar Besar River (groote rivier Bandjer) or the Banjarmasin River in its lower reaches) is an area along the Barito River Basin (DAS). The name Barito is taken based on the name Tanah Barito (formerly Onder Afdeeling Barito) which is upstream including the province of Central Kalimantan, but is often used to name the entire watershed of this river down to its estuary in the Java Sea in South Kalimantan which is called Muara Banjar/Kuala Banjar, The largest and longest river in South Kalimantan is the Barito River. In the Hikayat Banjar, the Barito River is also called the Banjar River and some call it the China River because of the many activities of Chinese traders on this river in ancient times.

The upper reaches of the Barito River are in the Schwaner mountains, stretching from the Central Kalimantan region in the northern part of Borneo Island to empties into the Java Sea, approximately 1,000 kilometers long. The average width of the Barito River is between 650 and 800 meters with an average depth of 8 meters. The width of the river at the funnel-shaped estuary reaches 1,000 meters, making the Barito River the widest river in Indonesia. Lately, sedimentation or siltation in the Barito River has gotten worse due to the increasingly widespread conversion of land from tropical forest/bamboo forest to oil palm/rubber land and reduced land cover in South Kalimantan and Central Kalimantan.

Fig. 4 Kalimantan island.

Trisakti Harbor is the largest and busiest port in Kalimantan which is located in Banjarmasin. For the depth of the river around Trisakti Port, Banjarmasin City, which is found in Navionics, it is estimated that the depth of the river is between 1-13 m. Based on the BMKG (Meteorology Climatology And Geophysics Council) Maritime Map, the wave height around the Barito River that will be passed is still in the calm category(0.1 – 0.5m). This is the operational route of the Multipurpose Waste Management vessel, starting from the Trisakti Port of Banjarmasin in the direction of South Kalimantan to the Java Sea, this route covers a distance of ± 40 nautical miles

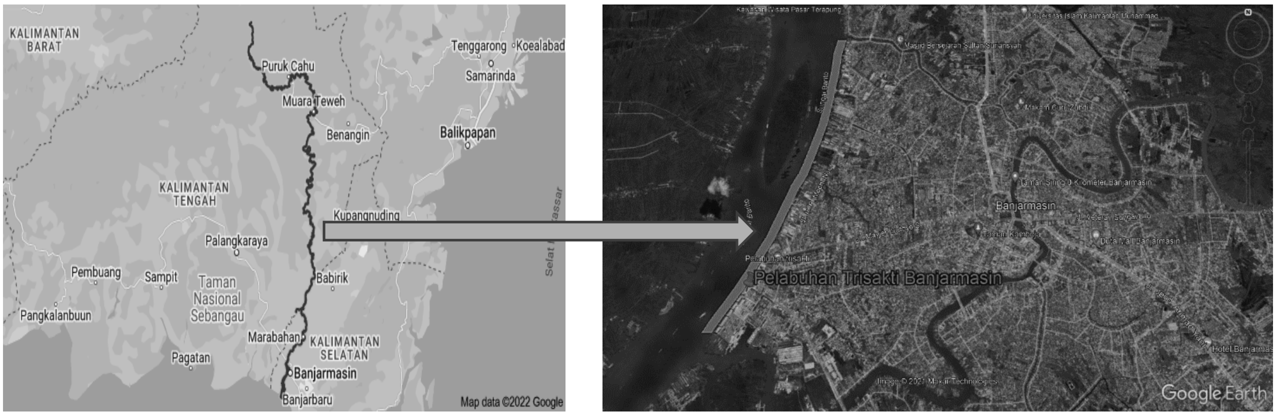

Fig. 5 Barito River.

Trisakti Port is the largest and busiest port in Kalimantan which is located in Banjarmasin. This port serves as a gateway for the flow of goods in and out of export-import as well as goods between islands. This port is a class IA port within Pelindo III. Within the Pelindo III environment, this port is in second place after the Tanjung Perak Port in Surabaya.

3.2 Ship Data

Ship data, main size correction and ship stability are still the same, taken from previous research (Preliminary Design of Multi-Purpose Waste Management Ship for Indonesian Waters).

3.3 Ships Electrical

Table 1. Electrical ships data

No	Name	Watt	Amount	Total (Watt)
1	Conveyor Motor	15	2	30
2	Echo Sounder	24	1	24
3	Radars	240	1	240
4	Magnetic Compass	24	1	24
5	GPS	9	1	9
6	Radio	15	1	15
7	Main Lamp	12	10	120
8	Side Lamp	5	2	10
9	Anchor Lamp	8	2	16
10	Morse Lamp	500	1	500
11	Flashing Light	8	1	8
12	Spotlight	50	4	200

13	Navigation Lamp	100	2	200
14	Stren Light	25	1	25
15	Ballast Pump	750	1	750
16	Fuel Oil Pump	750	1	750
17	Lubricating Oil Pump	1500	1	1500
18	Fresh Water Pump	750	1	750
19	Sewage Pump	750	1	750
Total (Watt)				5921
Total (Kw)				**5,921**

3.3 Solar irradiation data

The following is data on the length of sunlight at the location of the City of Banjarmasin, Province of South Kalimantan, Indonesia. Map Coordinates -03.31875°,114.592583° / -03°19'07", 114°35'33". Time zone: UTC+08, Asia/Makassar [WITA].

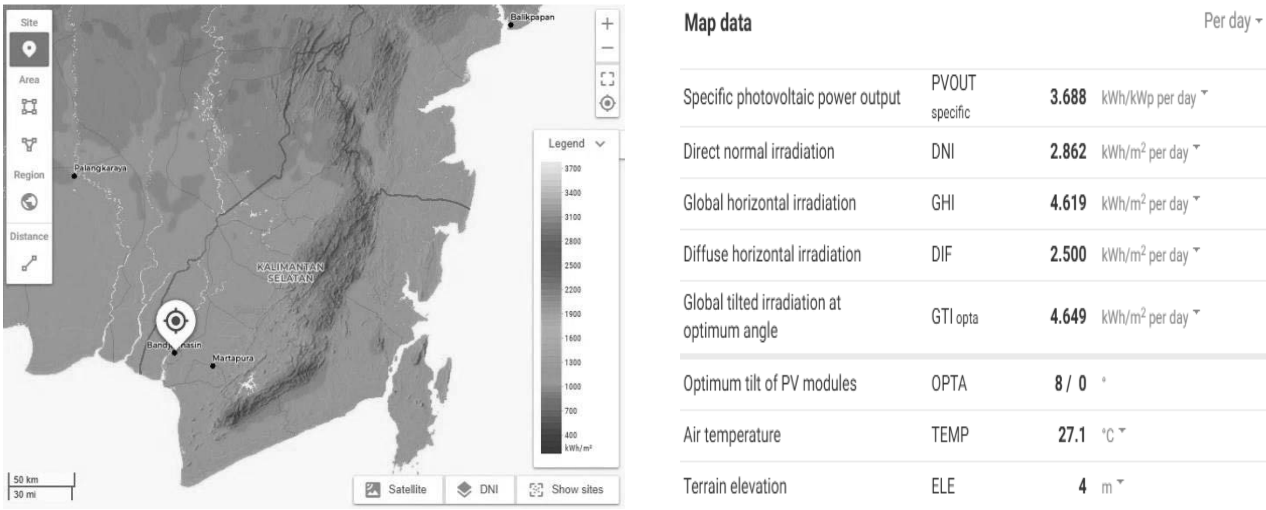

Fig. 6 Total photovoltaic power output map.

4. Result and discussion

4.1 Main dimension calculation

The main size is still the same, there are no changes as shown in table 1. The results of equations 1-8 are expressed in graphical form using the help of ms. Excel. The L/H, L/B, and B/T ratio charts are three charts. Each of these ratios will produce the main dimensions of the ship. There are length, width, height, and draft. Then the primary dimension is corrected against the criteria. If it meets the criteria, the calculation can continue to the next stage. If it does not meet the criteria then the main dimension calculation is repeated. The other main dimensions and the ship's weight are calculated using the Maxsurf software, presented in the table below.

Table 2. Main dimension of ship

Dimension	Value	Unit
L	20,000	m
B	8,250	m

H	3,800	m
T	1,300	m
Cb	0,422	
Cp	0,734	
Cw	0,802	
Cm	0,576	
Weight	53	Ton

After the main size is obtained, the size must be corrected based on the standard . If it does not meet the standard, the size can be changed until it meets the standard that has been set.

Table 3. Main dimension of ship correction

Parameter	Method	Ratio	Design	Remark
L/B1	Insel & Molland	5,9 - 15	7,143	Fulfilled
B/H	Insel & Molland	0,7 - 4,1	2,171	Fulfilled
S/L	Insel & Molland	0,19 - 0,51	0,279	Fulfilled
S/B1	Insel & Molland	0,9 - 4,1	1,989	Fulfilled
B1/T	Insel & Molland	0,9 - 3,1	2,154	Fulfilled
B1/B	Insel & Molland	0,15 - 0,3	0,3	Fulfilled

4.2 Resistance

In calculating the design resistance of the catamaran waste recycling ship using maxsurf software with criteria from Insel & Molland (1992) for catamaran type ships. The following is the result of the obstacle analysis

Table 4. Ship resistance analysis results

.No.	Speed (Kn)	Power (kW)	No.	Speed (Kn)	Power (kW)	No.	Speed (Kn)	Power (kW)	No.	Speed (Kn)	Power (kW)
1	0	--	11	1,5	0,244	21	3	1,753	31	4,5	5,473
2	0,15	0	12	1,65	0,321	22	3,15	2,012	32	4,65	5,996
3	0,3	0,002	13	1,8	0,411	23	3,3	2,294	33	4,8	6,549
4	0,45	0,008	14	1,95	0,516	24	3,45	2,6	34	4,95	7,134
5	0,6	0,018	15	2,1	0,638	25	3,6	2,931	35	5,1	7,75
6	0,75	0,034	16	2,25	0,776	26	3,75	3,287	36	5,25	8,399
7	0,9	0,057	17	2,4	0,932	27	3,9	3,669	37	5,4	9,081
8	1,05	0,088	18	2,55	1,107	28	4,05	4,078	38	5,55	9,796
9	1,2	0,129	19	2,7	1,301	29	4,2	4,514	39	5,7	10,547
10	1,35	0,181	20	2,85	1,517	30	4,35	4,979	40	6	12,157

From the table above for a ship speed of 6 knots, a total resistance of 3.9 kN is obtained with a power of 12.157 kW. Based on the results of the calculation of resistance and driving force, the selection of the main engine used is as follows.

- Engine Name : Yanmar 1GM10C Engine
- Type : Vertical 4-cycle water-cooled diesel engine

- Number of Cylinders : 1
- Bore and Stroke : 75 mm x 72 mm (2.91 in. x 2.83 in.)
- Cooling System : Direct seawater cooling
- Rated output power : 6.7 kW (9.1 hp) x 2
- Rated Speed : 3600rpm
- Alternator : 12V - 40A
- SFOC : 215 g/KWh
- Dimensions : 554mm x 410mm x 485mm
- Engine Weight with Marine Gear : 75 kg (167 lb)

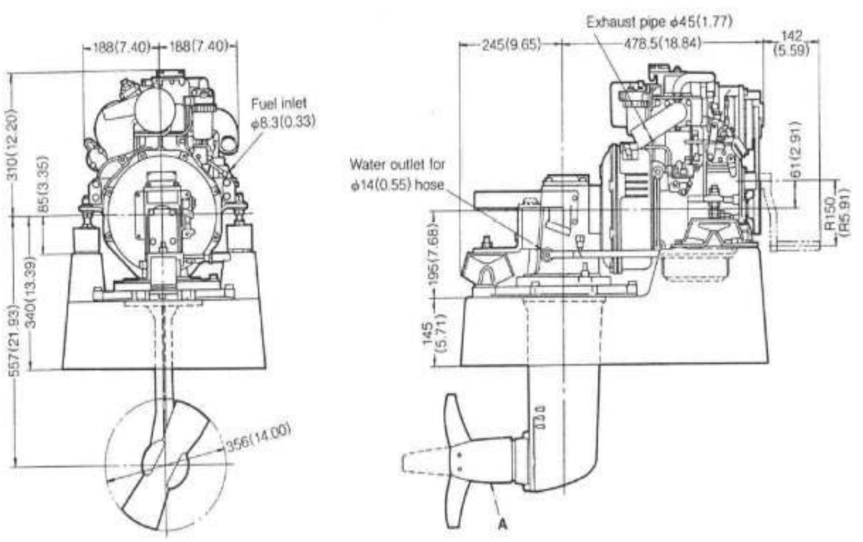

Fig. 7 Main engine.

4.3 Displacement

4.3.1 Light Weight Ton

LWT or called Light Weight Tonnage is the physical weight of the ship and is the measure used when the ship is sold as scrap metal. Light Weight Tons are often also referred to as ship displacement when the ship is empty and only contains the standard equipment required (if there is fuel and water only to start the engine and water to fill the boiler).

1. Hull Weight

Hull Area	= 376 m^2 (from maxsurf)
Plate Thickness	= 6 mm
Ship's Steel Weight	= 7,850 Ton/m^3
Plate Volume = Hull Area x Plate Thickness	= 376m^2 x 6 mm
	= 2.256 m^3
Hull Steel Weight	= Ship Steel Weight x Plate Volume
	= 17.710 tons

2. Deck Weight

Deck Area	= 136 m^2 (from autocad)
Plate Thickness	= 6 mm
Ship's Steel Weight	= 7,850 Ton/m^3
Plate Volume	= Deck Area x Plate Thickness

= 136 m^2 x 6 mm
= 0.816 m^3
Hull Steel Weight = Ship Steel Weight x Plate Volume
= 6.406 tons

3. Hull Frame Construction Weight
   Weight of Steel Hull + Ship Deck = 24.115 Tons
   20% of the ship's steel weight = 4.823 tons

4. Superstructure Weight
   Deck Area = 86.4 m^2 (from autocad)
   Plate Thickness = 3 mm
   Ship's Steel Weight = 7,850 Ton/m^3
   Plate Volume = Deck Area x Plate Thickness
   = 86.4 m^2 x 3mm
   = 0.259 m^3
   Hull Steel Weight = Ship Steel Weight x Plate Volume
   = 2.035 tons
5. Roof Weight (Deck 1)
   Deck Area = 42.5 m^2 (from autocad)
   Plate Thickness = 3 mm
   Ship's Steel Weight = 7,850 Ton/m^3
   Plate Volume = Deck Area x Slab Thickness
   = 42.5 m^2 x 3 mm
   = 0.128 m^3
   Hull Steel Weight = Ship Steel Weight x Plate Volume
   = 1.001 tons
6. Roof Weight (Deck 2)
   Deck Area = 12.5 m^2 (from autocad)
   Plate Thickness = 3 mm
   Ship's Steel Weight = 7,850 Ton/m^3
   Plate Volume = Deck Area x Slab Thickness
   = 12.5 m^2 x 3 mm
   = 0.075 m^3
   Hull Steel Weight = Ship Steel Weight x Plate Volume
   = 0.589 tons
7. Super Structure Construction Weight
   Superstructure Weight + Roof Weight = 3.624 Tons
   20% of the ship's steel weight = 0.725 tons

The overall LWT weight of the ship is shown in the table below:

Table 5. Total LWT

LWT				
No	Item	Weight (kg)	Number	Total (kg)
1	Hull Weight	17710	-	17710
2	Deck Weight	6406	-	6406
3	Hull Contructions	4823	-	4823
4	Super Structure	2035	-	2035

5	Roof Weight (Deck 1)	1001	-	1001
6	Roof Weight (Deck 2)	589	-	589
7	Super Structure Construction	725	-	725
8	*Main Engine*	75	2	150
9	Conveyor	750	1	750
10	Motor Conveyor	5	2	10
11	Hydrolic	4	2	8
12	Garbage	989	1	989
13	Net	0,5	2	1
14	*Oil Skimmer*	150	1	150
15	*Oil Absorbent Roll*	0,20	2	0,4
16	*Oil Absorbent Socks*	1,50	6	9
17	IBC Tank	70	4	280
18	*Oil Transfer Pump*	67	1	67
19	*Hydraulic Power Pump Diesel*	975	1	975
20	*Solid Floating Boom*	87,5	20	1750
21	*Hose Reel*	650	2	1300
22	*Dredger*	1200	1	1200
23	*Dredger Pump*	15	2	30
24	*Spuds*	1000	2	2000
25	*Ladder and Swing Winches*	360	1	360
26	*Crane*	1000	1	1000
27	*Echo Sounder*	3	1	3
28	Radar	3	1	3
29	Magnetic Compass	7,5	1	7,5
30	GPS	0,89	1	0,89
31	Radio	2	1	2
32	*Fire Extinguisher*	8	7	52,5
33	HT	0,3	5	1,5
34	*Life Jacket*	0,74	5	3,7
35	*Life Buoy*	2,5	2	5
36	Lamp	20	-	20
37	Pump	10	5	50
38	*Solar Panel*	28,9	16	462,4
39	*Charge Controler*	2,6	4	10,4
40	Battery	254	2	508
41	*Intverter*	9,8	2	19,6
42	Medical Supplies	1	-	1
		Total		45468,890

4.3.2 Dead Weight Ton

DWT or called Deadweight tonnage is the total weight that can be transported by a ship including cargo, fuel, clean water, ballast water, equipment and ship equipment. DWT is also interpreted as a measure of how heavy a ship can be loaded (max load) up to the summer draft at the Plimsoll mark at the water line with a specific gravity of 1,025 (water in which the ship floats) so everything that can be loaded: the weight of the crew, supplies, fresh water, fuel, reply water also if there is. The total weight of all cargo that rides on the ship is called DWT. But not including the weight of the ship.

Dead Weight Tonnage or DWT is the overall weight of the ship in a state of full load and ready to sail minus the weight of the empty ship including engines, machinery and piping. So, DWT is dead weight which contains the sum of the weight of the cargo, fuel, lubricating oil, fresh water, ballast, provisions (supplies), goods in the form of consumption, passengers and crew (ABK). Overall DWT weight can be displayed in the table below:

Table 6. Total DWT

DWT		
No	Item	Weight (Kg)
1	Fuel Oil Main Engine	80
2	Fuel Oil Genset	31
3	Lubricating Oil	2
4	Fresh Water	260
5	Crew	725
6	Oil Spill and Waste	5516
Total		6614

4.4 Design, equipment, and facility

Fig. 8 Design of ship.

Since this research is still in the early design stage, there will be several design options. Each design has a different capacity but has the same function. The front of the ship has a navigation deck, where the ship's steering wheel is located. Like other commercial ships, this ship also follows the international rules in terms of safety, namely SOLAS (Safety of Life at Sea). According to SOLAS, the equipment on the navigation deck is the Echo Sounder Radio, Compass, Radar, GPS, etc. Using equation (1) this ship is equipped with a solar panel with a capacity of 1.8 kWh. Depending on the placement of the solar panels and the number of them, the capacity may vary. Also equipped with a battery by following equation (1) the battery capacity is 2x30 kWh. Like with solar panels, the capacity of this battery can change according to the electricity needs on the ship. The tool for picking up the waste uses a conveyor belt with a power of 0.5 kW at 20m/min speed. The ship is equipped with a garbage bin with a capacity of 27m^3 for one trip. If it is complete, it will be dumped at the nearest port.

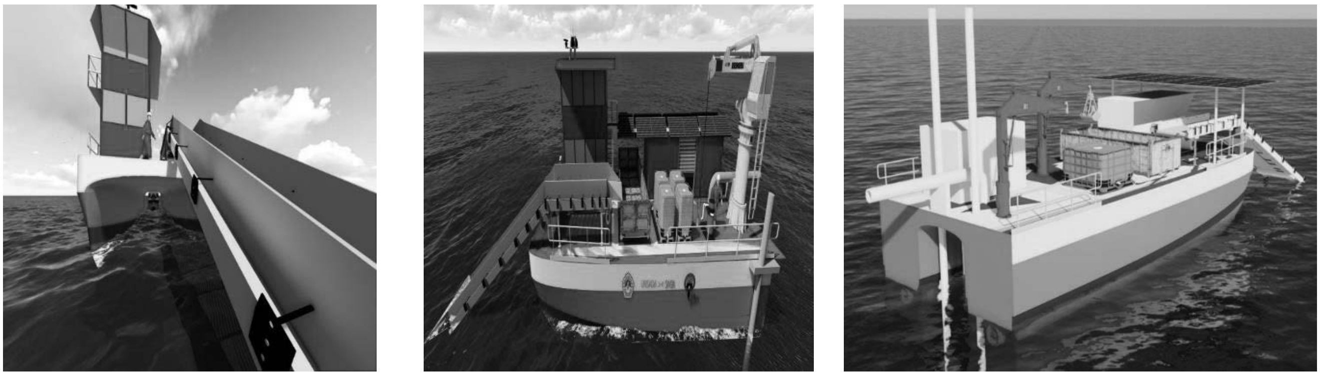

Fig. 9 Design of ship.

There is a warehouse behind the navigation deck for storing oil booms, oil skimmers, and dispersants. The oil boom is used to widen the oil spill inside the ship. Where the suction capacity of the oil skimmer is 10l/m. An oil skimmer is a tool to suck up oil spills. If the spill is too dense, an oil dispenser can be used first. It was explained earlier that this ship is a multipurpose ship. This ship is also equipped with a cutter section type dredger. The capacity of the dredging itself is 1m3/h. The capacity of the oil spill storage tank is 1000l for one trip. This ship is equipped with a powerful 330 HP engine for a maximum speed of 15 knots. When picking up trash, which is only 6 knots with the required power is 15 HP.

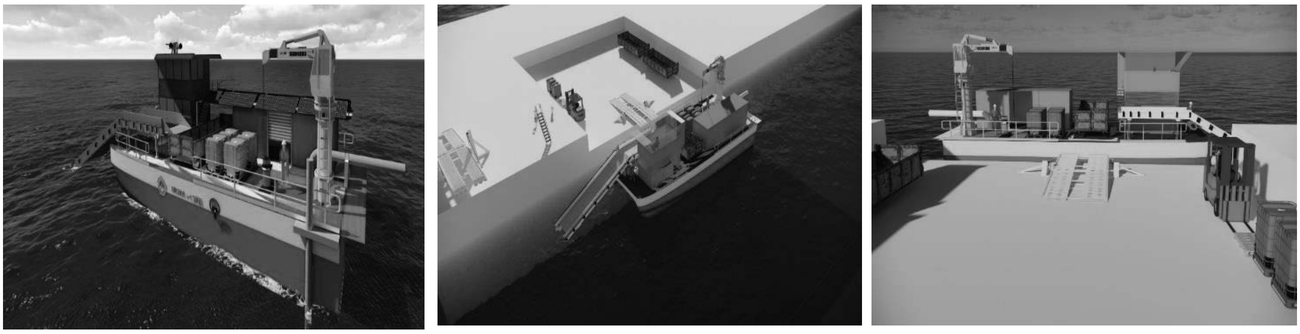

Fig. 10 Design of ship.

This is another one-of-a-kind design. Several cranes help operate the oil boom, and other cranes can assist with garbage collection. If the oil and garbage tanks are complete, they must be disposed of at the nearest port. A reception facility is a place in the port to store the remains and waste from the ship. The following viewpoints and design criteria for future oil skimming systems are a result of operational issues and decreased efficiency caused by the inappropriate hydrodynamic design of existing oil recovery vessels. **High transit speed:** An oil recovery operation needs to get started as quickly as feasible following an accident, so a reasonable transit speed is essential. The oil is first highly concentrated close to the source. Currently, the oil recovery system in place is quite effective at removing a significant amount of surface water, which prevents the polluted area from spreading further. Additionally, it stops the primary oil body from deteriorating, which would make operation more difficult. Consequently, a vessel used for oil skimming must be able to operate in both a particular transit mode and a suitable oil skimming configuration. With a lot of construction work, two alternate arrangements for the SHORV were made possible. Using the vessel in two distinct orientations, optimal one for transit and the other for skimming service, or altering the draft by raising the skimming module above the waterline while transiting, are other alternatives for obtaining fast transit speeds.

Design of the bow and intake zone: Because a thin oil film is typically dispersed over a sizable oil recovery region, the system needs to have a wide intake opening to ensure efficient functioning. If the vertical bow enables the oil skimmer to directly contact the vessel's leaking sidewall and so provide a barrier (such as the catamaran's hull) for the spreading oil. The best technique to cope with oil spills brought on by leaking or even damaged tankers is probably to do this. It was necessary to create unique flexible arc fenders to further increase this barrier effect. high effectiveness across all operating speeds For the whole working speed range, the hydrodynamic performance of the real oil skimming device must be optimized. Since thin oil films must be gathered at relatively high speeds (> 3 kN), the efficiency of the skimming operation shouldn't be restricted to calm sea conditions. While the ship is directly over a leaky tanker, for instance, the oil recovery system must still function well even when the ship is moving at a slow or even idle pace. Artificial currents must be created by extra pumps or the ship's propulsion system since the majority of oil skimming vessels need to sail at a minimum speed to give a steady feed from the skimming gear.

Hull hydrodynamic optimization: Vortices and breaking waves are two flow disturbances that greatly affect the oil recovery process. A couple of vertical counter-rotating vortices may occur as a result of flow separation from the hull structures caused by poorly constructed skimming devices or the sidewalls of the intake sections. By removing the surface oil layer from the entrance in front of the oil skimming module, the ensuing horseshoe vortex system significantly hinders oil removal. Because the center of the created vortex is squeezed beneath the surface of the water, it behaves like an oil sump, drawing stored oil down the vessel and directing it away from the real oil skimming mechanism. By redirecting the incoming flow via a dividing vane type grating and redirecting the strong vertical downward flow, one may avoid the induction of energetic vortices as shown in oil recovery vessel MODs. This creates a smooth flow pattern in the horizontal direction.

Streamline skimming device: The majority of oil skimming techniques perform well in still water, which is similar to lab settings. The skimming device must be continuously tuned to the water level, which necessitates a far greater building effort, in order to maximize the ratio between the quantity of oil separated and the amount of liquid collected overall and so enhance efficiency in actual sea conditions. By adding a series of buoyancy-controlled hydrofoil type blades immediately below the waterline, oil recovery boats based on the float ramp principle can be improved. The water flow is channeled underneath the hull while the horizontal blades perfectly follow the curves of the ocean, cutting just the polluted layer from the water's surface and sending it into the oil reservoirs. The quantity of water that gathers is significantly decreased by this rough pre-separation of oil and water at the front of the ramp. In generally, it can be said that the oil needs to be carefully directed to the area where it will be eliminated from the water's surface. Due to the huge volume of water that gathers on the high seas, oil recovery boats based on the hole-in-water concept (SHORV, Neuwerk) in particular do not adequately satisfy this need.

Blockage effect: Maintaining a thin oil film flow rate via the large entrance is important to continuously feed the skimming device with oil that has spilled. When the flow in the intake region is blocked, the stagnation area grows and dirty water is diverted to the surface near the ship. Only the top layer of the water discharge needs to be filtered in order to minimize this passing effect, and the majority of the water discharge needs to be sent through or below the oil recovery system with the least amount of resistance feasible. Correct seakeeping conduct: High waves in front of oil weirs or skimming modules can have a substantial impact on how well oil recovery systems function on the high seas. Incoming waves are constantly reflected off the vertical side walls, especially in the upstream sea. Within the intake region, the superposition of the original and reflected wave fields creates a chaotic three-dimensional seaway, leading to a high surface elevation just in front of the oil weir. The ensuing breaking waves encourage the combining of oil and water, greatly increasing the amount of toxic water that must be eliminated. In order to reduce the high surface elevation in front of the oil weir without disrupting the flow field on the water's surface or impairing the ship's mobility, vertical wave dampers positioned on the inner side walls of the intake area are the ideal solution. Additional dynamic stresses caused by waves must be considered in the design of the oil skimmer's moving parts, along with all other service circumstances, such as transportation, operation, and survival. maneuverability of the ship.

4.5 Ships stability

Calculation of Ship Stability using Maxsurf Stability software. With reference to the criteria of Intact Stability

(IS) High Speed Craft (HSC) 2000 Annex 7 Multihull and IMO A.749 (18) Chapter 3. This calculation is carried out on several loadcase criteria with the following analysis results.

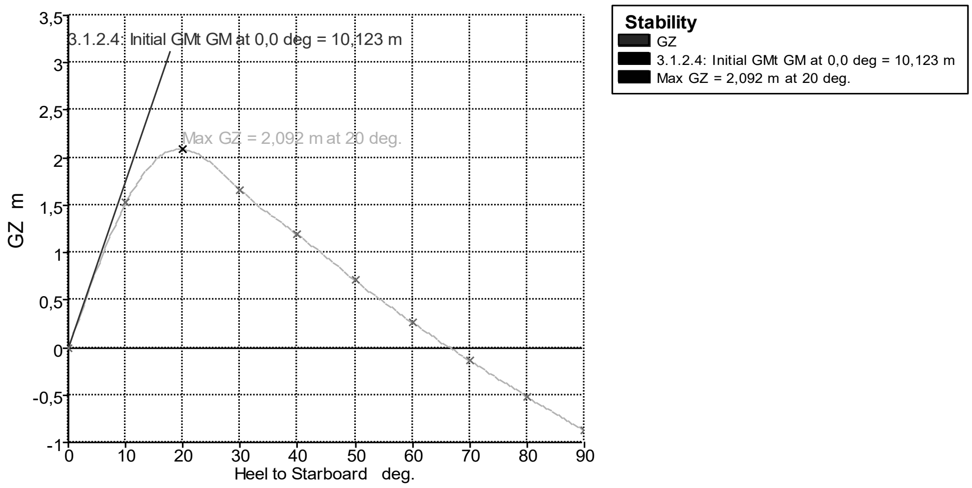

Fig. 11 Curve stability.

The image above shows the stability curve of the designed ship. The results show that the curve meets the ship stability criteria as shown in the table below:

Table 7. Stability criteria

Code	Criteria	Value	Units	Actual	Status	Margin %
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 30	3,1513	m.deg	46,3894	Pass	+1372,07
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.1: Area 0 to 40	5,1566	m.deg	60,5441	Pass	+1074,11
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.2: Max GZ at 30 or greater	0,200	m	1,658	Pass	+729,00
A.749(18) Ch3 - Design criteria applicable to all ships	3.1.2.4: Initial GMt	0,150	m	10,123	Pass	+6648,67

5. Conclusion

From the results of the research above, several conclusions can be drawn

1. The results of the calculation of the main dimensions of the vessel meet all the specified correction criteria with a crew of 3 people. The main size estimates are as follows Length 20 m, Breadth 8.25 m, Height 3.8 m and 1.3 m
2. The results of the calculation of the ship's resistance at a speed of 6 knots is 3,9 KN and the required power is 12,157 with 2 engine.
3. Calculation of ship stability has met the standardaccording to the rules of IMO (Internasional Marine Organization) Code on Intact Stability.
4. Alternative renewable energy not only uses solar energy with solar panels but can also use other energies.

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