Design of Self-Propelled Container Barge for Logistics Transportation of Samarinda-Kotabangun

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Abstract

General cargo transportation using containers is preferred recently, the main reason in selecting the containers compared to conventional cargo is having a standardized protection system, so the cargo will be safer. On the Samarinda - Kota Bangun route, transportation for logistics distribution mainly uses land transportation mode, this mode of transportation is highly influenced by traffic conditions and the roads. For this reason, using water transportation is considered, cargo transportation using a container ship will be efficient, and will overcome the obstacle of land transportation modes, in the present study, a self-propelled container barge (SPCB) is designed to increase the efficiency of the cargo distribution. To determine the main dimension of the ship, the parent method is adopted, the ship dimension is obtained from taking into account main dimension ratios. After the main dimension is determined, the Lines Plan drawing is produced using Maxsurf, then a general arrangement of the ship is drawn by Autocad. The SPCB is designed which has a nominal capacity of 140 TEU. As for trim and stability analisys, the largest trim occurs at 0% DWT, and All of the stability criteria of IMO are satisfied with four variations of ship's weight.

Kata Kunci: *Container, logistic transportation, Samarida-Kotabangun, self-propelled container barge*

1. Introduction

In recent years, cargo transportation using containers has experienced a significant increase. The main reason for selecting the container compared to conventional cargo transportation is having a standardized protection system, so the cargo is safe. Moreover, the container shape is homogeneous so it simplifies loading, unloading, and handling, and it has various types in terms of handling storage [1].

The most common mode of transportation in logistic is road. In case of Samarinda - Kotabangun route, it uses trucks. The most common mode of transportation in logistic is road. In case of Samarinda - Kotabangun route, transportation in logistics uses trucks. This transportation mode is greatly influenced by traffic and road conditions, and in many cases, this transportation mode is often delay due to congestion and road damage, as consequently, it results an ineffective transportation because it interrupts the transportation flow. Eventually, it will increase travel cost. The cause of road damage is often over capacity of the truck, the load is very heavy compared to the strength of the road.

The use of a self-propelled container barge (SPCB) is considered very efficient because it can solve problems in container transportation rather than using land transportation modes. In the future, if development of small ports in several places along the city route increases, then the SPCB will have substantial role in the logistic transportation. SPCB can operate at low-depth ports and ports without loading/unloading equipment [2]. And SPCB can be an effective mode of transportation to distribute containers from large ports to small ports. In addition, the SPCB can be used as a buffer for container ships that are loading/unloading at the port so that ships do not have to berth to the port and be served by port cranes [3].

There are several methods to determine a ship dimension namely statistical method or trend curve approach, iteration (trial and error) method, and parent method. In the case of inland and sea water ways of Kalimantan, those methods have been applied to design some type of ships. For example, the statistical method was used to determine the design of a water ambulance [4], and to design a catamaran for a water transportation mode [5], the iteration method was performed to determine main dimensions of a multipurpose of fishing boat [6]. Furthermore, Wulandari, et al used parent design approach to design a skimmer boat [7], and Alamsyah, et al. applied the method to design a catamaran hull fishing vessel in water ways of East Kalimantan [8]. In the present study, the parent method is applied to design a self-propelled container barge to support logistics transportation in Samarinda–Kotabangun.

2. Methods

2.1. Data Collection

The present study is focused on the design of the Self-Propelled Container Barge which will be operated in the Mahakam watershed. This study is performed to support the transportation of Samarinda - Kotabangun. Maxsurf and Autocad are used to design the Ship model, The Parametric Design Approach is the method applied in the design process. The design results are main dimensions, general arrangement, and ship stability analysis according to IMO. The route from Samarinda - Kotabangun - Samarinda is 162.68 Nm or the equivalent of 301.28 Km.

2.2. Ship Dimension Determination

In the present study, the parent method is used, a ship reference data is needed to determine the ship dimension, and optimization model is performed to get the optimal initial ship main dimension. The main dimension of the ship will then be re-checked (iteration) until the optimal dimension is obtained according to the dimension ratio.

2.3. Technical Ship Design Calculation

After the initial main dimension is obtained, then a technical calculation of the dimension is carried out. This calculation uses Microsoft Excel. The technical calculations carried out to complete this study are as follows:

- Calculation of Resistance
  Calculation of resistance on this ship using the Holtrop method.
- Engine Power Estimation
  After the total resistance is obtained, it can be calculated the ship's power from the EHP, DHP, then the ship's BHP. The results of this calculation will later become a reference for the selection of the ship's engine used.
- Calculation of Ship Weight
  After calculating the power, we calculate the weight of the ship which consists of the LWT and DWT of the ship.

2.4. Lines Plan Design

Lines plan is produced using Maxsurf Modeler. The reference for making this line plan is the ship line plan with the existing monohull ship shape. Then to refine the results of the line plan obtained from Maxsurf, AutoCAD software is used.

2.5. General Arrangement Design

After drawing the lines plan, then a general arrangement is produced using AutoCAD. The general arrangement is the required space planning according to its function and equipment for example cargo room, engine room, etc.

3. Results and Discussion

3.1. Ship Dimensions

For determining the main dimension of the ship, a ship reference data named Amberes is used. The main dimension data of the vessel is obtained from Baltic Shipping website [9]. However, using the Amberes data to determine ship dimension by applying calculation approach is not satisfied the dimension ratio. Then the main dimension of the ship is modified to meet these ratios. The main dimension and the ratio after calculation are as follows:

Main Dimensions
Lpp : 87.3 m
B : 12 m
H : 6 m
T : 4.5 m

Main Dimension Ratio [10]:
L/B = 6.97 Satisfied;
Range 4.7<L/B<7.63
B/T =2.67 Satisfied;
Range 1.84 < B/T < 2.98
L/T = 18.6 Satisfied;
Range 10<L/T<30
L/H =13.95 Satisfied;
Range 8.12 < L/H > 15.48
B/H =2.0 Satisfied;
Range 1.47 < B/H < 2.38

3.2. Technical ship design

3.2.1. Resistance Estimation

Calculation result of resistance using Holtrop method is as follow [11]:

$$R_{total} = R_F\left(1+k_1\right) + R_{app} + R_W + R_B + R_{TR} + R_A \quad (1)$$
$$= 53.243\ kN$$

3.2.2. Propulsion and Engine Power Estimation

The results of propulsion and engine power estimation are as follows:

$$EHP = Rt \times Vs \quad (2)$$
$$= 314.967\ kW$$

$$DHP = \frac{P_E}{\eta_H \times \eta_o \times \eta_r} \quad (3)$$
$$= 91.16\ kW$$

$$BHP = DHP \times \eta R \quad (4)$$
$$= 603.22\ kW$$

3.2.3. Displacement Calculation

The results of total weight calculation and displacement are as follows,

- Light Weight Tonnage (LWT)

Steel Weight

WST = 639.2 ton
KG = 3.61 m
LCG from AP = 43.63 m

Equipment & Outfitting Weight

WE&O = 103.2 ton
KGE&O = 6.75 m
LCG from AP = 24.12 m

Machinery Weight

WM = 37.144 ton
KG = 2.750 m
LCG from AP = 13.317 m
Total LWT = 779.511

- Dead Weight Tonnage (DWT)

Consumable Weight

W_{consum} = 27.792 ton
KG = 5.421 m
LCG dr AP = 11.735 m

Payload

$W_{payload}$ = 3348.409 ton
KG = (H-Hdb)*0.5+Hdb
= 3.500 m
LCG from AP = 49.192 m
total DWT = 3376.2

- Total Weight & Displacement

Total weight = LWT + DWT
= 4149.54 ton
KG Total = 3.60 m
LCG Total (from AP) = 47.12 m
Ship Displacement = 4383 ton

- Displacement and Weight Check

Displacement - (LWT + DWT) > (2% - 10%)
Displacement - (LWT + DWT) = 233.46 ton

3.2.4. Stability

Stability is one of the criteria that must be satisfied in the ship design process [12]. In the present study, the ship stability is calculated with loadcase variations using Maxsurf Stability, the ship hull is first modeled before performing the stability analysis it has been conducted in the previous studies, the analysis results are then evaluated using IMO criteria [13, 14]. The Intact stability A.749 (18), Ch 3 - design criteria applicable to all ships as follows [15].

(A) Section A.749 (18), Chapter 3.1.2.1:
1) The area under the GZ curve in angle of sway 0º – 30º (deg) should not be less or equal to 3.151 m.deg.
2) The area under the GZ curve in swing angle 0º – 40º (deg) cannot be less or equal to 5.157 m.deg.
3) The area under the GZ curve in swing angle 30º – 40º (deg) should not be less or equal to 1,719 m.deg.

(B) Section A.749 (18), Chapter 3.1.2.2 the maximum GZ value that occurs at an angle 30º – 180º (deg) cannot be less or equal to 0.2 m.

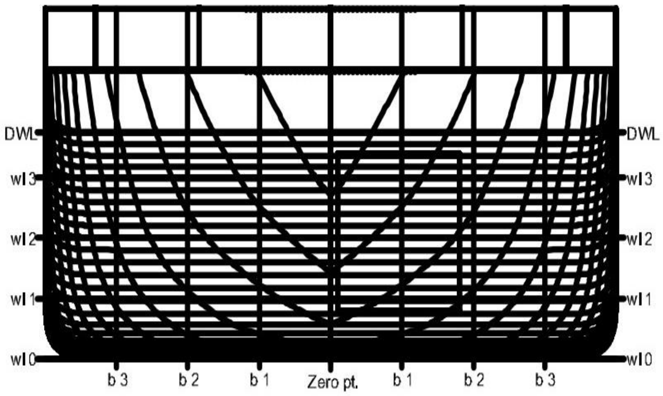
Section A.749 (18), Chapter 3.1.2.3 the angle at the maximum GZ value should not be less or equal to 25º (deg).

(D) Section A.749 (18), Chapter 3.1.2.4 the initial GM value at an angle of 0º (deg) cannot be less or equal to 0.15 m.

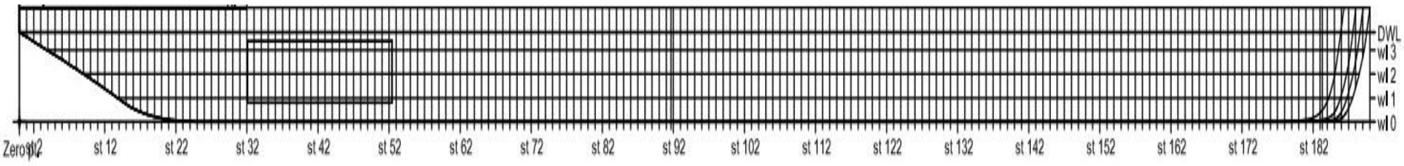
Stability corrections for all loading conditions using Maxsuf Stability satisfy the stability criteria and can be seen in the Tables 1, 2, 3, and 4 respectively.

Table 1. The result of stability analisys on the condition of 100% DWT

Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	3.1513	m.deg	23.758	Pass	+653.90
3.1.2.1: Area 0 to 40	5.1566	m.deg	40.608	Pass	+687.49
3.1.2.1: Area 30 to 40	1.7189	m.deg	16.85	Pass	+880.27
3.1.2.2: Max GZ at 30 or greater	0.200	m	1.717	Pass	+758.50
3.1.2.3: Angle of maximum GZ	25.0	deg	38.2	Pass	+52.73
3.1.2.4: Initial GMT	0.150	m	2.84	Pass	+1792.00



(a)



(b)

Figure 1. Lines plan, (a) body plan, (b) sheer plan

Table 2. The result of stabilitas analisys on the condition of 50% DWT

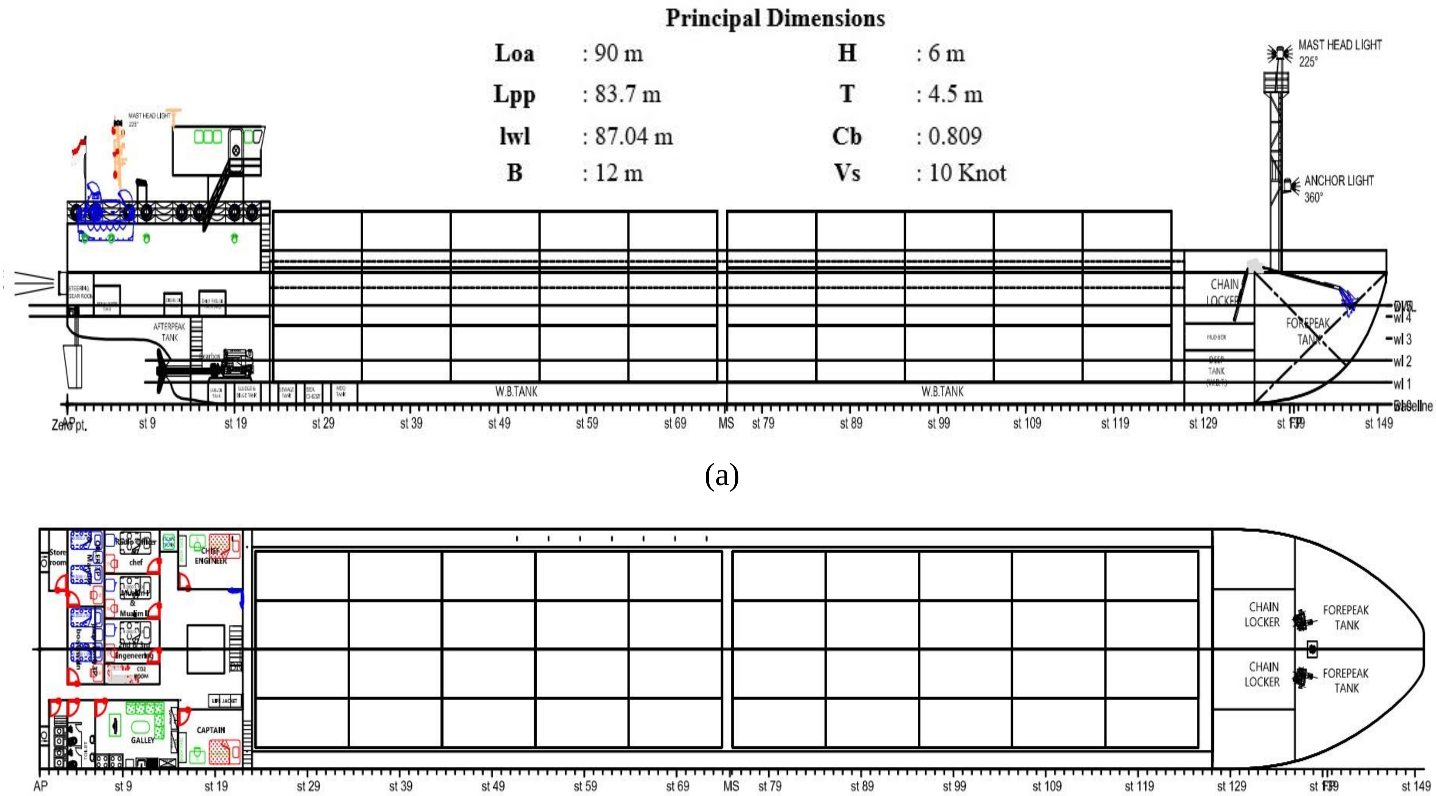
Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	3.1513	m.deg	9.55	Pass	+202.99
3.1.2.1: Area 0 to 40	5.1566	m.deg	14.35	Pass	+178.24
3.1.2.1: Area 30 to 40	1.7189	m.deg	4.8	Pass	+179.24
3.1.2.2: Max GZ at 30 or greater	0.20	m	0.51	Pass	+154.50
3.1.2.3: Angle of maximum GZ	25.0	deg	27.3	Pass	+9.09
3.1.2.4: Initial GMt	0.150	m	1.235	Pass	+723.33

Table 3. The result of stabilitas analisys on the condition of 25% DWT

Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	3.1513	m.deg	40.9715	Pass	+1200.15
3.1.2.1: Area 0 to 40	5.1566	m.deg	65.0451	Pass	+1161.39
3.1.2.1: Area 30 to 40	1.7189	m.deg	24.0736	Pass	+1300.52
3.1.2.2: Max GZ at 30 or greater	0.200	m	2.454	Pass	+1127.00
3.1.2.3: Angle of maximum GZ	25.0	deg	40.9	Pass	+63.64
3.1.2.4: Initial GMt	0.150	m	5.483	Pass	+3555.33

Table 4. The result of stabilitas Analisys on the condition of 0% DWT

Criteria	Value	Units	Actual	Status	Margin %
3.1.2.1: Area 0 to 30	3.1513	m.deg	60.9673	Pass	+1834.67
3.1.2.1: Area 0 to 40	5.1566	m.deg	86.3148	Pass	+1573.87
3.1.2.1: Area 30 to 40	1.7189	m.deg	25.3474	Pass	+1374.63
3.1.2.2: Max GZ at 30 or greater	0.200	m	2.636	Pass	+1218.00
3.1.2.3: Angle of maximum GZ	25.0	deg	25.5	Pass	+1.82
3.1.2.4: Initial GMt	0.150	m	11.810	Pass	+7773.33



(a)

(b)

Figure 2. General arrangement, (a) Side View, (b) Main Deck

3.2.5. Trim

Trim is the ship movement without evenkeel or ship movement around the Y-axis, trim occurs as a result of the unequal static moments from the distribution of gravity, trim is divided into three consisting of evenkeel, bow and stern trim [16]. The bow trim is a condition where the aft draft is higher than the bow and vice versa [17].

The trim calculation for Self-Propelled Container Barge used Maxsurf Stability Advance. Calculations with Variations 100% DWT, 50% DWT, 25% DWT, 0% DWT. The results of the calculation can be seen in Table 5:

Table 5. Trim calculation results

DWT Variations	Value
100%	-0.177
50%	0.342
25%	0.511
0%	0.611

3.2.6. Lines Plan Design

A lines plan is a drawing of the shipshape or a hull projection including a cross-section of the hull (body plan), forward/aft of the longitudinal hull (sheer plan), on portside/starboard side of horizontal sections of the hull on the waterline (half breadth plan). In designing the line plan, the Maxsurf software is used and the design of the lines plan can be seen in Fig. 1.

3.2.7. General Arrangement Design

General Arrangement is drawn using AutoCAD based on the lines plan. From the lines, the layouts of the waterline plan on the main deck, bottom so forth are taken. For the side view, the layout is taken from the sheer plan. And on the front view, the layout of the body plan is taken in the parallel area of the middle body. After calculating and obtaining the value, the design is carried out using AutoCAD. The general arrangement of the ship that has been drawn is shown in Fig. 2.

4. Conclusion

Based on the results, it can be concluded that the Self-Propelled Container Barge ship is designed to carry out Logistics Transportation with the shipping route Samarinda - Kotabangun - Samarinda which is 162.68 NM or 301.28 Km sails for 16 hours, it has the main dimensions as follows, Lpp = 83.7 m; Lwl = 87.04 m; B = 12 m; H = 6 m; T = 4.5 m: Vs = 10 knots. With the number of containers of 140 TEUs, the largest trim occurred at 0% DWT which is the stern trim of 0.611 m. All of the IMO Stability criteria are satisfied with all variations of ship weights. GZ max values are in the 100%, 50%, 25%, and 0% DWT are 0.512, 1.717, 2.454, and 2,674 m respectively, and with the angle of 27.3, 38.2, 40.9, and 25.5 degree respectively.

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