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THE FIXED BAFFLE EFFECT ANALYSIS TO FILLING TANKS VARIATION ON THE STABILITY OF 4999 DWT TANKERS

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Abstract

Tanker is a transportation to distribute the results of oil and gas exploration, where most of the exploration results come from the ocean. In this study, an analysis of the effect of adding fixed baffles with a certain number of baffles on the stability of the tanker will be carried out. The method in this study is to analyze the data of 4999 DWT tanker using Maxsurf Stability Software. The simulation was carried out in 4 percentage variations, namely 30%, 40%, 70%, and 90%, with full baffle installation in each tank. After calculating the stability analysis on the 4999 DWT tanker, it was found that the model I tank (without baffles) did not meet IMO standards. While the model II tank (1 fixed baffle), model III tank (2 fixed baffle), and model IV tank (3 fixed baffle) on various fillings have met IMO standards. Where the tank model IV (3 fixed baffle) has the best stability value with a GZ value of 1.881 m at 30% filling, 1.602 m at 50% filling, 1.051 m at 70% filling, and 0.706 m at 90% filling. It was concluded that the addition of a fixed baffle to the tank was effective in increasing the stability of the tanker.
Keywords: Stability, Baffle, IMO, Tanker

1. INTRODUCTION

Population growth and the economy in a country continues to increase, so that the need for energy will increase. Especially in fuel oil (BBM) energy because fuel can help move a country's economy such as the transportation sector, the industrial sector, and the government sector. Most of oil and gas exploration is in the ocean, where ships are the main means of transportation to distribute the exploration results. Ships transporting oil and liquefied gas have a high risk of accidents. In addition, the cargo is dangerous because it is flammable. The ship must have good stability to be considered seaworthy. The stability of a ship has been regulated by the International Maritime Organization (IMO).

Ship stability is the ship's ability to return to its original (normal) position from a heeling position after being subjected to forces as a result of external factors such as wind, current, waves, and internal factors which are changes in the distribution of cargo and the shape of the size of the ship [1].

The location of CG of the ship is very dependent on the placement of the weights on the ship. On an empty ship, the location of CG can be known from stability experiments but with loading, unloading, shifting cargo, fuel consumption, fresh water use and other activities on board. Therefore, the location of the ship's CG will change its position then we need to know for sure the location of the ship's point G after the activity. The ship can also be likened to a vertical scale with the fulcrum being the point G of the ship. The difference in load distribution that occurs in each loading condition will result in a change in the KG value, namely the vertical distance between the K (Keel) point and G (Centre of Gravity) point which will then affect the value of the enforcer arm (GZ) formed [2].

Baffles are commonly used to dampen the forces that occur on the tank walls caused by the oscillating motion of the ship so as to reduce the amount of fluid blowing by the oscillating motion of the ship itself. In addition, the baffle will reduce the speed of the water flow that tries to hit the wall at high speed [3]. Baffles can be placed on the tank wall vertically, horizontally, or a combination of vertical and horizontal [4].

The use of the new baffle design is expected to increase the stability of the ship. This baffle design can be applied to tankers without affecting the structure of the ship and the construction of the cargo hold. Therefore, this

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study will focus on ship stability with variations in the number of baffles and fluid filling conditions.

The target to be achieved in this study is to find out the most effective number of baffles to increase ship stability. From the results of the study, it is hoped that it can be useful for all parties, especially the shipping industry so that it can improve ship safety standards and reduce ship accident victims.

2. METHODOLOGY

This study was carried out through several stages, namely determining the ship model based on the main size of the ship, then making changes to the ship model, changing it with the addition of fixed baffles, and filling the tank at a certain percentage. As a result of these changes will be taken to affect the stability of the ship. This study was conducted in the hydrodynamics lab.

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2.1. Object of Study

Tanker ships with the addition of baffles are ships used as objects in this study. One thing that becomes a major concern before analyzing further is the need for the initial design of the ship.

Considering the stability of the ship has an important role in the ship, then before sailing the ship must meet the requirements regarding the feasibility of the ship in terms of stability. One of them is the stability regulation (GZ value) by the International Maritime Organization (IMO).

The analysis of this study is about the stability condition of the ship which has added baffles to the tanker to reduce the fluid flow by the oscillating motion of the tanker.

Figure 1. Oil Tanker 4999 DWT

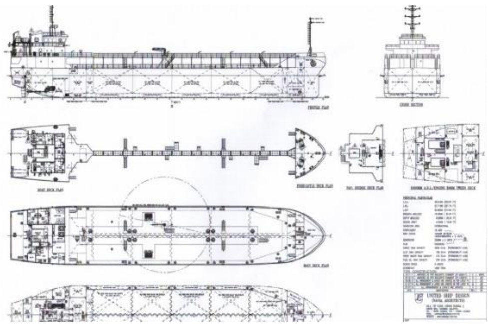

Figure 2. *General Arrangement* of Oil Tanker 4999 DWT

Table 1. Principal Dimension

Dimension		Value
Length Over All	(LOA)	89.91 m
Beam Over All	(B)	15.877 m
Hight	(H)	8 m
Draught	(T)	5.930 m
Speed	(Vs)	12 knots

The Principal Dimension were modeled using Maxsurf Modeller software. It was found that the CG (Center of Gravity) value of the tanker was 5.930 m.

2.2. Object Treatment

Stability analysis uses fixed parameters, namely the hull design and the main dimensions of the hull size such as LOA, B, T, H, and Vs. The modifier parameters include the number of baffles and the percentage of tank filling. Then it can be seen how the impact on stability changes.

2.3. Ship Stability

Ship stability is the ship's ability to straighten back to its initial position such as when the ship is being floated, not tilted to the right or left, as well as when sailing, due to external influences acting when the ship is tossed by the wind, waves or during loading and unloading activities, so that the ship can upright [5].

The important points contained in the stability of the ship are as follows :

1. The center of gravity (G) indicates the location of the ship's center of gravity, which is the point of capture of a center

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point of a downward force of gravity. The magnitude of the KG value is the high value of the metacentral point (KM) above the keel minus the metacentral height (MG).
2. The floating point (B) indicates the location of the ship's floating point, which is the catching point of the resultant forces pushing vertically upwards from the submerged part of the ship.
3. The metacenter point (M) is a pseudo-point of the boundary where G must not pass above it so that the ship always has positive or stable stability.

Stability is calculated under several loading conditions according to the standard IMO criteria. This stability analysis uses four filling tank conditions, namely:

1. Condition I: a tank filling of 30%.
2. Condition II: a tank filling of 50%.
3. Condition III: a tank filling of 70%.
4. Condition IV: a tank filling of 90%.

Referring to one of the publications of the International Maritime Organization (IMO), the Code on Intact Stability has been listed in chapter 3, the ship's stability capability must comply with the rules described in Table 2 as follows:

Table 2. IMO *code on Intact stability A.749 (18)*

Parameter	Criteria	Unit
Max Area of GZ 0 to 30	≥ 3,151	m.deg
Max Area of GZ 0 to 40	≥ 5,156	m.deg
Max Area of GZ 30 to 40	≥ 1,718	m.deg
Max GZ at 30 or greater	≥ 0,2	M
Angle of max. GZ	≥ 25	Deg
Initial Metacentric Height	≥ 0,15	M

2.4. *Baffle*

The use of baffles in a tank is divided into 2 (two) parts, namely fixed baffles and floating baffles. The advancement of baffles on tanks was developed by large companies involved in fluid delivery as well as shipbuilding. The fixed baffle is an anti-sloshing structure that is part of the inner wall for tankers with LNG cargo and is an integral part of the loading tank structure which has been developed by Samsung and has been patented in China, USA, and Europe [6].

The use of vertical baffles in a box-shaped fluid tank is a passive technique and includes a fixed structure in the tank which has been proven to be able to efficiently reduce sloshing waves in the tank [7]. The effect of vertical baffle height on a tank can also affect vortex waves. The higher the vertical baffle, the smaller the vortex waves. This will give the effect of reducing the impact pressure [8]. The effect of baffles that are placed horizontally and are in the middle of the fluid level and have dimensions and patterns of perforation distances have also been shown to reduce the sloshing effect [9].

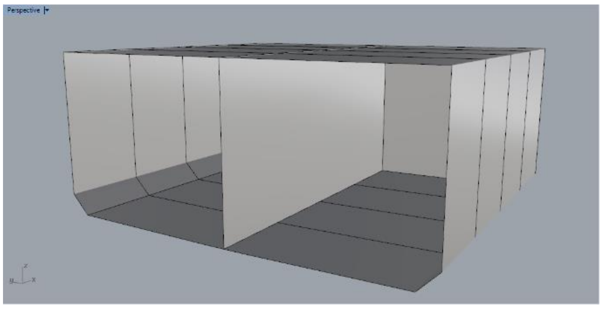

Figure 3. Vertical Direction Baffles System

2.5. Software

This research was conducted at the Computer Assisted Ship Planning Laboratory in the Department of Naval Architecture. The research used modeling software and stability analysis software (Maxsurf).

3. RESULT AND DISCUSSION

3.1. Modeling Process

The results were obtained by making models with Maxsurf Modeller software and analysis using Maxsurf software. Figure 4 shows a tanker tank model without using fixed baffles at all in its cargo space. Figure 5 shows a model of a tanker tank with the addition of 1 fixed baffle in its cargo space. Figure 6 shows a tanker tank model with the addition of 2 fixed baffles in its cargo space. While Figure 7 shows the tanker tank model with the addition of 3 fixed baffles in the loading space.

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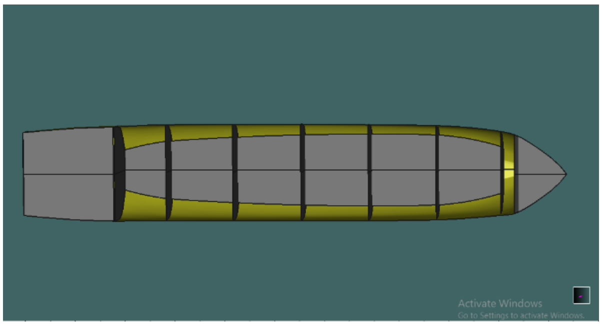

Figure 4. Tank Without Using a Fixed Baffle

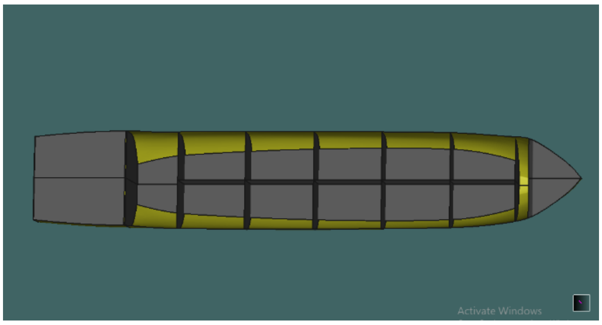

Figure 5. Tank Using 1 *Fixed Baffle*

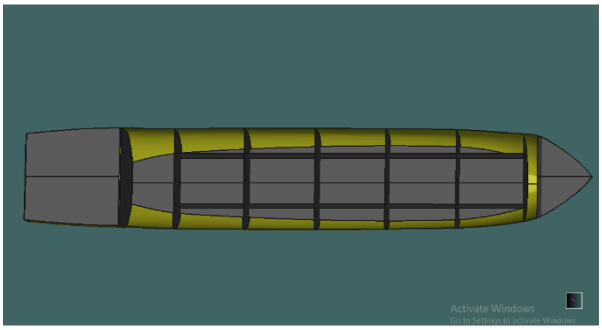

Figure 6. Tank Using 2 *Fixed Baffles*

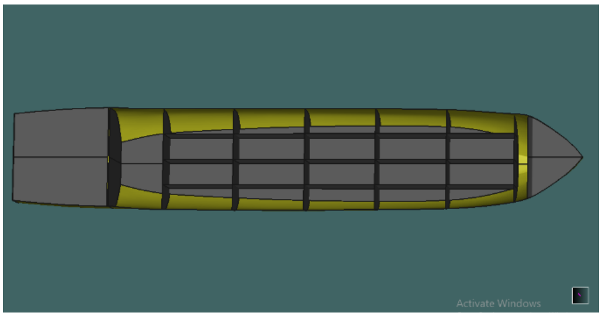

Figure 7. Tank Using 3 *Fixed Baffles*

3.2. Ship Stability Analysis

The tanker must have sufficient stability. The ship is continuously forced out of its straight position against the forces exerted by the fluid in the vessel's tanks. Three concentration points play an important role in the stability review, namely points G (center of gravity), B (center of buoyancy), and M (metacenter).

The following is the result of data from stability testing on ship models with the addition of baffles and without baffles at predetermined conditions (30%, 50%, 70%, 90%) of the stability test parameters that have been determined.

Based on table 3, the GZ value of tankers without the addition of fixed baffles at 30% filling is declared not to meet the IMO stability testing criteria section A.749(18) Ch 3 - Design criteria Applicable to all Ships. While the other filling meets the criteria. The graph of the GZ value can be seen in Figure 8.

1. Condition I

No	Parameter	Kriteria IMO	Jumlah *Fixed Baffle*			
			0	1	2	3
1	Area 0 to 30	3,1513	0.0000	19,3375	21,0720	25,2914
2	Area 0 to 40	5,1566	0,0000	32,4762	35,7020	42,9647
3	Area 30 to 40	1,7189	- 0,7175	13,1388	14,6300	17,6733
4	Max GZ at 30 or greater	0,200	0,472	1,362	1,571	1,881
5	Angle of maximum GZ	25,0	61,8	41,8	45,5	1,881
6	Initial GMt	0,150	-1,065	2,327	2,755	43,6
	Status		*Fail*	*Pass*	*Pass*	*Pass*

Table 3. Tank ship with 30% filling

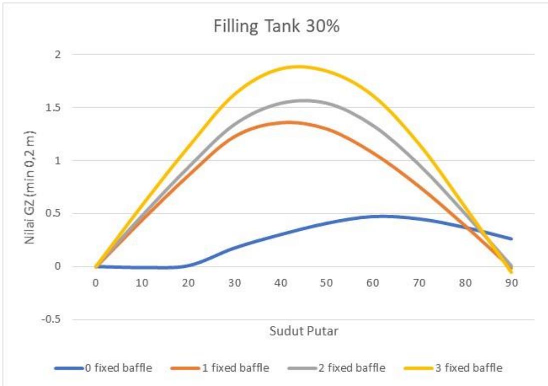

Figure 8. Graph of GZ value for condition I

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2. Condition II

No	Parameter	Kriteria IMO	Jumlah *Fixed Baffle*			
			0	1	2	3
1	Area 0 to 30	3,1513	0,5204	19,0224	21,1277	23,6734
2	Area 0 to 40	5,1566	0,9075	30,7319	34,4923	39,0814
3	Area 30 to 40	1,7189	0,3871	11,7096	13,3646	15,4080
4	Max GZ at 30 or greater	0,200	0,295	1,180	1,353	1,602
5	Angle of maximum GZ	25,0	68,2	35,5	38,2	43,6
6	Initial GMt Status	0,150	-0,296 *Fail*	2,411 *Pass*	2,742 *Pass*	3,052 *Pass*

Table 4. Tank ship with 50% filling

Based on table 4, the GZ value of tankers with the addition of 1 fixed baffle at 50% filling is declared to meet the IMO stability testing criteria section A.749(18) Ch 3 - Design criteria Applicable to all Ships. While the other filling meets the criteria. The graph of the GZ value can be seen in Figure 9.

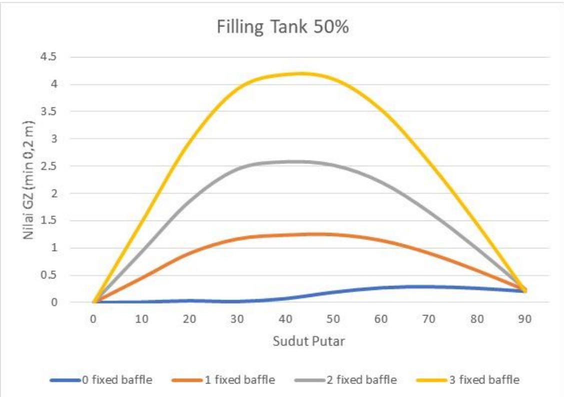

Figure 9. Graph of GZ Value at Condition II

3. Condition III

No	Parameter	Criteria IMO	Number of *Fixed Baffle*			
			0	1	2	3
1	Area 0 to 30	3,1513	5,4907	13,2199	14,3825	13,2743
2	Area 0 to 40	5,1566	9,7480	20,8138	22,4635	20,2084
3	Area 30 to 40	1,7189	4,2573	7,5939	8,0809	6,9341
4	Max GZ at 30 or greater	0,200	0,479	0,779	0,827	0,706
5	Angle of maximum GZ	25,0	47,3	40,0	40,0	40,0
6	Initial GMt Status	0,150	0,185 *Pass*	2,053 *Pass*	2,281 *Pass*	2,463 *Pass*

Table 5. Tank ship with 70% filling

Based on table 5, the GZ value of tankers with the addition of 2 fixed baffles at 70% filling is declared not to meet the IMO stability testing criteria section A.749(18) Ch 3 - Design criteria Applicable to all Ships. While the other filling meets the criteria. The graph of the GZ value can be seen in Figure 10.

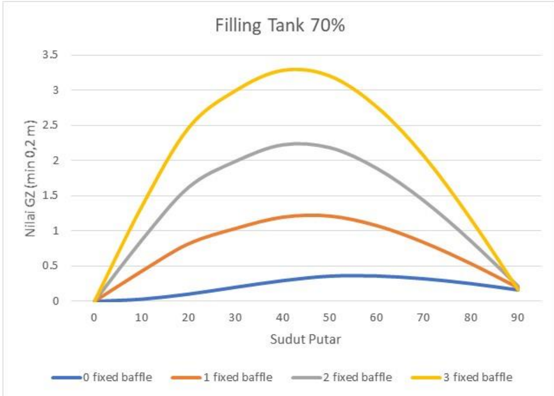

Figure 10. Graph of GZ Value at Condition III

4. Condition IV

No	Parameter	Kriteria IMO	Jumlah *Fixed Baffle*			
			0	1	2	3
1	Area 0 to 30	3,1513	2,2619	15,6038	17,5126	18,4365
2	Area 0 to 40	5,1566	4,7216	24,3936	27,5244	28,7464
3	Area 30 to 40	1,7189	2,4597	8,7898	10,0118	10,3100
4	Max GZ at 30 or greater	0,200	0,362	0,910	1,032	1,051
5	Angle of maximum GZ	25,0	55,5	40,9	40,9	40,9
6	Initial GMt Status	0,150	0,091 *Fail*	2,271 *Pass*	2,529 *Pass*	1,681 *Pass*

Table 6. Tank ship with 90% filling

Based on table 6, the GZ value of tankers using 3 fixed baffles on all fillings is declared to meet the IMO stability testing criteria section A.749(18) Ch 3 - Design criteria Applicable to all Ships. The graph of the GZ value can be seen in Figure 11.

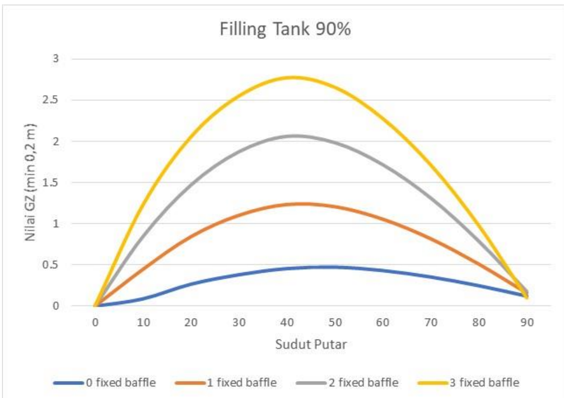

Figure 11. Graph of GZ Value at Condition IV

Based on Tables 3, 4, 5, and 6, the stability of the 4999 DWT tanker with the addition of fixed baffles states that the addition of fixed baffles produces a stability value that satisfies the IMO criteria. Meanwhile, ships without the addition of fixed baffles based on tables 3,4,5, and 6, show that this value does not meet the criteria set by IMO. This result states that the addition of fixed baffles on tankers will make the GZ value even greater. The results of the above analysis show that the addition of fixed baffles on tankers can increase the stability of the ship.

4. CONCLUSION

The results of the stability analysis of the 4999 DWT tanker after the addition of several fixed baffles with variations in the number and various fluid fillings that have been carried out in this final project research show that the results of ships without baffles do not meet the standards of IMO. Meanwhile, ships with 1 fixed baffle, ships with 2 fixed baffles, and ships with 3 fixed baffles at various fillings meet IMO standards.

The ship with the addition of 3 fixed baffles is the most effective 4999 DWT tanker model in increasing the stability value of the ship which can be seen from the results of the GZ value of 1.881 at 30% filling, 1.602 at 50% filling, 1.051 at 70% filling, 0.706 at filling 90%. Therefore, it can be concluded that the addition of fixed baffles on the 4999 DWT tanker is effective in increasing the stability capability of the tanker.

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