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Analysis Of Wave Height To Ship Motion With Displacement Of 7,597 Tons By Finite Element Method

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Abstract

Seakeeping is the ship's ability to stay afloat on the waves. The ship's maneuverability is greatly influenced by external factors related to the state of the sea and the waters in which the ship sails. Calculating seakeeping with various variations of depth, current, and wave height is needed for ship safety when sailing in the calculation of seakeeping using linear strip theory to calculate the response of heaving and pitching movements while roll damping theory for rolling movements. In this study, the ship's motion is calculated using the Finite element method software Hydrodynamic Diffraction and Hydrodynamic Time Response. For variations in wave height and water depth, referring to the conditions of Indonesian waters, from the reference, variations in wave height of 3 m, and 5 m (based on sea state WMO). In contrast, the current variation uses a current with a speed of 10 knots and a current depth of 10 T, 15 T, and 20 T. Based on the data obtained in data processing, it can be seen that the high value of the wave frequency obtained at 90 and 270 degrees wave direction is relatively high. The value of the roll spectrum in the direction of 0 and 270 degrees is large and can cause rolling on the ship. In the direction of 0 and 270 degrees, the wave resistance can be reduced by the ship.

Keywords: Seakeeping, Ship Motion, Modeling, Degrees of Freedom

1. Introduction

By their very nature, the oceans and the atmosphere form a combined thermodynamic system, which constantly exchanges heat, mass, and momentum. It means that any force imposed from one fluid to another causes a change in boundary conditions between them, sometimes called "inter facial-conditions.

Due to the strong coupling between the two fluids, the movement in the atmosphere will create movement at the sea surface. These waves created by the movement of the atmosphere are "Wind Waves." The wind that blows on the sea surface is the primary generator of ocean waves.

The ship is a form of sea transportation that transports goods, passengers, and mining materials. in all areas with certain water areas. Because most of the 2/3 of the earth's surface are water, ships have been by humans since ancient times as an essential means of transportation for trade relations, the spread of religion, the search for gold or spices, diplomatic relations, and others.

In operating the ship, there are several obstacles, one of which is the environmental load in the form of wave height. Wave height affects the ship's operation, which can hinder the ship on its way to its destination.

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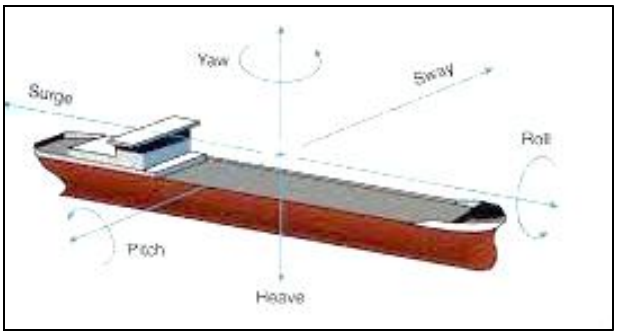

Fig. 1. Ship motion

The response of rolling, pitching, and heaving motion will ultimately affect the comfort and safety of the crew and the goods being transported. The ship's shape is very influential on the characteristics of the operability movement. Vessel operability is the amount of time at sea during which the structure can still operate by the specified performance and the correlation of wave height at which the criteria will be exceeded. Characteristics of ship models that can emphasize the ship's response to operational conditions at sea are the main criteria that must be met by ships, which are closely related to ship movement characteristics.

In the study of ship motion, the motion of what is reviewed is a movement that is only capable of responding by the ship, namely rolling, heaving, and pitching. In obtaining treatment from ship waves have two types of motion. General equation of ship in heaving condition below:

$$a\ddot{z} + b\dot{z} + cz = F0 \cos \omega et \quad (1)$$

Where Inertial Force Fa is (- $a\ddot{z}$) , Damping Force Fb is b$\dot{z}$, Restoring Force Fc is cz and Exciting Force F is $F0$ cos ωet. General equation of ship in pitching condition is:

$$d\ddot{\vartheta} + e\dot{\vartheta} + h\vartheta = M_0 \cos \omega et \quad (2)$$

Where inertial moment is $d\frac{d^2\vartheta}{dt^2}$, damping moment is $e\frac{d\vartheta}{dt}$, restoring moment is $h\vartheta$ and exciting moment M_0 cos ωet. General equation of ship in rolling condition is:

$$a\frac{d^2\Phi}{dt^2} + a\frac{d\Phi}{dt^2} + c\Phi = M0 \cos \omega et \quad (3)$$

Where inertial moment is $d\frac{d^2\vartheta}{dt^2}$, damping moment is $e\frac{d\vartheta}{dt}$, restoring moment is $h\vartheta$ and exciting moment M_0 cos ωet.

1.1. Respons Amplitude Operator

RAO is also referred to as Transfer Function because RAO is a tool to transfer external loads (waves) in response to a structure. The general form of the RAO equation in the frequency function is as follows:

$$S\phi(\omega e) = S\zeta(\omega e)\,|H(\omega e)|^2$$

$$S\varphi = S\zeta(\omega e)\,[\,\emptyset a\; S\zeta\,]^2$$

$$RAO = \frac{Motion\ response\ amplitude}{Wave\ amplitude} = (\,\emptyset a\; S\zeta\,)^2$$

Where, Sζ (ωe) is wave spectrum density function, [m^2 -sec] Sφ (ωe) is movement response spectrum density function [m^2 -sec], Sφ is movement response spectrum [m] $|H(\omega e)|^2$ is response Amplitude Operator (RAO), Φa is movement response amplitude [m] atau [deg], ζa is wave amplitude [m].

2. Materials and Methods

The ship data used in the research, in the research the ship used is a general cargo ship. The following is the main size data of the ship:

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Table 1. Main Dimensions

	Measurement	Value	Units
1	Displacement	7597	t
2	Volume (displaced)	7412.004	m^3
3	Draft Amidships	6.400	m
4	Immersed depth	6.400	m
5	Immersed depth of st	6.400	m
6	Immersed depth amid	0.000	m
7	WL Length	92.494	m
8	Beam max extents o	14.999	m
9	Beam max on WL	14.999	m
10	Beam extents on WL	14.996	m
11	Beam on WL of stati	14.996	m
12	Beam extents on WL	0.000	m
13	Beam on WL amidshi	0.000	m
14	Wetted Area	2243.344	m^2
15	Max sect. area	95.684	m^2
16	Sect. area amidships	0.000	m^2
17	Waterpl. Area	1255.390	m^2
18	Prismatic coeff. (Cp)	0.837	
19	Block coeff. (Cb)	0.835	
20	Max Sect. area coeff	0.997	
21	Waterpl. area coeff.	0.905	
22	LCB length	-43.196	from z
23	LCF length	-45.046	from z
24	LCB %	-46.701	from z
25	LCF %	-48.702	from z
26	VCB	3.321	m
27	KB	3.321	m
28	KG fluid	0.000	m

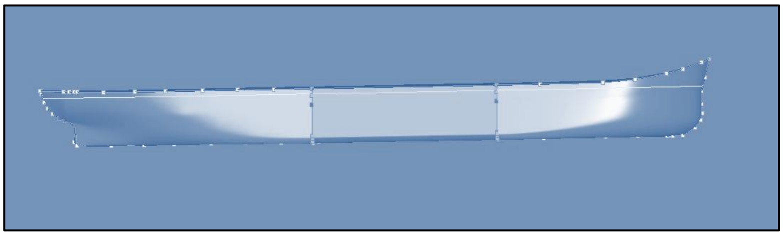

Fig. 2. Ship Modeler

The ship model in this study uses the finite element method, and for analysis of ship, motion using Maxsurf motion advanced while analyzing the influence of currents on ship movement using hydrodynamic time response. Then after getting the results of the RMS value from the software, a manual calculation of the ship's motion was carried out using excel for seakeeping validation.

2.1. Types of Ships and Damping Factors

At the data input stage is complete, the modeler of the ship that has been made is opened in the maxsurf motion advance application. The speed variation used in the ROA calculation experiment this time is 10 knots, and In the spectra table menu, there are variations in wave height, namely: 1m, 2m, and 3m. and the adjustment of the type of ship and the damping factor is as follows:

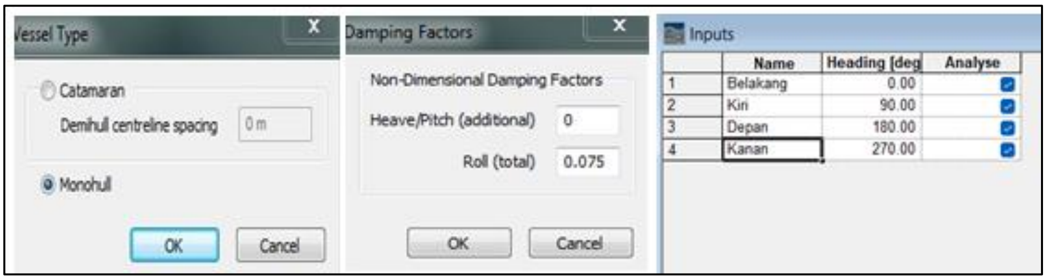

Fig. 4. Input data

3. Result

In this study, the ship's motion is calculated using the Finite element method software Hydrodynamic Diffraction and Hydrodynamic Time Response. For variations in wave height and water depth, referring

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to the conditions of Indonesian waters, from the reference, variations in wave height of 3 m, and 5 m (based on sea state WMO). In contrast, the current variation uses a current with a speed of 10 knots and a current depth of 10 T, 15 T, and 20 T. The analysis of the software used is in the form of frequency and RAO in each condition. The following is a graph of RAO for each condition that has been analyzed 3.1 Data Calculation With Wave Height 2 m with Front Angle 0, 90, 180 and 270 degrees

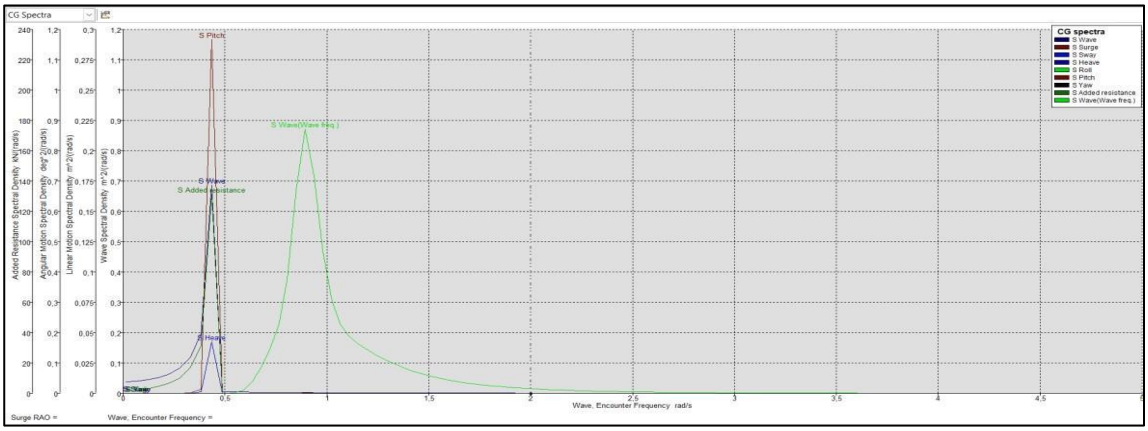

Fig. 5. Front Angle 0 Degree

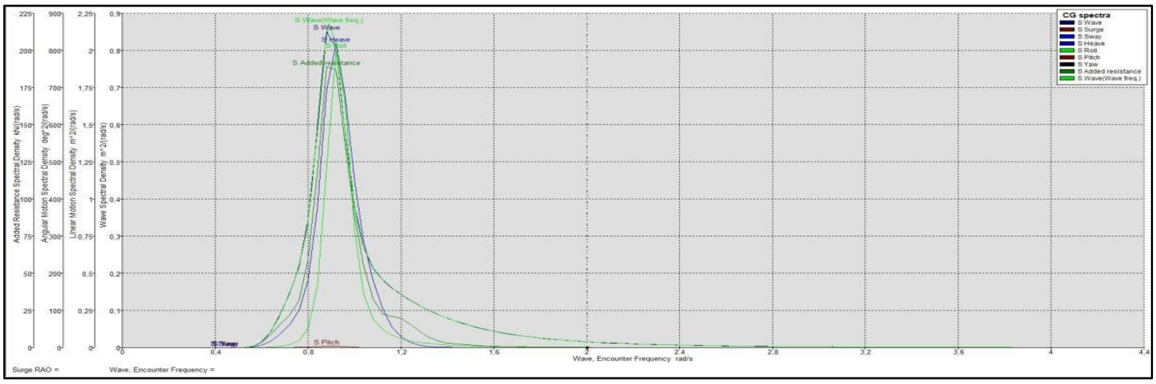

Fig. 6. Front Angle 90 Degree

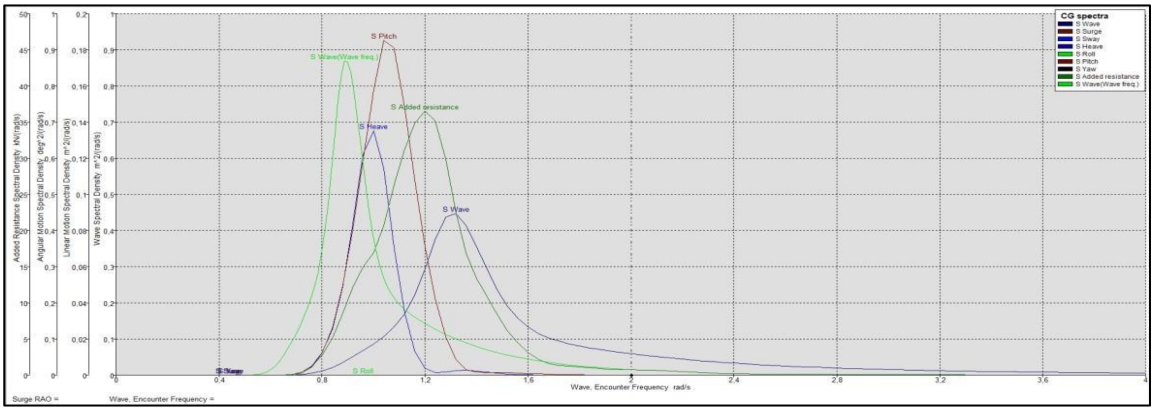

Fig. 7. Front Angle 180 Degree

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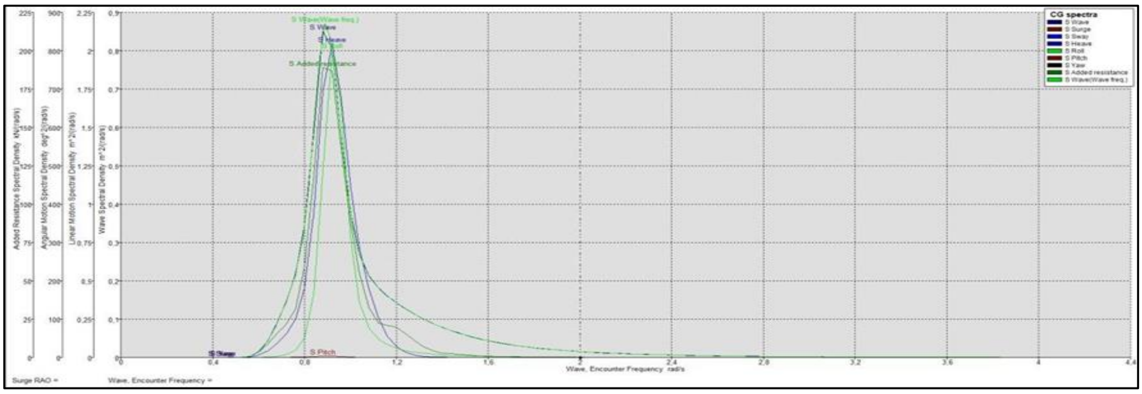

Fig. 8. Front Angle 270 Degree

3.2. Data Calculation With Wave Height 5 m with Front Angle 90 and 180 degrees

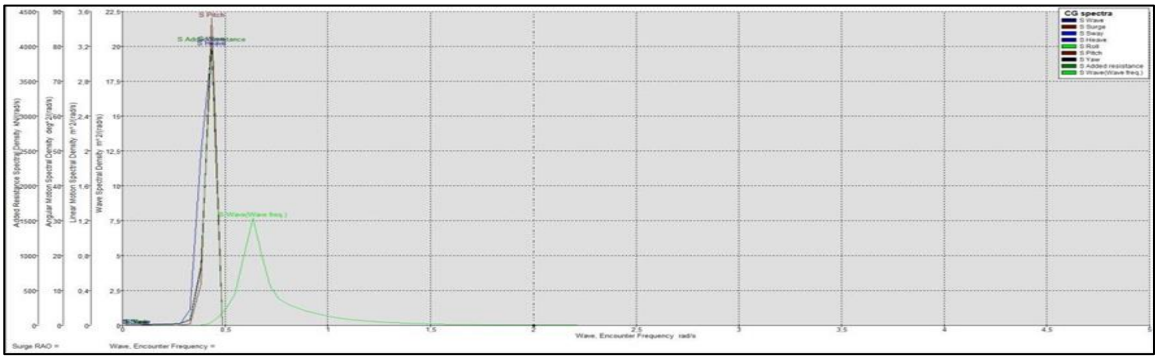

Fig. 9. Front Angle 0 Degree

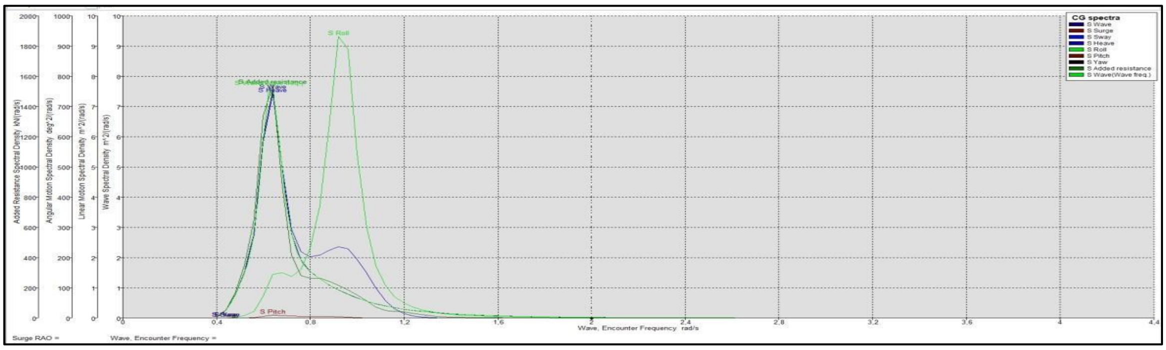

Fig. 10. Front Angle 90 Degree

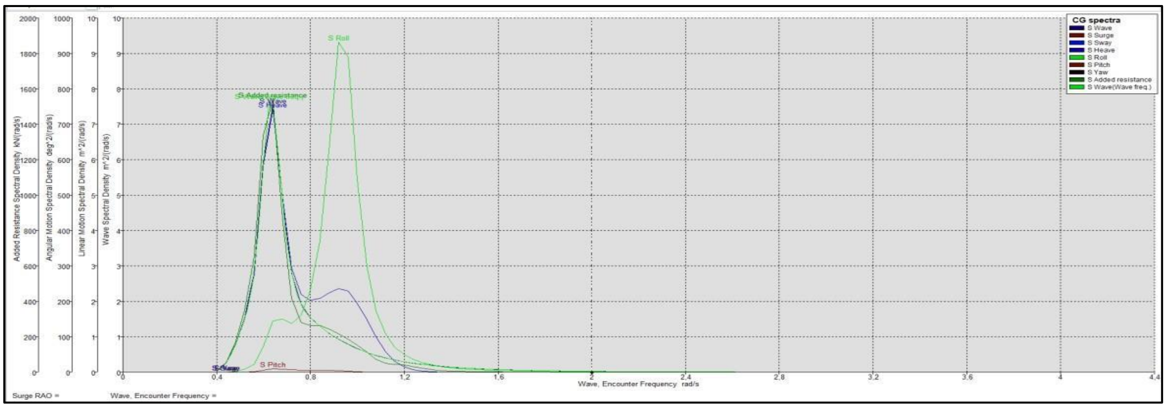

Fig. 11. Front Angle 180 Degree

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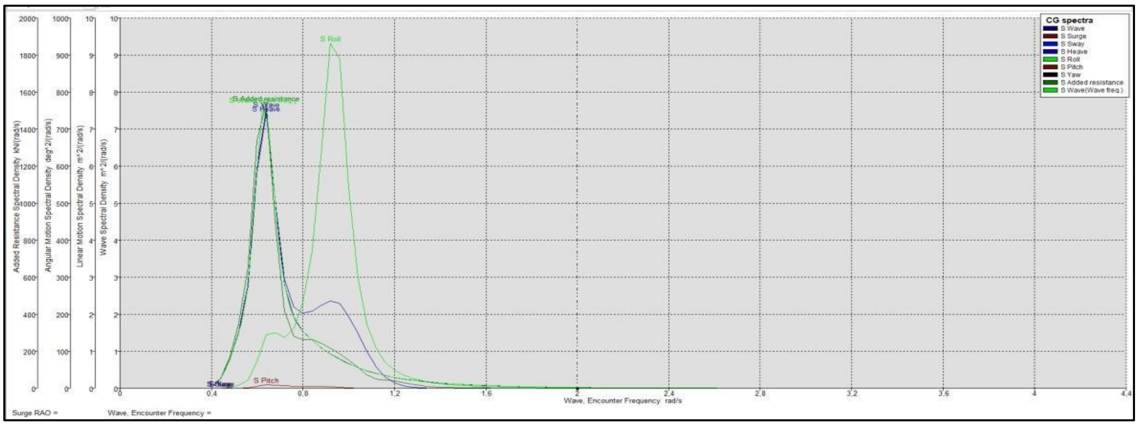

Fig. 12. Front Angle 270 Degree

Based on the data obtained in data processing, it can be seen that the high value of the wave frequency obtained at 90 and 270 degrees wave direction is relatively high. The value of the roll spectrum in the direction of 0 and 270 degrees is large and can cause rolling on the ship. In the direction of 0 and 270 degrees, the wave resistance can be reduced by the ship.

4. Conclusions

Based on the results of data processing using Maxsurf, it can be concluded that the direction of the waves on the ship greatly affects the degree of balance of the ship. It can be seen that there is not much rolling in the direction of waves 0 and 270 degrees, while in the direction of waves 90 and 180 degrees, it is most likely that the ship will be rolling. Critical damping can reduce the force of freedom.

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