The Effect of Waves on the Maneuvering Characteristics of Ferry Vessel

Mansyur Hasbullah*[1], Daeng Paroka[1], Hanisa[1]
[1]Departemen of Naval Architect, Faculty of Engineering, Hasanuddin University
Jl. Perintis Kemerdekaan km. 10 Tamalanrea - Makassar, 90245
*Email: mansyur_hasbullah@yahoo.com

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Abstract

Wave is one of the natural phenomena that give effect to the cruise ship. The energy produced by the wave is very large that makes the ship turn directions. Therefore the turn has an error coordinates of starting point of ship. Deviation of the coordinates has made a farther distance and increase of fuel consumption, so the operational costs being higher. The research would predict the drift angle, the ship speed and large of rudder angle to be used after the ship got the influence of wave. Taking into account the motion of surge, sway, yaw. Simulations performed by using Delphi software, with variations of the height of wind H_w = 0.5 m, 1 m, 1.5 m and 2 m, flatness of the wave = 0.01, the speed of the wind ratio U_w/U= 0 – 20 m/s and wave direction coming $\psi_w = 0^o$ - 180^o on the side of the ship . The biggest of drift angle happened on 50^o wave direction. The biggest of rudder angle happened on 110^o wave direction while the maximum ship speed happened on 160^o wave direction.

Keywords: *Drift angle, maneuvering, rudder angle, ship speed, wave*

1. Introduction

1.1. Background

Ship maneuvering characteristics is influenced by several external factors: which include two important things which are sea state and state of the waters. This needs to be understood in view of the limited ability of the vessel to face the weather and sea waters, as well as the movement of the ship in the water also requires sufficient space. One of the external factors that influence is a wave. Meanwhile, internal factors (ship) is the weight of the vessel, the dimensions of the vessel, hull, engine (propeller), and rudder system (steering system).

The influence of the waves against the yaw motion stability is very important to be analyzed, especially while the ship to be operating in wave conditions at far greater length than the length of the ship and the ship's position is on the slopes of the wave. This condition is known by the phenomenon of surf - riding. In this condition, the yaw motion of the vessel can be unstable despite steering control is given. The vessel will turn and move with the waves, the ship position will ultimately sideways against the waves and eventually sink or reversed.

2. Theoretical Basis

2.1. Ship Motion

The motion behavior of the ship is divided into six-degrees of freedom (six-degree of freedom), namely surge, sway, yaw, heave, roll and pitch are shown in Fig. 1.

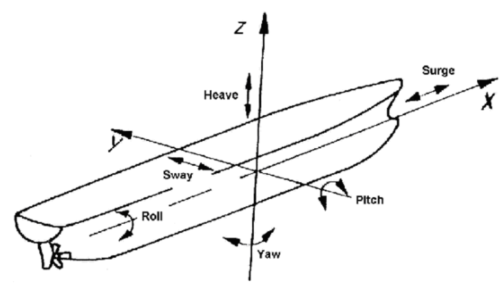

Figure 1. Six degrees of freedom of movement of ships

The motions definition of Fig. 1 are described below:

- *Surge* is one of the translational motion where the vessel experienced on the *x* axis, the motion is not the case of mass change of the vessel and so there is no point bouyancy protects force.

- *Sway* is one of the translational motion of the ship experienced displacement in the *y*-axis (move sideways), on the motion of the ship's center of gravity has not changed or fixed so there is no change of the mass of the ship and the point also bouyancy not move and no force protects.
- *Yaw* is one of the rotational motion of a moving ship spins on the *z* axis so that if observed from the above it can be seen moving ship rotates.
- *Heave* is a movement up and down the ship vertically.
- *Roll* is wobbling motion which is the rotational motion of the ship on the *x* axis.
- *Pitch* is the angular movement of the rotating fore and aft of the transverse axis of the ship, along the y-axis.

2.1. Steering Ship

Rudder is a device to change direction ship by changing the direction of fluid flow that result in changes of ship direction. The steering wheel is placed at the threshold of the back hull (stern) behind the propeller driven mechanically or hydraulically from the bridge by moving steering wheel. Because of the important role of steering the foresail then set in SOLAS International Convention in Chapter II-1 Construction regarding subdivision and stability, machinery and electrical installations.

Rudder has the ability to maintain direction in accordance with the command. Since the requirements for passenger ships steering the wheel of one type of blade that is widely used is the type of Van Amorengen with specifications between -35° to 35° and rudder employment rate of 2.3°-7° each second. The minimum requirement for an average rate rudder is determined by the classification society. It is required that the rudder can be moved 35° from the port towards 35° to starboard in no more than 30 seconds.

For steering blade construction drawings can be seen in Table 1.

Table 1. Standard maneuverability ship by IMO (Resoluiton MSC 137 (76) 2002)

Ability	Test	Creiteria
Turning ability	Turning test with max. Rudder Angle (35 deg.)	Advance <4.5 L Tactical diameter <5.0 L
Initial turning ability	10°/Z-test 10°	Distance ship rudder run before execution <15 L2nd
Stopping ability	Stopping a stern test with full	Track reach <15 L
Course-keeping and yaw-checking ability	10°/Z-test 10°	1st overshoot <(L/U) (10s <L/U, 30s)10° <(30s <L/U)20° 2nd overshoot <(L/U <10s)25° <17.5 + 0.75 (L/U)) (10s <L/U <30s) ° <(30s <L/U)40°

The maneuver used in the experiments at sea following a recommendation from the trial maneuvering code of ITTC (1975) and the IMO circular MSC 389 (1985). IMO also determine the appearance of some of the results on posters, bucklet and maneuvering bucklet in IMO Resolution A.601 (15) (1987).

3. Methodology

3.1. Location and Time Research

This research was conducted in the laboratory of hydrodynamics, Naval Architect Department, Faculty of Engineering, University of Hasanuddin.

The vessel which were used as a sample of this research is Ro-Ro Ferry KMP SULTAN Murhum 300 GT with the primary measure shown in Table 2.

Table 2. Dimensions of the vessel

No	Top size	Coefficient Form	Size Rudder	System Propulsion
1	LOA = 36.4 m	Cb = 0.63	Hr = 1.559 m	D = 1.1
2	LWL = 35.73 m	Cm = 0.986	lR = 1.331 m	N = 4
3	LBP = 31.5 m	Cw = 0.886	N = 2	n = 8.578
4	B = 8.7 m	Cp = 0.804	yR = 2.55 m	YP = 2.55
5	H = 2.65 m		xr = -15.75 m	
6	T = 1.65 m			
7	V = 10.5 Knot			

Source: PT. IKI (Shipbuilding Industry Indonesia)

4. Result and Discussion

4.1. Coefficient of Hydrodynamics

For calculating the coefficient of hydrodynamic hull according to Yoshimura and Ning Ma with semi-empirical method, which considered 3 (three) movement of ships that are surge, sway and yaw. To run the program, required input data from the vessel which is the object of research. The procedure or display the data input on the Delphi program is as follows:

- Input ship main dimensions

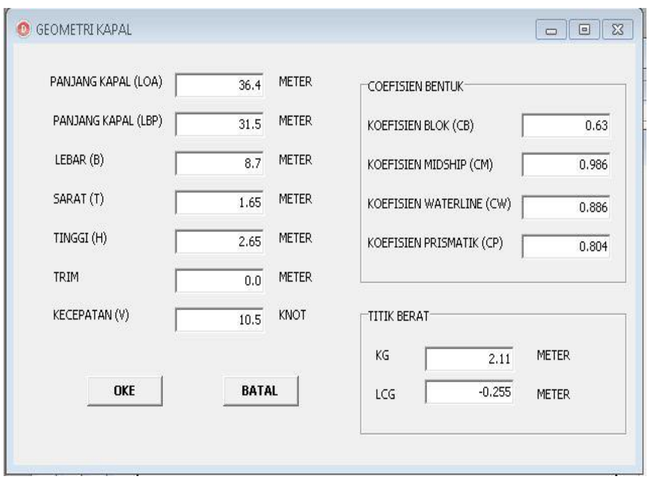

Figure 2. Display form data input ship main dimensions

- Once the input data completed, then input the data section (section width, height and wide section section) as well as waveform data (height and flatness of the wave)

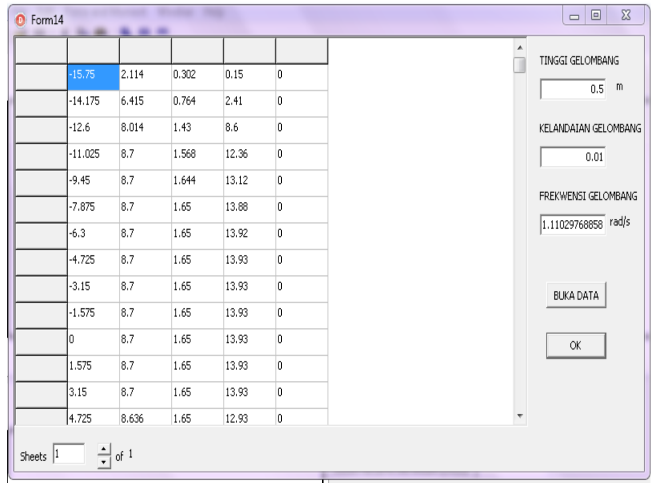

Figure 3. Display form data input section and wave

- The next step is a data input propulsion

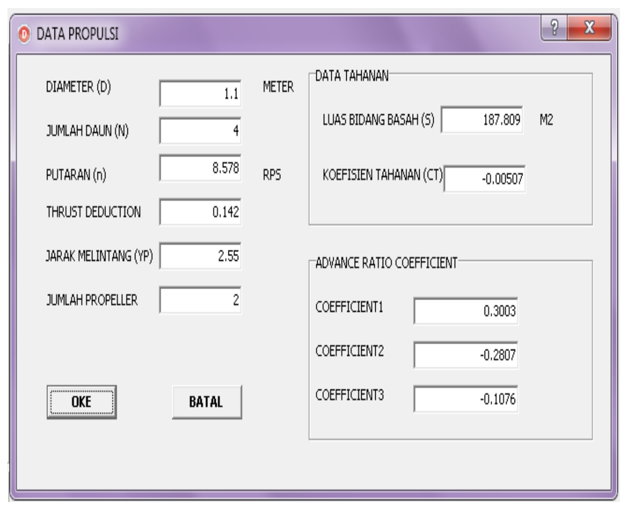

Figure 4. Display form data input propulsion and ship resistance

- Furthermore, the boat input steering data

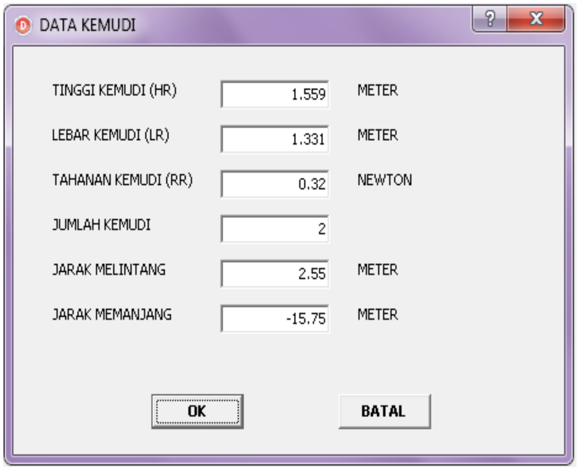

Figure 5. Display form data input steering the boat

- Input field catch the wind

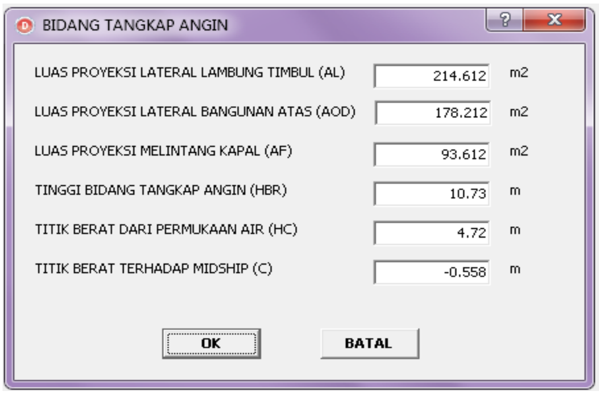

Figure 6. Display form data input capture wind field

- To get the predictions of the hydrodynamic coefficients derived motion maneuver the ship then used formulas according to Yoshimura and Ning Ma (2003) conducted by the method of semi - empirical. At Delphi software coefficients hydrodynamic hull open window, press ok then the figures showing coefficient forces and moments hydrodynamic hull.

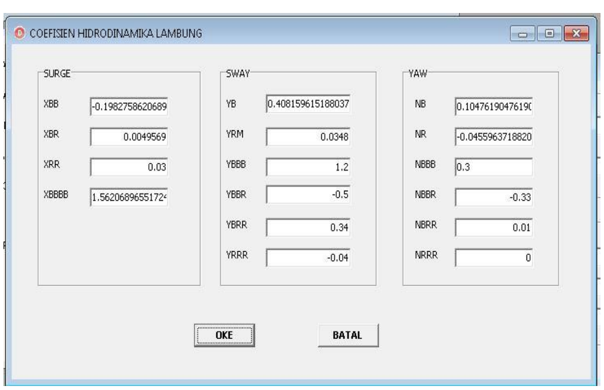

Figure 7. Display form calculation results hydrodynamic force and moment coefficients hull

- The result of the calculation of force and moment coefficients in the direction of the wind surge, sway and yaw as a function of the direction the wind comes against the hull are given in the form of a curve as shown in the figure below.

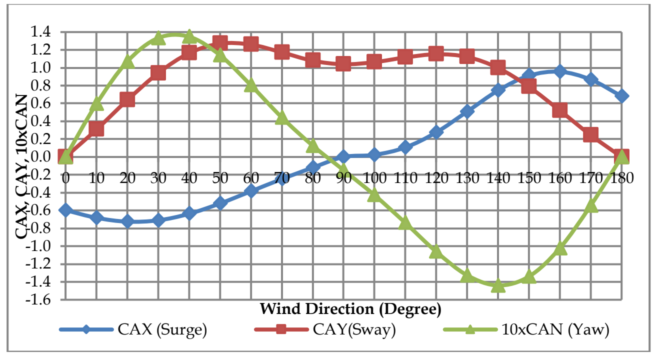

Figure 8. Relationship comes wind direction with wind force and moment coefficients on the motion of surge, sway and yaw

Fig. 8 shows the relationship between the direction of the wind coming with the wind force and moment coefficients. The coefficient in question is the coefficient of wind forces and moments on the motion surge (CAX), coefficient of wind forces and moments on the motion sway (GEO) and the coefficient of wind forces and moments on the motion of yaw (CAN) were calculated using the Fujiwara equation with a higher degree of accuracy than previous methods, using physical components, the flow resistance longitudinal, cross flow resistance, lift and induced obstacles. For surge coefficient (CAX) on the wind direction 90º, CAX = 0 and tend to fall in the direction of the wind coming 80º - 0º i.e. CAX = -0.11944 up -0.5962. Then came the wind rose in the direction 100º - 180º, ie CAX = 0.0239 to 0.681 and the highest value of CAX at 160º direction the wind comes, namely 0.955. For coefficient sway (CAY) in the direction of the wind coming 00 value ie 0 and tends to rise to the direction the wind comes 10º - 50º, the GEO = 0 to CAY = 1.27.

The greatest value also occurs in the direction the wind comes 50º is 1.27 and tend to fall in the direction of the wind coming 60º - 90º, the GEO = 1.259 up to 1,038. While on the direction the wind comes 100º - 120º, up the GEO = 1.062 to 1.151. For directions coming wind 130 ° - 180 °, GEO value tends to fall, namely CAY = 1.121 to the direction of the wind 180º come back with value 0. For coefficient yaw (CAN) in the direction of the wind coming 0º - 40º tends to rise namely to CAN CAN = 0.595 = 1.347. At the direction of the wind coming 50º - 140º, the value of which fell CAN CAN = 1.14 to CAN = -1.439. And come up again in the direction of wind 150º - 170º, i.e. CAN CAN = = -1.339 to -0.544.

4.2. Effects Against Wave Drift Angle

Based on the purpose of this study was to know the effect of the waves against the ship maneuvering characteristics and get the value of drift angle, rudder angle which affects the speed of the ship. To obtain these results used wind speed and wave height is varied and carried out simulations using the Delphi program. Wave height (Hw) used was 0.5 m, 1 m, 1.5 m and 2 m. Wind speed used is 0 m / s, 10m / s and 20 m / s while the direction of the wind come together with the wave direction which ranges from 0º-180º with 10º intervals can be seen in Figs. 4-9.

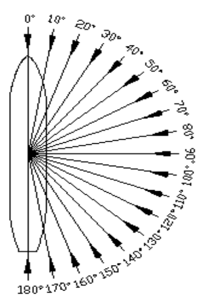

Figure 9. Directions came the wind and waves on the hull

Variables that influence on the size of the ship in addition to wind drift angle is the wave. The amount of drift angle obtained by simulation with the results as in the Fig. 10.

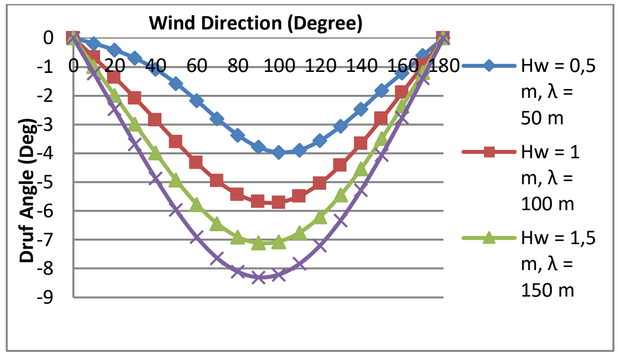

Figure 10. Drift angle various incident angle of wind for wind speed of 0 m/s

Fig. 10 shows the comparison of the magnitude of the drift angle and wind angle of incidence ranging from 0 - 180° for a wide variety of wave height and wind speed of 0 m/s. For the blue curve illustrates the wave height (Hw) of 0.5 m and the flatness of 0.01 wave. Furthermore, 1 m, 1.5 m and 2 m with the same wavelength flatness of 0.01. The value *drift angle* (deg) ship rectilinear motion obtained on the ship, and the magnitude of each drift angle in seen in Table 3.

Table 3. Table drift angle when the wind speed of 0 m/s

Hw, λ	Come Wind Direction								
	100°	110°	120°	130°	140°	150°	160°	170°	180°
0.5 m, 50 m	- 3.97	- 3.88	- 3.56	-3.06	- 2.47	- 1.81	-1.21	-0.60	0.00
1 m, 100 m	- 5.70	- 5.48	- 5.04	-4.42	- 3.62	- 2.80	-1.89	-0.95	0.00
1.5 m, 150 m	- 7.06	- 6.75	- 6.20	-5.45	- 4.53	- 3.49	-2.36	-1.19	0.00
2 m, 200 m	- 8.21	- 7.83	- 7.20	-6.33	- 5.27	- 4.06	-2.76	-1.39	0.00

Hw, λ	Come Wind Direction									
	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
0.5 m, 50 m	0.00	-0.19	-0.41	-0.70	-1.08	-1.58	-2.17	-2.80	-3.37	-3.79
1 m, 100 m	0.00	-0.67	-1.36	-2.09	-2.84	-3.61	-4.33	-4.96	-5.42	-5.68
1.5 m, 150 m	0.00	-0.99	-1.98	-2.99	-3.98	-4.93	-5.77	-6.44	-6.90	-7.11
2 m, 200 m	0.00	-1.23	-2.46	-3.69	-4.87	-5.97	-6.91	-7.64	-8.11	-8.30

The influence of wave height on the ship drift angle is greater then the angle of the wave height will be even greater drift boat. Drift angle changes because of the influence of the force surge, sway and yaw moment can be seen in Figs. 11 - 13.

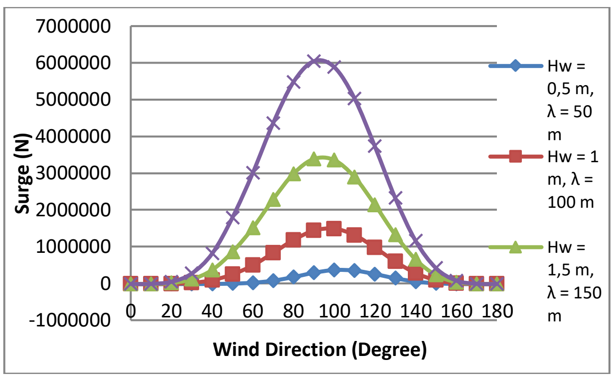

Figure 11. Force surge came various angles of wind for wind speed of 0 m/s

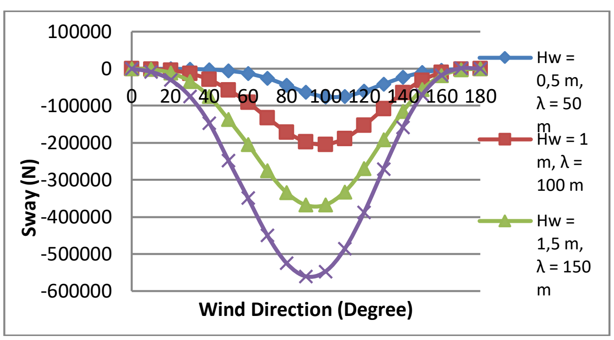

Figure 12. Force sway various angles to the wind speed wind comes 0 m/s

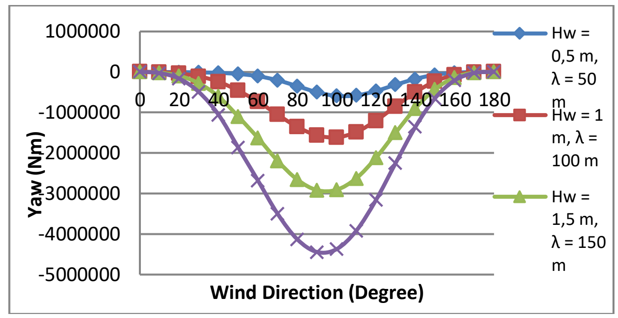

Figure 13. Yaw moment came various angles of wind for wind speed of 0 m/s

From Figs. 11 until 13, indicating that the value of the force surge, sway and yaw moments have influence to change the drift angle on the ship. Force sway and yaw moments have an enormous influence on the change of angle of drift that consists of several elements of the hull, steering, wind and waves. The greater the value of the force sway and yaw moment of the magnitude of drift angle deviation is also getting bigger. This can be seen in a value force sway and yaw moment when the wave height of 0.5 m and 1 m primarily at an incidence angle of 100º waves.

For the wave height (Hw) of 0.5 and 1 m deviation The drift angle when the incidence waves angle 100º. As for the wave height of 1.5 m and 2 m primarily at 90º angle of attack. Similarly to the largest deviation drift angle when the incident angle 90º waves. For the value of each - each element of the hull, rudder, propeller, wind and wave force surge, sway and yaw moment can be seen in the figure below.

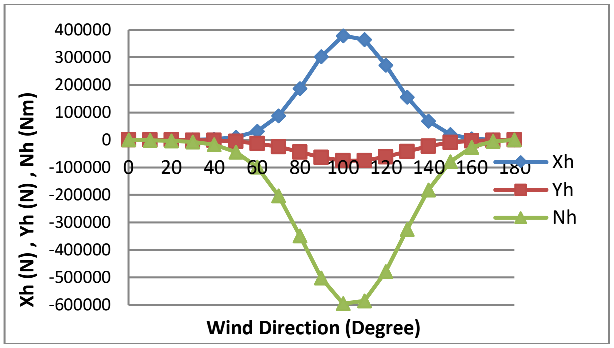

Figure 14. Forces and moments coming hull various angles to the wind speed wind 0 m/s

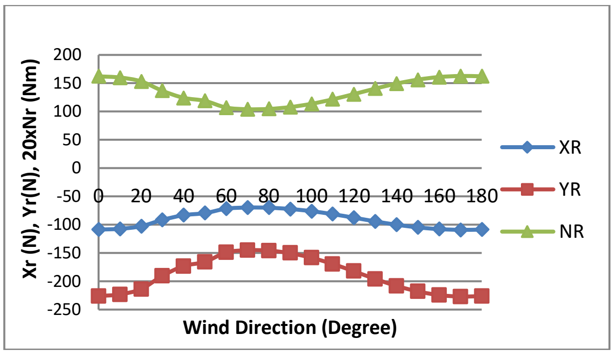

Figure 15. Forces and moments came wind rudder various angles to the wind speed of 0 m/s

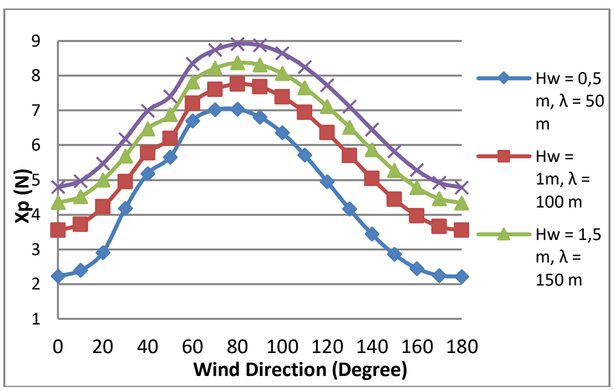

Figure 16. Propeller-force wind came various angles to the wind speed of 0 m/s

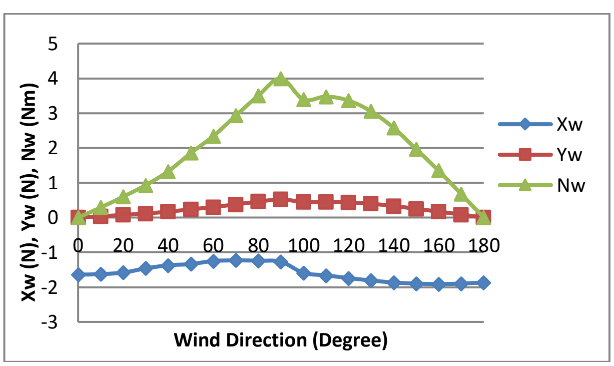

Figure 17. Forces and moments come breeze wind various angles to the wind speed of 0 m/s

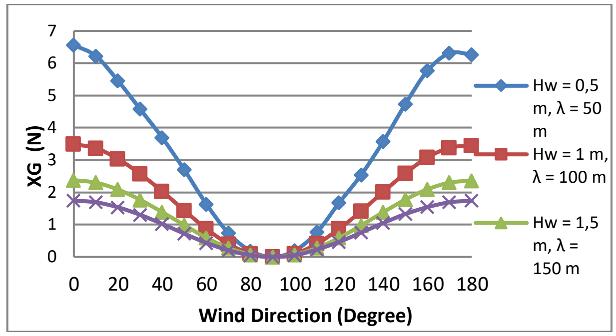

Figure 18. Force surge wave wind coming at various angles to the wind speed of 0 m/s

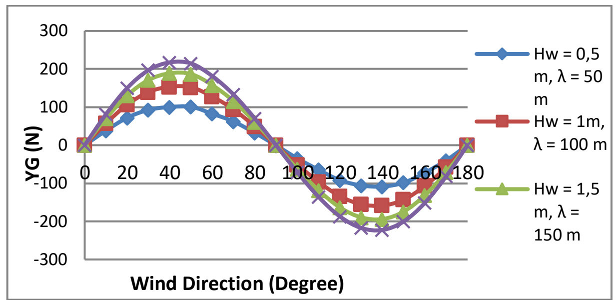

Figure 19. Force sway wave coming at various angles to the wind speed wind 0 m/s

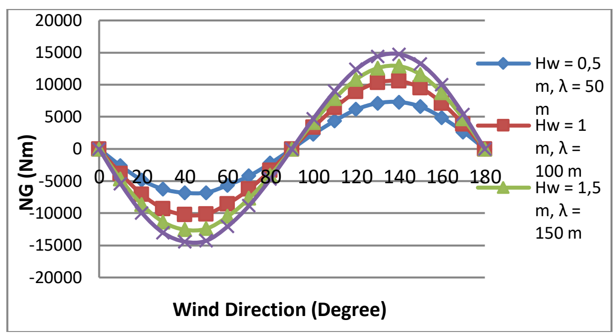

Figure 20. Yaw moment various angles coming wave of wind for wind speed of 0 m/s

Description of the forces and moments acting on the ship direction of surge, sway and yaw caused by the hull, propeller, rudder wind and waves at various angles come to the ship. Surge force caused by the hull tend to be larger than the force surge caused by the waves. Therefore, the surge toward the hull more dominant force than the force of the waves. Force surge due to gastric primarily at an incidence angle of 90 ° while the wind force due to surge during the largest wave came wind direction 180°.

The force due to sway due to wave at the direction the wind comes less than 90° is positive and at greater than 90° is negative while the force of the hull is negative. The maximum yaw moment due to the hydrodynamic hull moments occur at an angle of 90 ° while the wind came the moment of the wave reaches a maximum value at an incidence angle of 140º wind. Forces and moments acting on the vessel hull and wave as a result it can be concluded that the force in the direction of sway and yaw moment in the direction to have a dominant influence on drift angle and steering angle.

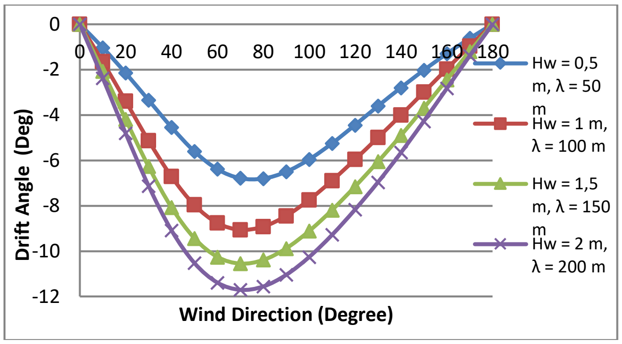

Figure 21. Drift angle at various angles to the wind speed of wind came 10 m/s

Fig. 21 shows that the effect of high waves against the ship drift angles are greater the higher the waves the boat drift angle will be even greater. At the time of wave height (Hw) of 0.5 m and a 80º angle of incidence of wind drift angle of the total of -6.803º. For the wave height of 1 m The drift angle when the angle of incidence of wind drift angle 70º where -9.059º. As for the wave height (Hw) of 1.5 m and 2 m The drift angle when the incident angle of 70º wind.Once the process is done constantly running, so that each magnitude drift angle(deg) vessels for a wide variety of length and height of the waves presented in Fig. 21.

Drift angle changes because of the influence of the force surge, sway and yaw moment when the wind speed of 10 m / s can be seen in Figs. 22 - 23.

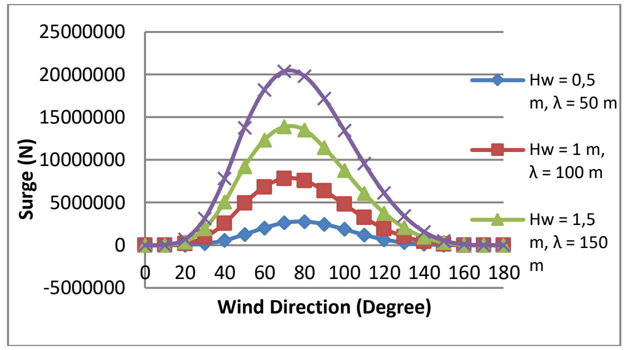

Figure 22. Moment came surge at various angles to the wind speed of wind 10 m/s

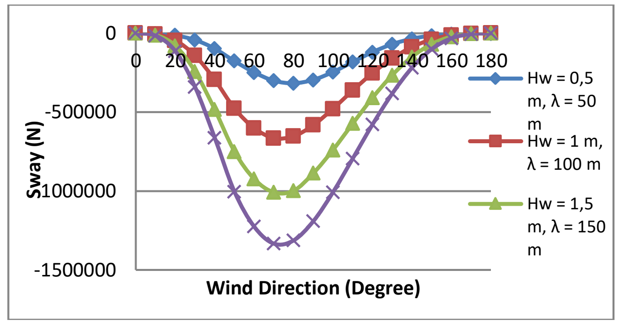

Figure 23. Yaw moment came at various angles to the wind speed wind 10 m/s

From Figs. 22 to 23, indicating that the value of the force sway and yaw moment of the direction of the wave direction, where the force of sway and yaw moment consists of elements (hull, propeller, rudder, wind and waves). Force sway and moments yaw affects the drift angle is evident from the above picture is good value force sway and moments yaw, the greater the incidence angle of the wind against the ship, then the value of the force sway and moments yaw getting bigger until the angle of incidence of wind equal to 800 for the high waves of 0.5 m. In the incident angle is greater than 900 wind and wave height of 1 m, 1.5 m and 2 m, the value force sway and yaw moment is getting smaller with increasing incidence angle of the wind against the ship. When the wind incidence angle equal to 180º, the value force sway and yaw moment is equal to 0. And the value force sway and yaw moments occur in the largest wave direction 80º to wave height of 0.5 m. While the greatest value force sway and yaw moment to wave height of 1 m, 1.5 m and 2 m occurs when the incident angle of 70º wind.

It can be concluded that the value of drift angle and value force sway and yaw moment proportional. The greater the value of the force sway and yaw moments then drift angle will also increase and vice versa the smaller the value force sway and yaw moments then drift angle will also be smaller.

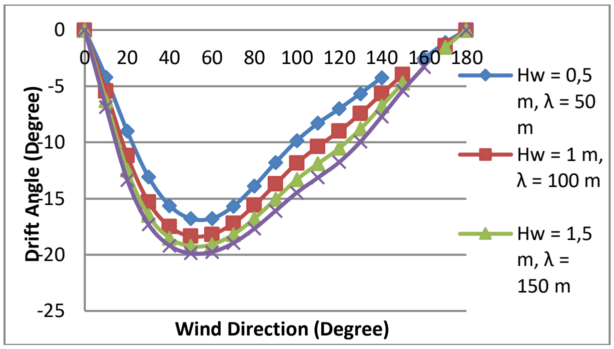

Figure 24. Drift angle at various angles to the wind speed of wind came 20 m/s

From Fig. 24, wind speed of 20 m/s wind the greater the incidence angle of the boat, then the boat drift angle increases. In the incident angle of wind 0 - 50º, the greater drift angles with increasing incidence angle of the wind against the ship. When the incident angle of the wind 60 - 170º then drift angle smaller vessels. As for the direction the wind comes, the amount of drift angle 180º ship is 0.

Based on the figure to the incident angle of wind 0 - 180°, or in other words the direction the wind comes either from the stern and bow of the drift angle in the direction of the wind coming. Because the forces and moments acting on the vessel due to hull, propeller, rudder, the wind and the waves can be concluded that the force direction of sway and yaw moment in the direction of a very dominant influence on the drift angle changes.

The influence of wave height on the ship drift angle is greater wave height then the angle of drift boats will be even greater. At the time of wave height of 0.5 m and a 50º angle of incidence of wind drift angle of the total of -16.785º. Wave height of 1 m for drift angle when the angle of incidence largest wind drift angle 50º where -18.348º. As for the wave height of 1.5 m and 2 m The drift angle when the incident angle of 50º wind.

Once the process is done constantly running, so that each magnitude drift angle (deg) vessels for a wide variety of high and long waves when the wind speed of 20 m/s are presented in Fig. 25.

Drift angle changes because of the influence of the force surge, sway and yaw moment when the wind speed of 20 m/s can be seen in Figs. 25 - 27.

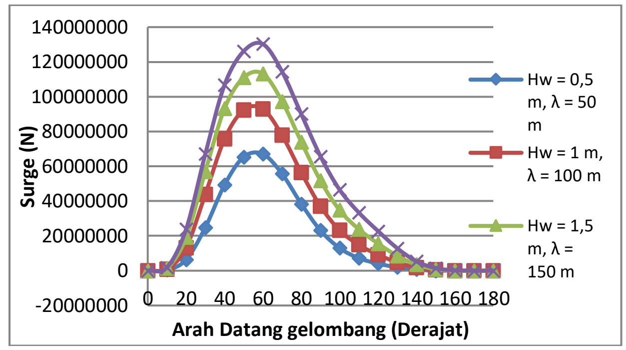

Figure 25. Force surge at various angles to the wind speed of wind came 20 m/s

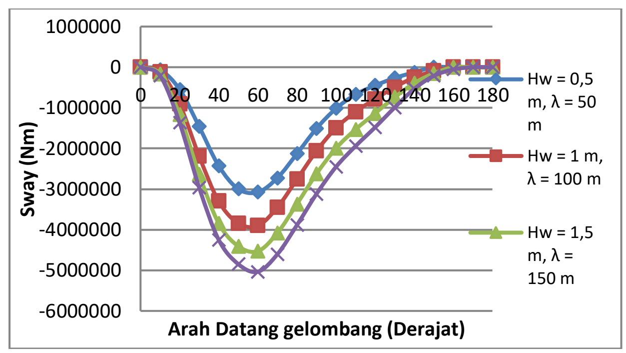

Figure 26. Force sway at various angles to the wind speed of wind came 20 m/s

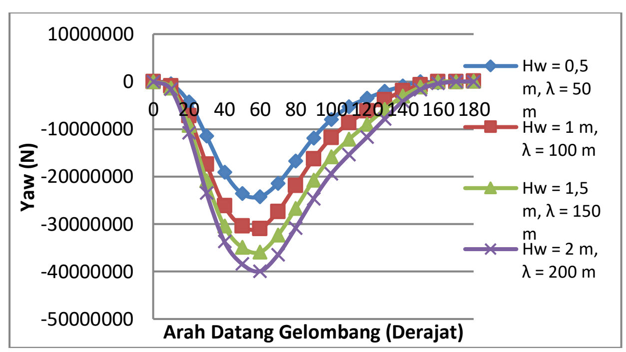

Figure 27. Yaw moment came at various angles to the wind speed wind 20 m/s

Figs. 26 and 27, indicating that the value of the force sway and yaw moment of the direction of the wave direction, where the force of sway and yaw moment consists of elements (hull, propeller, rudder, wind and waves). Force sway and moments yaw affects the drift angle is evident from the above picture is good value force sway and moments yaw, the greater the incidence angle of the wind against the ship, then the value of the force sway and moments yaw getting bigger until the angle of incidence of wind equal to 60º to high waves of 0.5 m. In the incident angle greater than 70º wind and wave height of 1 m, 1.5 m and 2 m, the value force sway and yaw moment is getting smaller with increasing incidence angle of the wind against the ship. When the wind incidence angle equal to 180º, the value force sway and yaw moment is equal to 0 °. And value force sway and yaw moments occur in the largest wave direction 60º for all variations of the wave height.

It can be concluded that niali drift angle and value force sway and yaw moment proportional. The greater the value of the force sway and yaw moments then drift angle will also increase and vice versa the smaller the value force sway and yaw moments then drift angle will also be smaller. Drift angle difference is significant as variations in wind speed, the greater the wind speed boats drift angle will be greater so that the steering angle required to maintain the trajectory of the vessel will also be greater.

4.3. Effects Against Wave Drift Angle

The amount of rudder angle obtained by simulation performed in the Delphi program. As a result of the simulation rudder angle when the wind speed of 0 m/s is shown in Fig. 28.

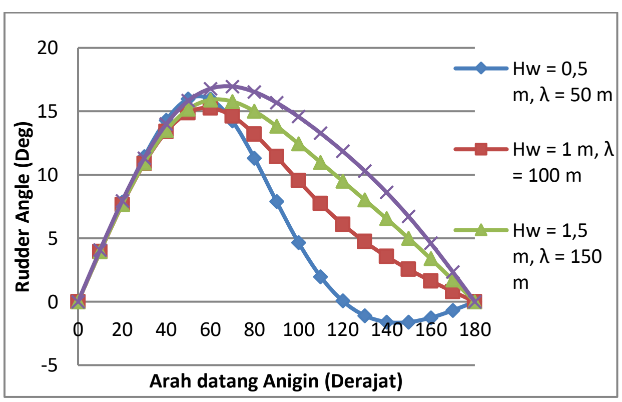

Figure 28. Rudder angle figure at different angles to the wind speed wind comes 0 m/s

To maintain the trajectory of the ship due to the drift angle that occurs due to the waves then, the wheel should be tilted up to certain angle so that the movement of the ship remains on track or path specified. Fig. 28 for the comparison of the amount of rudder angle (deg)ships and wind angle of incidence ranging from 0-180° degreesfor varying wave height of 0.5 m, 1 m, 1.5 m and 2 m and a constant wind speed is equal to 0. For the blue curve illustrates the wave height of 0.5 m, then red 1 m, green and purple 1.5 m 2 m and the flatness of 0.01 wave. From the picture above can be seen that the larger the incident angle of the wind, the greater the value of rudder angle ranging from 0-60º, As for the direction the wind comes 70-180º rudder angle values tend to be smaller. For the wave height of 1 m, 1.5 m and 2 m direction rudder angle from the direction the wind comes 0-180ºopposite the direction of the wind coming. For the wave height of 0.5 m on the current direction of the wind coming 0-130º directions rudder angle in the opposite direction to the direction came the wind while the wind came 140-180º rudder angle toward the direction of the wind coming. Each size of rudder angle can be seen in Fig. 29.

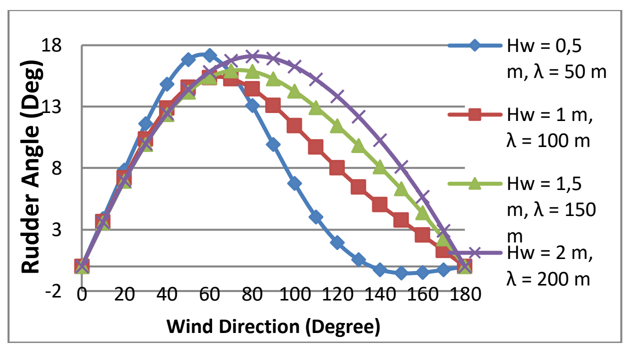

Figure 29. Rudder angle at various angles to the wind speed of wind came 10 m/s

From Fig. 29 can be seen that the larger the incident angle of the wind, the greater the value of rudder angle ranging from 0-60º for a wave height of 0.5 m. As for the wave direction 70-180º rudder angle values tend to be smaller. For the wave height of 1 m, 1.5 m and 2 m direction rudder angle coming from the direction of wind 0-80º the greater it is. Meanwhile, when the direction of the wind coming 90-180º directions rudder angle gets smaller.

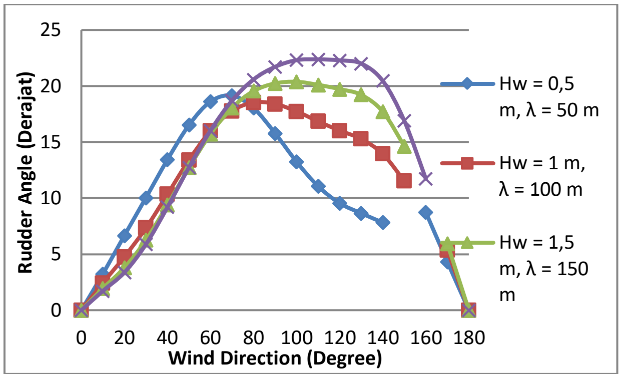

Figure 30. Rudder angle at various angles to the wind speed of wind came 20 m/s

From Fig. 30 it can be seen that the greater the incidence angle of the wind, the greater the value of rudder angle ranging from 0-60° for wave height of 0.5 m. As for the wave direction 70 - 180° rudder angle values tend to be smaller. For the wave height of 1 m, 1.5 m and 2 m direction rudder angle coming from the direction of wind 0 - 80° greater. While at the time the direction the wind comes 90 - 180° directions rudder angle gets smaller.

Waves can cause the yaw motion of the vessel to become unstable and the steering wheel can not control the yaw movement of the vessels, especially when the ship operates at the waves coming from the stern of the ship (following seas). Because the motion of the ship can not be controlled then the ship will tend to turn so that sideways to the waves and finally the loss of stability (sink).

4.3. Effect of Waves Against Ships Free

The speed and wave direction have a very significant influence on the operational speed of the ship.

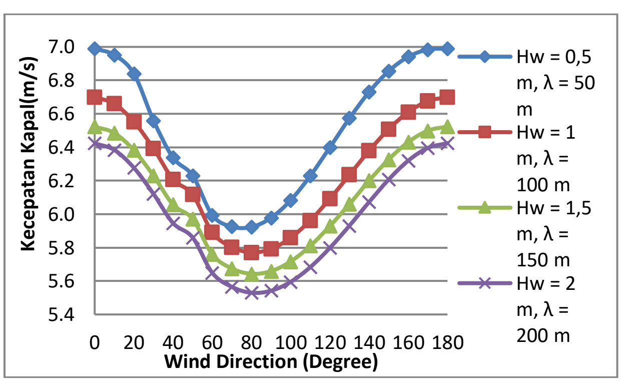

Figure 31. Speed vessels in various wind incidence angle and wind speed of 0 m/s

Fig. 31 illustrates the direction the wind comes 0 - 80°, the greater the incidence angle of the wind, the speed of the ship will be smaller. As for the direction the wind comes greater than 80°, the speed of the ship was also greater with increasing incidence angle of the wind against the ship. By the time the wind speed ratio and the speed of the ship is equal to 0, the ship's speed increases from the first speed boat - first with 5.4 m/s. When there is a change in the drift angle, the speed of the vessel decreased where the gradient of the decline the longer - getting smaller.

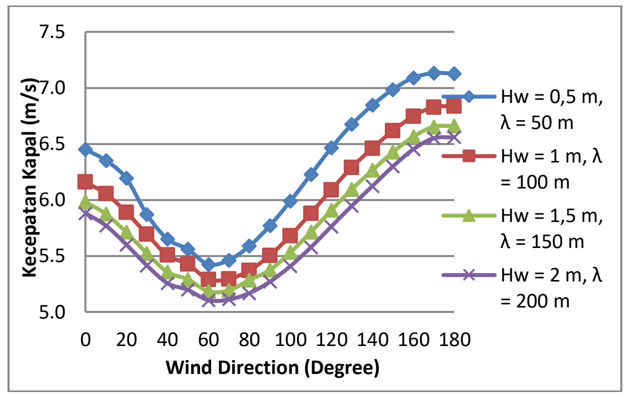

Figure 32. Vessel speed at various angles come wind and wind speed of 10 m/s

Fig. 32 depicts the wind speed ratio and the speed of the vessel resulting drift angle and yaw rate is never stable. Changes drift angle and yaw speeds cause the vessel speed will always vary in each direction of the wind coming towards the ship. By the time the wind direction came less than 60° or in other words the ship operates on the bow wave, ship resistance increases due to surges that can cause the boat speed is significantly reduced.

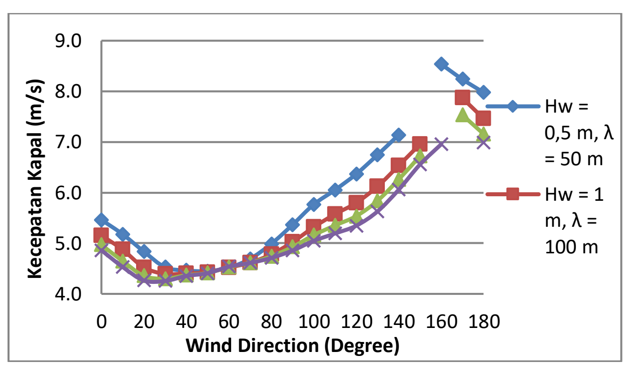

Figure 33. Pictures of the ship's speed at various angles come wind and wind speed of 20 m/s

From Fig. 33 illustrates that in the coming wind direction 0-20º, the greater the incidence angle of the wind, the speed of the ship will be smaller. As for the direction the wind comes 30-180º the greater the wind coming toward the ship's speed is also getting bigger.

Factors that affect the speed of the ship is a force surge and sway arising from the hull, propeller, rudder, wind and waves. The value of the surge and sway force is inversely proportional to the speed of the ship. In this case, if the value force big surge and sway the speed of the ship will be smaller, and if the value force small surge and sway the speed of the ship will be even greater. Values have great influence on the value of the surge force is the value of the force caused by the hull, while the forces and moments due to the propeller, rudder, wind and waves tend to be smaller.

5. Conclusion

From analysis results which are obtained in previous calculation, it can be concluded that:

- Height wave and length wave give the influence the characteristics of maneuvering of ferry ship. Length and height of large wave result the value move the small surge.
- Biggest changed value drift become of the direction come the wave 50º and high of wave 2m with the value of biggest drift = -1.9 > 8º. For puddle angle corner become of the direction come the wave 110º and height of wave 2 m, where angle corner puddle to gyrate = 22.3820.
- the biggest ship speed become of direction come the wave 160º and high of wave 2 m equlto 8.535 m/sec.

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