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Ship's maneuverability in strong wind

IM Namkyun*, Van-luong TRAN**

* Professor, Division of Maritime Transportation System, Mokpo National Maritime University, Mokpo 571-2, Korea
** Division of Maritime Transportation System, Graduate school of Mokpo National Maritime University, Mokpo 571-2, Korea

ABSTRACT: *This paper deals with effect of wind forces and moment acting on the training ship SAE NURI. The results of drift angle and counter rudder angle due to wind effect are calculated by using the static equilibrium method especially with nonlinear mathematical expression, and then the critical wind velocity is found out. The given results can be applied directly to T/S SAE NURI in handling under the wind condition and used for merchant ships as a referential tool.*

KEY WORDS: *Ship's maneuverability, drift angle, critical wind velocity.*

1. Introduction

Many studies and papers relate to effect of wind to ship's maneuverability have been published, Hasegawa and Im (2003) introduced comparison method in which wind forces and moment were compared with rudder and thrusters forces and moment respectively. More recently, Lee (2007) used linear mathematical expression and equilibrium equation to calculated critical wind velocity.

The given results in this study can be applied directly to T/S SAE NURI in handling under the wind condition and used for merchant ships as a referential tool or utilized as educational materials.

2. Mathematical ship model

In this study, the training ship SAE NURI was adopted as a ship model, according to Katsuro Kijima (2000), the equation of ship maneuvering motion is introduced as follow:

$$(m'+m'_x)(\frac{L}{U})(\frac{\dot{U}}{U}\cos\beta-\dot{\beta}\sin\beta)+(m'+m'_y)r'\sin\beta=X' \quad (1)$$

$$(m'+m'_y)(\frac{L}{U})(\frac{\dot{U}}{U}\sin\beta+\dot{\beta}\cos\beta)+(m'+m'_x)r'\cos\beta=Y' \quad (2)$$

$$(I'_{zz}+J'_{zz})(\frac{L}{U})(\frac{\dot{U}}{L}r'+\frac{U}{L}\dot{r}')=N' \quad (3$$

* namkyun.im@mmu.ac.kr, 061)240-7213

** vanluong_tran@yahoo.com

3. Critical wind calculation

With the relative wind on or abaft the port beam, all ships require starboard helm and vice versa. The closest approach to the wind as speed is reduced with full rudder on constitutes a critical wind angle. This angle is maximized by having the lateral center of area of the above-water parts ahead of the lateral center of area of the below-water parts. If the above-water lateral center of area is far behind that of the hull, especially if the rudder effectiveness is low, the critical angle will become very small and the ship will actively seek the wind.

3.1 Counter rudder angle and drift angle

To calculate the critical wind velocity, equilibrium equations are suggested as H. Yasukawa's method , it means that when the ship can maintain her course or ship can keep its position in one fixed point, total the external forces and moments acting on ship are equilateral and the sum of those forces and moments must be zero, respectively as follow:

$$0=Y'_H(\beta)-(1+a_H)F'_N(\beta,\delta)\cos\delta+Y'_W(U_W,\theta_W) \quad (4)$$

$$0=N'_H(\beta)-(x'_R+a_Hx'_H)F_N(\beta,\delta)\cos\delta+N'_W(U_W,\theta_W) \quad (5)$$

from equations (20), (21) with $F'_N\cos\delta$ is annulled we have:

$$(Y'_H+Y'_W)(x'_R+a_H x'_H)-(N'_H+N'_W)(1+a_H)=0 \quad (6)$$

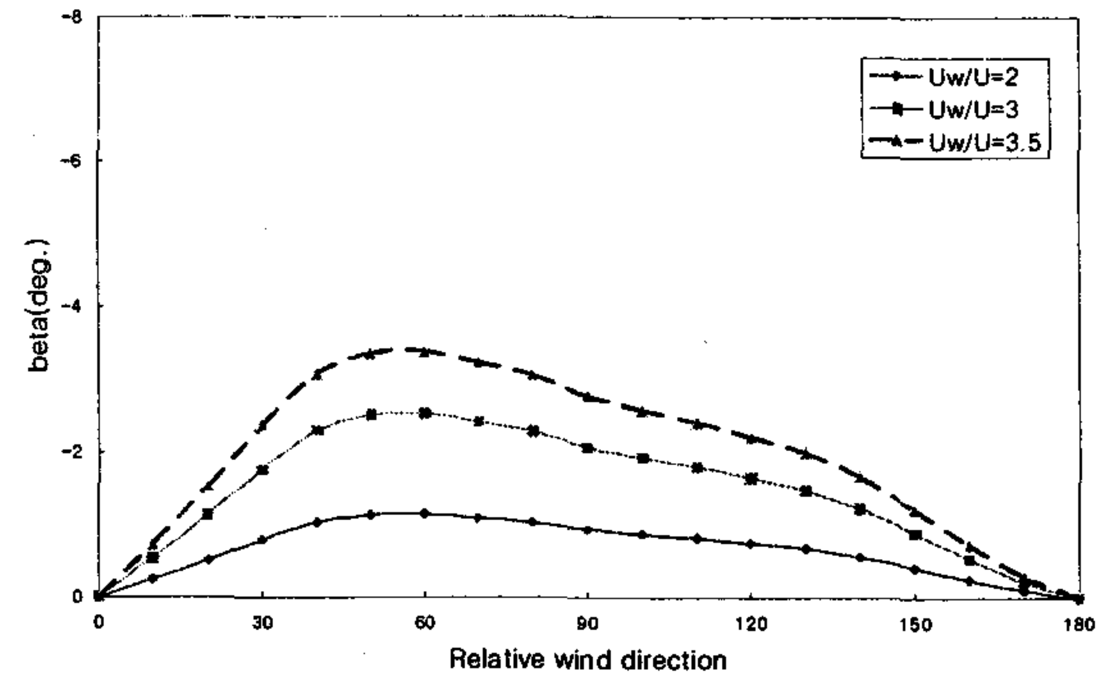

Fig. 1 Variation of drift angle due to relative wind velocity and direction

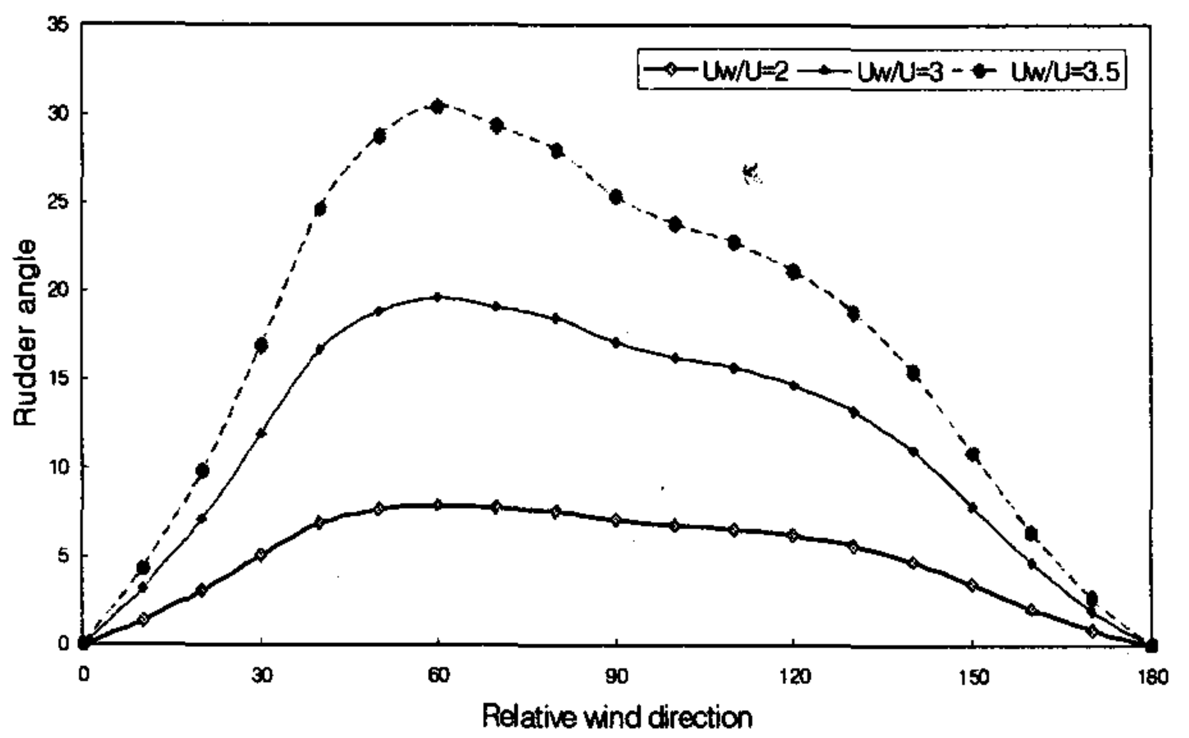

Fig. 2 Counter rudder angle due to relative wind

3.2 Critical wind velocity

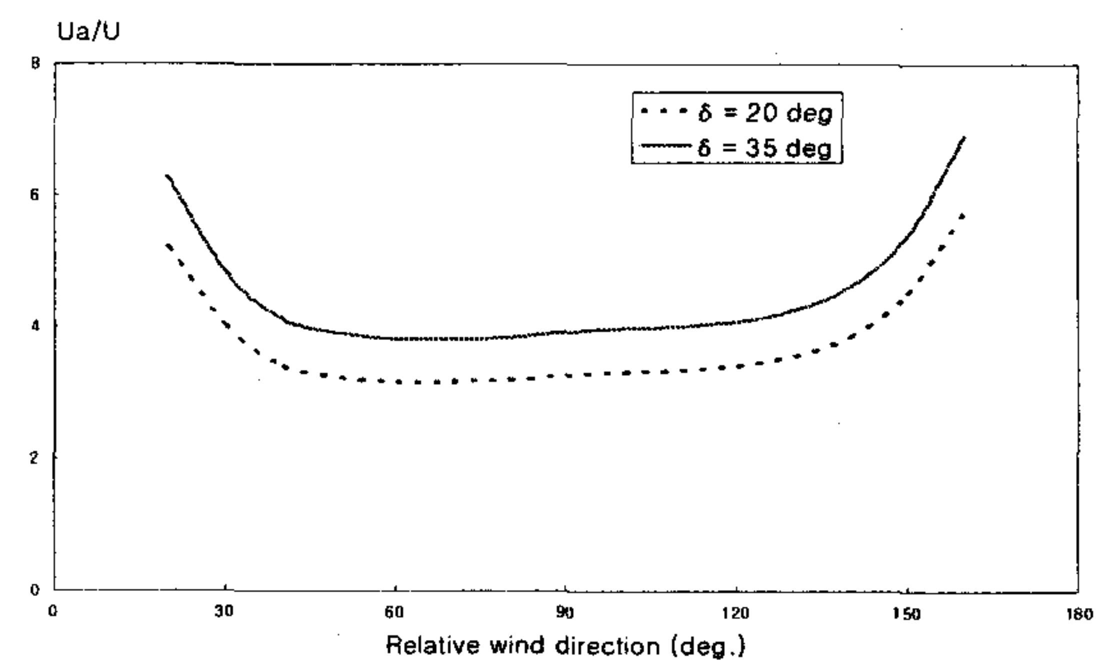

Fig. 3 Critical wind velocity with fixed rudder angle

When we take a look at Fig. 3, the model ship kept her course to one fixed point under the wind effect without any deviation by using rudder, the critical wind velocity in the vertical axis is equaled with each rudder angle value and depended on the relative wind direction.

In this study, non-linear expressions (such as equation 20) were used to compute hydrodynamic forces and moment so that the critical wind velocity is much more detail and seems to be satisfied.

When the vessel enter port areas or congested waters, the ship speed would be kept in certain reasonably value, for SAE NURI model, if her speed is less than 5 knots bow thruster should be used due to strong wind. We can easily recognize that with the assistance of bow thruster the value of counter rudder angle would be reduced about 20% by having a comparison with the result in Fig. 8.

4. Conclusion

In this paper, the results of drift angle and counter rudder angle due to wind effect were calculated by using the static equilibrium method to study the effect of strong wind to ship's maneuverability. Non-linear method was used to find out critical wind velocity in certain direction, it means that these results would be more satisfied than some data was published before, the combination of using both rudder and bow thruster was also mentioned in this study. The given results in this study could be applied directly to T/S SAE NURI in handling under the wind condition and used for merchant ships as a referential tool or utilized as educational materials.

However, more simulations should be carried out to verify these results when vessels are navigated under strong wind in open sea and in port areas. These works will be considered in the future.

References

[1] Isherhood, R.M. (1972), "Wind Resistance of Merchant Ship", Trans. RINA, vol.115, p.327-338.

[2] K. Kijima, Y. Nakiri and Y. Furukawa (2000), "On a Prediction Method for Ship Maneuverability", Proceedings of the CPMC 25, p.7.

[3] Hasegawa and Im, N. K (2002), "A Study on Critical of Wind Velocity of a Ro-Ro Passenger Ship Equipped with Side Thrusters in a Port", Journal of the Kansai Society of Naval Architects, Japan, No. 238, p. 71-76.

[4] H. Yasukawa "Application of a simulation Method for Ship Maneuverability to Maneuvering Booklet", vol. 107, p. 87-97.