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Araştırma Makalesi

Kayıcı Teknelerde İleri Hızın Yan Ötelenme Kuvveti ve Savrulma Momentine Olan Etkisi

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ÖZET

Bir çok alanda yaygın bir şekilde kullanılmakta olan kayıcı tekneler sakin suda seyretseler dahi deplasman tipi teknelerden farklı bir hidrodinamik davranışa sahiptir. Bu durum bu tip teknelerin manevra parametrelerinin hesaplanmasını cazip bir hale getirmektedir. Bu çalışmada farklı ilerleme hızları ve farklı hücum açılarında, kayıcı bir tekneye etki eden yan ötelenme kuvveti ve savrulma momentini URANS yöntemi yardımıyla elde edebilmek için sayısal statik sürüklenme analizleri yapılmıştır. Sonuçlar yan ötelenme kuvveti ve savrulma momentinin ileri hız değişiminden ciddi oranda etkilendiğini ve bunun sonucunda hidrodinamik türevlerin %50'nin üstünde bir değişime uğradığını göstermektedir. Bu nedenle özellikle ön kayıcı ve kayıcı bölgelerde, kayıcı teknelerin hidrodinamik türevlerinin doğru bir şekilde tahmin edilebilmesi için ileri hızın hesaplamalara dâhil edilmesi gerekmektedir.

Anahtar Kelimeler: Kayıcı tekne, statik sürüklenme, yan ötelenme kuvveti, savrulma momenti

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Research Article

The Effect of Forward Speed on Sway Force and Yaw Moment for Planing Hulls

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ABSTRACT

Planing hulls, commonly used in many areas, have different hydrodynamic behavior than the displacement hulls, even in calm water. Therefore, this makes the calculation of the maneuvering parameters of these hulls appealing. In the present study, a planing hull's numerical static drift analyses are performed using the unsteady RANS approach to evaluate the sway force and yaw moment at different angles of attack and advance velocities. The results show that the sway force and yaw moment are considerably affected by the advance velocity change, resulting in a variation of hydrodynamic derivatives above 50%. Thus, the forward speed should be included in the calculations for the accurate prediction of hydrodynamic maneuvering derivatives of planing hulls, especially in pre-planning and planing regimes.

Keywords: Planing hull, static drift, yaw moment, sway force

Article history: Received 27/10/2021 – Accepted 17/12/2021

1. Introduction

With the globalization of the world, time becomes very important in terms of transportation not only on highways and railways but also in a seaway. Due to this fact, the design of high-speed vessels is becoming an important topic both in commercial and military fields. Since the hydrodynamic lift force, which is dominant compared to the other forces, causes high translational and rotational motions in the planing regime, the determination of these hulls' hydrodynamic characteristics can be more complicated. Similar to this complexity of the vertical and lateral motions in calm water and waves, prediction of maneuvering performance of these hulls is deemed to be challenging.

Maneuvering is one of the most challenging problems in the hydrodynamic field and it is commonly investigated with experiments, numerical methods and empirical formulations. Due to several difficulties and lack of experimental facilities, numerical methods or empirical formulations are generally applied for the prediction of maneuvering performance of the vessels. The maneuvering motion of a vessel can be directly simulated or tested. However, direct maneuvering simulation is rather difficult, and it requires significant computational time. Hence, system-based approaches, which require a mathematical model, are used to predict the maneuvering performance.

Amongst the different mathematical models, the Abkowitz model (Abkowitz 1964), the MMG model (Yoshimura 2005, Yasukawa and Yoshimura 2015) and Norrbin's model (Norrbin 1970) are generally used for the maneuvering studies in the literature. In order to implement the mathematical models, the hydrodynamic derivatives should be calculated using static and dynamic techniques experimentally or numerically. Although the maneuvering studies in the literature generally focus on low-speed displacement types of vessels, there are also some studies for the planing hulls. The studies in this field were first conducted using experimental techniques. In this regard, Plante et al. (1998) performed pure sway, pure yaw and yaw with drift experiments to get a better insight into hydrodynamic forces and moments acting on a planing hull during maneuvering. In this study, draught, trim angle, forward speed and sway and yaw velocities were changed systematically to explore their effects on the forces and moments. The authors also developed a mathematical model to formulate maneuvering of the vessel. The static model tests' results were found to be in good agreement with those of dynamic results. Kimoto et al. (2004) and Katayama et al. (2005) conducted comprehensive experiments to understand the behavior of the planing hull during maneuvering. The authors firstly implemented the oblique towing test using three different planing hulls and measured the forces and moments acting on the hull. They also measured the trim angle, heel angle and sinkage during the oblique towing tests to understand the effect of these tests on running attitude. Moreover, they performed PMM tests for a better understanding of this phenomenon. The results showed that the running attitude was significantly affected by drift angle, forward speed and L/B (ratio of length and beam). Katayama et al. (2009) developed a simulation that is based on experimental data to understand the behavior of a high-speed trimaran during maneuvering. Kazerooni and Seif (2017) investigated the influence of the forward speed on hydrodynamic derivatives of a planing hull experimentally and it was found out that forward speed has a significant effect on hydrodynamic derivatives.

In addition to these studies conducted using the experimental methods, the empirical formulations can be used to predict the hydrodynamic response of the planing hull during maneuvering. Lewandowski (1994, 1995 and 1996) presented empirical equations to predict the trajectory of the planing hulls as well as roll, sway and yaw motion coefficients. These equations were derived from the experiments performed by Brown and Klosinski (1994a and 1994b). Since the empirical methods have some limitations, they can be mainly used for preliminary design studies. Due to this fact, some researchers tried to predict this type of motion using 2D and 2D+t methods to overcome this problem.

Morabito (2015) calculated the side forces and yawing moment acting on a planing hull by integrating wedge impact forces predicted by Judge (2000). The forces and moments were predicted when the heel angle equals zero and the results were compared with experimental data. The author obtained promising results at keel-wetted length 1.5-3 beams. In a recent study by Tavakoli and Dashtimanesh (2018), a 2D+t model was developed to simulate PMM tests for planing hulls. The results obtained using the developed model were found to be in good agreement with the experimental data. Ghadimi and Panahi (2019) investigated the effect of the step on forces and moments acting on the planing hull numerically during steady yawed motion. They found out that the yawing moment for non-stepped and stepped planing hulls were similar, while the sway force and roll moment predicted for stepped planing hulls were smaller than those of non-stepped planing hulls.

Within this framework, there are still several parameters (e.g., forward speed, loading coefficient, deadrise angle, etc.) that need to be investigated to understand their effects on the maneuvering of planing hulls. Also to the best of the author's knowledge, the studies investigating the maneuvering motion of planing hulls using the CFD approach are scarce in the literature. The main purpose of this study is to show the effect of the forward speed in the planing regime on sway force, yaw moment as well as related hydrodynamic derivatives (i.e., Y_V, $N_{V,}$ etc.) numerically.

The commercial CFD solver was used in numerical computations to discretize URANS (Unsteady Reynolds Averaged Navier-Stokes) equations using the finite volume method. The overset mesh technique was adopted to solve the flow field around the planing hull. The verification study was performed, and the results were validated with the available experimental data. Following this, the static drift simulations were conducted at different Froude numbers and drift angles to compute sway force and yaw moments and hence hydrodynamic derivatives.

2. Numerical Modelling

In this part, the numerical modeling is explained including 3 subsections. Firstly, the planing hull model is presented and the test matrix is explained. After that, detailed information about the numerical model is given such as physical modeling, boundary conditions, computational domain.

2.1. Planing Hull Model and Test Cases

In the present study, the C2 model, which is one of the Naples warped hard chine hulls systematic series, was used. The main particulars of the planing hull model and the 3D view are presented in Table 1 and Figure 1, respectively. The details of the planing hull model can be found in the study of De Luca and Pensa (2012). The test matrix is given in Table 2, and the schematic view of the cases is shown in Figure 2, where G and β represent the center of gravity and the angle of attack, respectively.

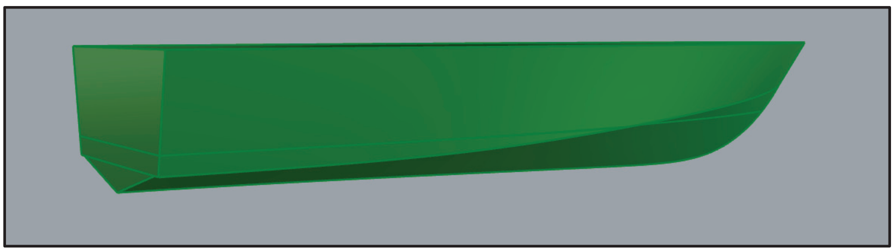

Figure 1. The 3D view of the planing hull model

Table 1. The main particulars of the model

Main Particular	Symbol	Unit	C2 Model
Overall Length	L_{OA}	m	2.611
Waterline Length	L_{WL}	m	2.400
Waterline Beam	B_{WL}	m	0.660
Draught	T	m	0.122
Wetted Surface	S	m^2	1.500
Longitudinal Center of Gravity	LCG	m	0.945
Vertical Center of Gravity	VCG	m	0.171
Displacement	Δ	kg	96.82

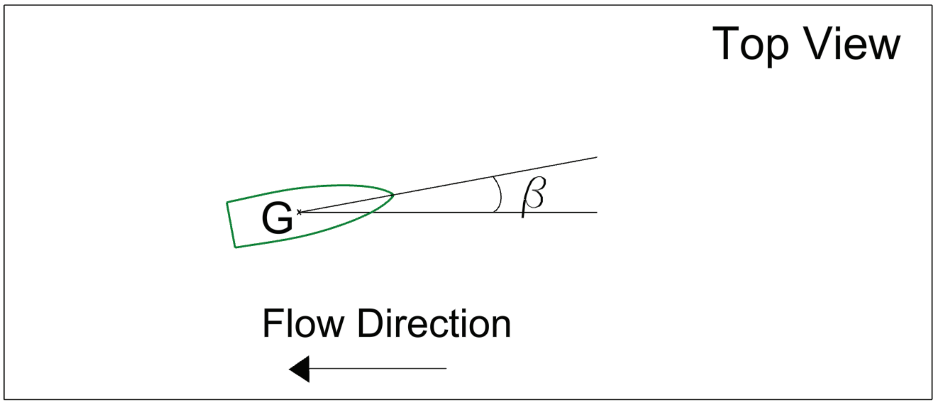

Figure 2. The schematic view of the test matrix

Table 2. The numerical test matrix

V (m/s)	Fn = $V/\sqrt{gL_{WL}}$ (-)	-β (degree)
2.5	0.515	0, 3, 5, 7, 10
3.0	0.618	0
3.5	0.721	0, 3, 5, 7, 10
4.0	0.824	0
4.5	0.927	0, 3, 5, 7, 10
5.0	1.030	0
5.5	1.134	0, 3, 5, 7, 10
6.0	1.237	0

It is noted that if β equals zero that means the vessel is symmetrical with respect to the centerline. Therefore, the outputs of these cases mean typical resistance simulations. The angle of attack (β) was selected and altered from 0 to 10 systematically in the pre-planing and the planing regimes as given in Table 2 to see the influence on the sway force and yaw moment.

2.2. Physical Model

In the numerical calculations, a commercial viscous solver, Star CCM+ 14.02, based on the Finite Volume Method (FVM) was used in all numerical simulations. The governing equations are the conservation of the mass and the momentum equations. The flow was assumed 3D, unsteady, fully turbulent, incompressible and Newtonian. To model the pressure-velocity coupling in the pressure field, SIMPLE (Semi Implicit Pressure Linked Equations) algorithm was utilized. The segregated flow model was selected and the VOF (Volume of Method) method was used in order to consider the free surface effects. So as to minimize the NVP (Numerical Ventilation Problem), the HRIC (High-Resolution Interference Capture) scheme was modified as proposed in the study of Mancini (2016).

Table 3. The main features of the physical model

Convectional discretization	Second-order
Temporal discretization	First-order
Turbulence model	k-ε
Pressure Link	SIMPLE
Interpolation option	Linear
Iteration per one time-step	10

Also, the k-ε turbulence model, which has been widely used in studies on planing hulls (e.g., Sukas et al. 2017, Kahramanoglu et al. 2020), was selected. The wall y+ was kept between 30 and 300 for this turbulence model as recommended by Siemens PLM (2019). The hull was presumed to be free to sink and trim in all analyses to replicate the experiment conditions. Therefore, DFBI (Dynamic Fluid-Body Interaction) module was activated to represent the 2 DOF (Degree of Motion) motion accurately. Time step resolution was set to 0.002 s by considering the ITTC (2011) recommendations. The main features of the physical model are presented in Table 3.

2.3. Computational Domain, Boundary Conditions and Mesh Generation

A rectangular computational domain was used to investigate the 2DOF motions of the planing hull. As shown in Figure 3, the right side of the computational domain was selected as pressure outlet, while the others were selected as velocity inlet. The computational domain dimensions were set to 7 B_{WL} down and 3 B_{WL} up from the overset region and 21 B_{WL} side to avoid any possible reflection or deflection of the free surface. The size of the computational domain and the boundary conditions were selected similar to other studies in the literature conducted using planing hulls (Mousaviraad et al. 2015, Kahramanoglu et al. 2021). During the simulations, the trim angle was measured around Y-axis and the hull was kept free up or down in Z-direction.

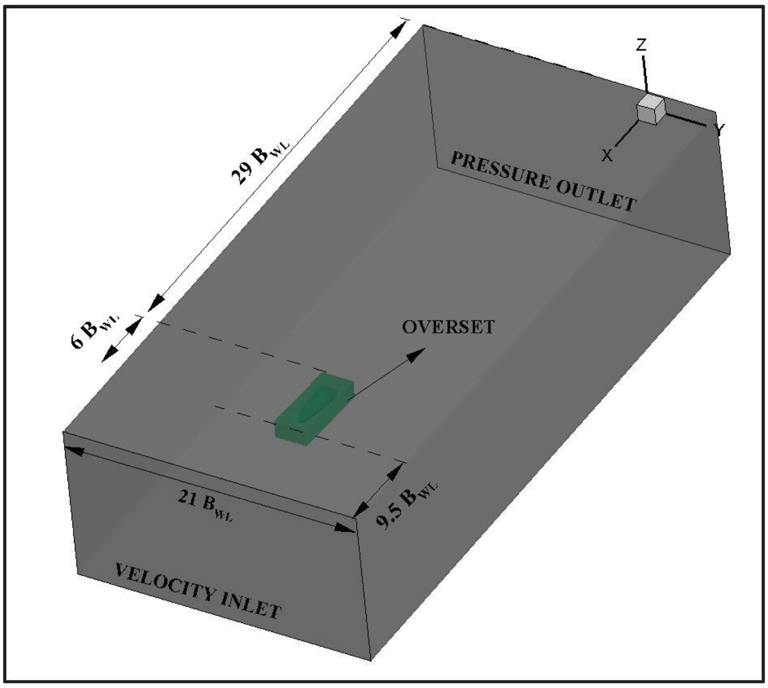

Figure 3. Representation of computational domain and the boundary conditions

The computational domain was discretized with a finite number of fully hexahedral elements. The overset mesh, which is one of the advanced meshing techniques, was applied to represent high translation and rotation motions accurately. In this mesh technique, the computational domain is divided into two main zones, namely the overset and the static. The mesh was refined from static to overset zones and the transition zone, which is also called the overlap zone, was created to provide a smooth transition between the cells. The grid resolution around the planing hull can be seen in Figure 4.

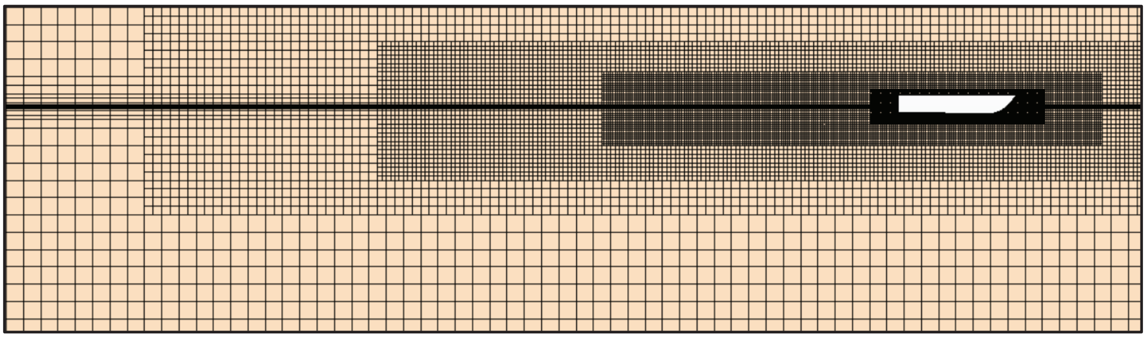

Figure 4. Grid structure around the planing hull

3. Verification Study

The verification study was performed using GCI (Grid Convergence Index) method, which is commonly used in numerical ship hydrodynamic studies (e.g., Duman and Bal 2019). The method based on Richardson Extrapolation (1910) was applied by following the methodology proposed by Celik et al. (2008) to determine the grid spacing and time step uncertainties. The detailed information can be found in related references (Stern et al. 2001, Celik et al. 2008).

In order to implement this procedure, three different solutions in terms of grid spacing and time-step are required. The refinement factors were selected as $\sqrt{2}$ and 2 for grid spacing and time step size, respectively. They were kept constant during the verification study. The forward speed was also kept constant at V=3.5 m/s (i.e., Fn = 0.721) and the angle of attack was set to zero. The element numbers and time step sizes are listed in Table 4.

Table 4. The element numbers and time step sizes

	Element Number	Time Step Size
Coarse	0.16×10^6	0.002 s
Medium	0.38×10^6	0.004 s
Fine	1.33×10^6	0.008 s

Figure 5 shows the effects of grid spacing and time step size on resistance and trim angle. The results for different grid spacing and time step resolution, as well as uncertainty percentage (%U) of the numerical solution, are given in Table 5. It should be also noted the iterative uncertainty was neglected since it is recessive among them (Larsson and Zou, 2014).

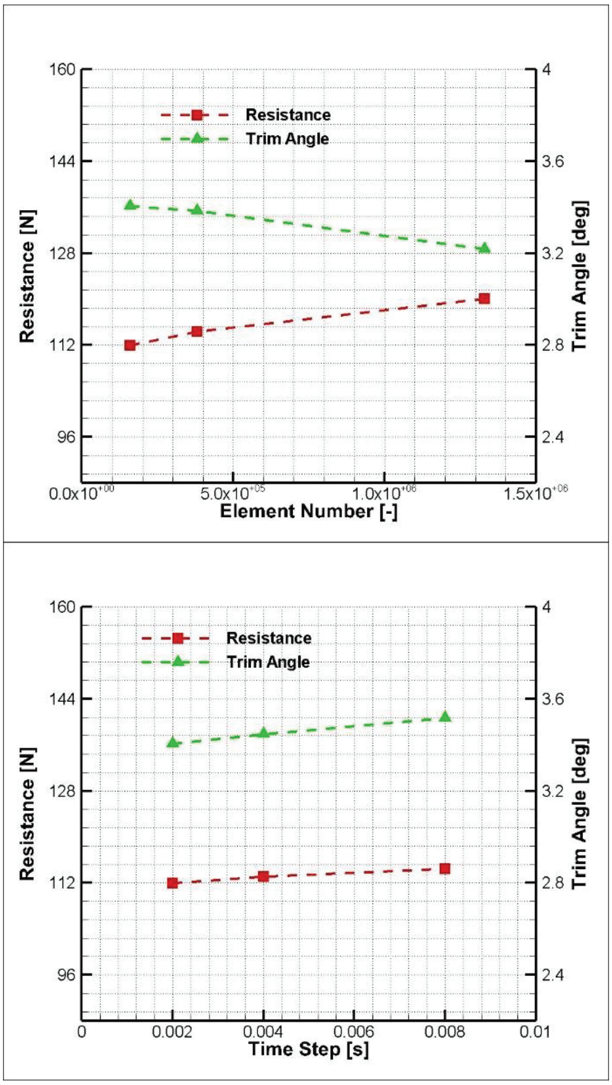

Figure 5. Results of the total resistance and trim angle in terms of element number and time step size (V= 3.5 m/s, β = 0°)

Table 5. The uncertainty values of resistance and trim angle in terms of grid spacing and time step

	Grid Spacing		Time Step	
	Resistance	Trim	Resistance	Trim
Fine	111.98	3.405	111.98	3.405
Medium	114.32	3.384	113.04	3.445
Coarse	120.04	3.217	114.38	3.516
R	0.409	0.126	0.799	0.563
U %	1.812	0.111	4.733	1.895

4. Results

In this part, the numerical results are presented in 2 subsections. Before presenting the results of the static drift simulations, the results of the towing simulations (zero drift angle) are given to show the consistency of the numerical model and validation purposes.

4.1. Towing Tank Analyses (Zero Drift Angle)

In order to show the accuracy of the numerical calculations, the numerical results are generally validated with the experimental data. Before the validation, the consistency of the numerical results should be checked for scalar values (e.g., resistance, trim, sinkage, etc.). In this regard, Figure 6 shows the change in resistance and trim values with time at Fn=0.721. As can be seen in Figure 6, convergence is obtained for resistance and trim values.

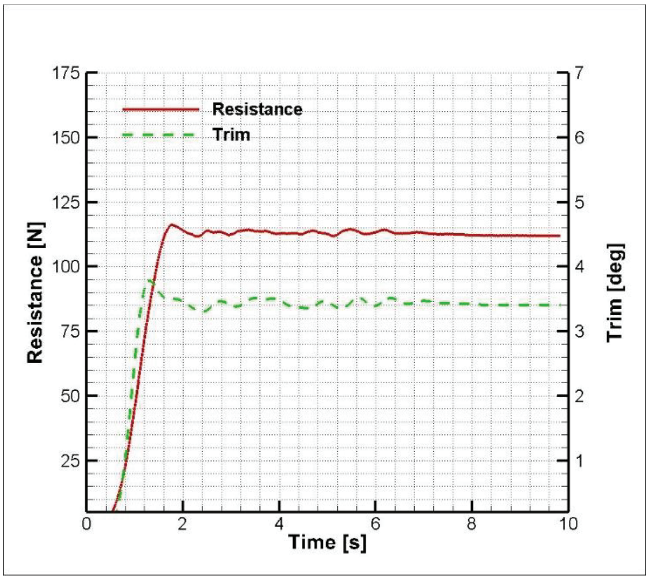

Figure 6. Time history of the resistance and trim values

Following this, as the numerical ventilation is one of the significant problems for the planing hulls, the volume fractions of the fluids should be checked to prove that there is no numerical ventilation under the hull. Figure 7 shows the VOF scalar scene at Fn=0.721. As shown in Figure 7, the air is not present under the hull.

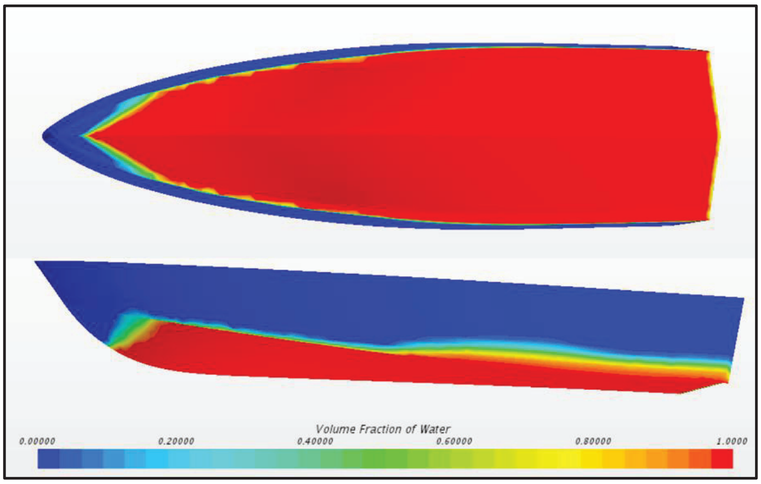

Figure 7. The volume fraction of the fluids

Figure 8 shows the free surface deformation calculated with the numerical solver are compared with the experimental data. As can be seen in Figure 8, the wave elevation is in good agreement with the experimental data with some differences at the peak values.

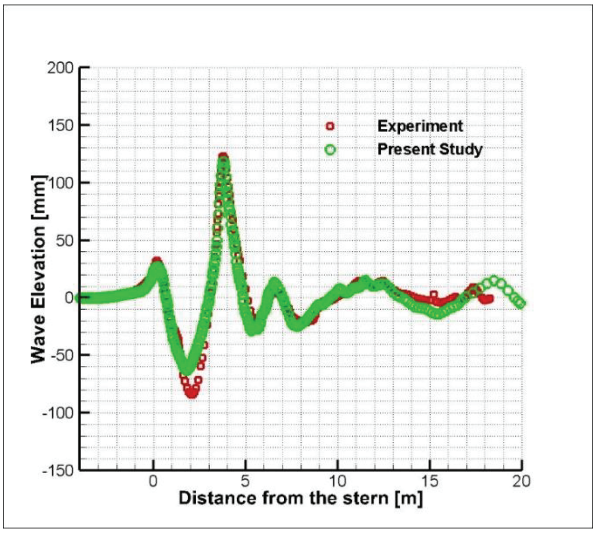

Figure 8. The wave-cut at (y/B = 1.704) (Fn = 0.721)

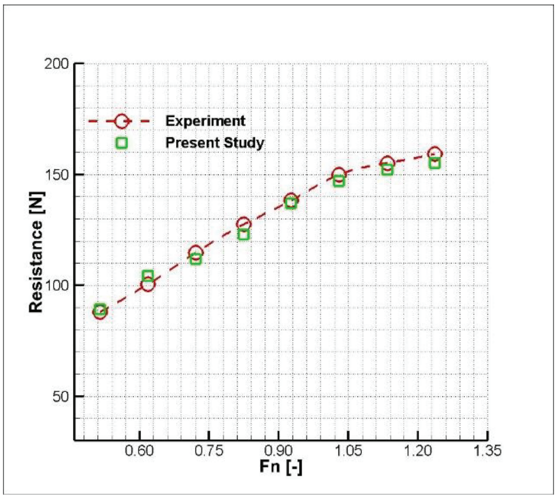

Figure 9. The comparison of the total resistance

The resistance, trim and dynamic wetted area values are also compared with experimental data in Figures 9 and 10, respectively. As shown in Figure 9, the resistance values correspond very well with the experimental data. With regard to trim values, the results match with the experimental data up to Fn= 0.75 where the pre-planing regime is expected to start. After Fn=0.75, there is around a 10% difference between the experimental results and CFD results. This might be because of the measurement difficulties during the experiments and/or the numerical modelling. Furthermore, similar to total resistance values, the dynamic wetted area values obtained from the numerical model are found to be in good agreement with the experimental data at different Froude numbers, as given in Figure 10.

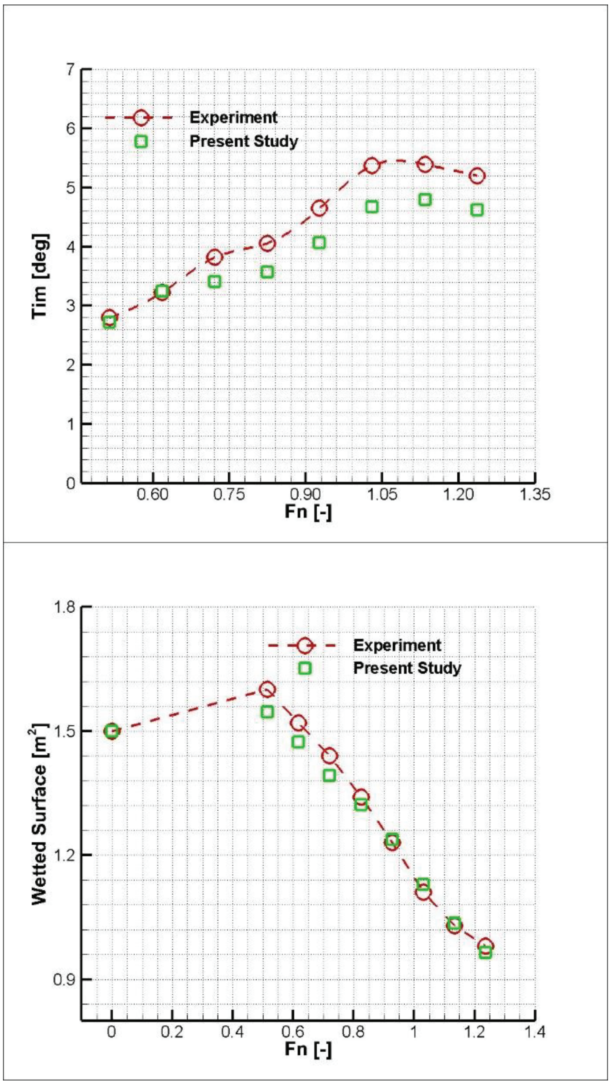

Figure 10. The comparison of the trim values and wetted surface areas

4.2. Static Drift Analyses

As shown in the test matrix (i.e., Table 2), the analyses were performed for different drift angles. Due to the lack of experimental data, the numerical results could not been validated. The measured forces and moment at different drift angles are non-dimensionalized using Equation (1), (2) and (3) similar to Katayama et al. (2005) to make a fair comparison.

$$X' = \frac{F_X}{\frac{1}{2}\rho L_{WL} T V^2} \tag{1}$$

$$Y' = \frac{F_Y}{\frac{1}{2}\rho L_{WL} T V^2} \tag{2}$$

$$N' = \frac{M_Z}{\frac{1}{2}\rho L_{WL}^2 T V^2} \tag{3}$$

Here; F_X, F_Y and M_Z depict the longitudinal force, the sway force and the yaw moment acted on the hull, respectively and ρ is the density. L_{WL} and T represent the load water line and draught, while V depicts the forward velocity. The total non-dimensional longitudinal force (X'), sway force (Y') and yaw moment (N') values are listed in Table 6 and plotted in Figures 11 and 12 at different angles of attack and forward speeds. Even the angles of attack are systematically altered, it is still observed that the forces and moments convergence as similar to Figure 6.

Table 6. Total non-dimensional longitudinal force, sway force and yaw moment values

	V = 2.5 m/s			*V = 3.5 m/s*			*V = 4.5 m/s*			*V = 5.5 m/s*		
-β (°)	X'	Y'	N'	X'	Y'	N'	X'	Y'	N'	X'	Y'	N'
3.0	0.0975	0.0241	0.0080	0.0641	0.0274	0.0054	0.0469	0.0241	0.0019	0.0346	0.0124	0.0018
5.0	0.0979	0.0423	0.0140	0.0654	0.0492	0.0096	0.0471	0.0413	0.0037	0.0346	0.0238	0.0027
7.0	0.1002	0.0649	0.0204	0.0670	0.0742	0.0134	0.0481	0.0594	0.0056	0.0357	0.0371	0.0037
10.0	0.1037	0.1058	0.0317	0.0714	0.1207	0.0177	0.0503	0.0877	0.0067	0.0365	0.0579	0.0042

As shown in Figures 11 and 12, the trend of non-dimensional sway force and yaw moments are different at different forward speeds. Therefore, it is expected that the hydrodynamic derivatives, which can be derived from static drift analyses, should be different. To calculate the hydrodynamic derivatives, a third-degree polynomial is fitted ($y = ax + bx^3$) to the non-dimensional values using the least square method for each case as follows:

$$v' = \frac{v}{V} = \frac{V\sin\beta}{V} = \sin\beta \tag{4}$$

$$Y' = Y_V'\, v' + Y_{VVV}'\, (v')^3 \tag{5}$$

$$N' = N_V'\, v' + N_{VVV}'\, (v')^3 \tag{6}$$

Here, v' is the non-dimensional sway velocity.

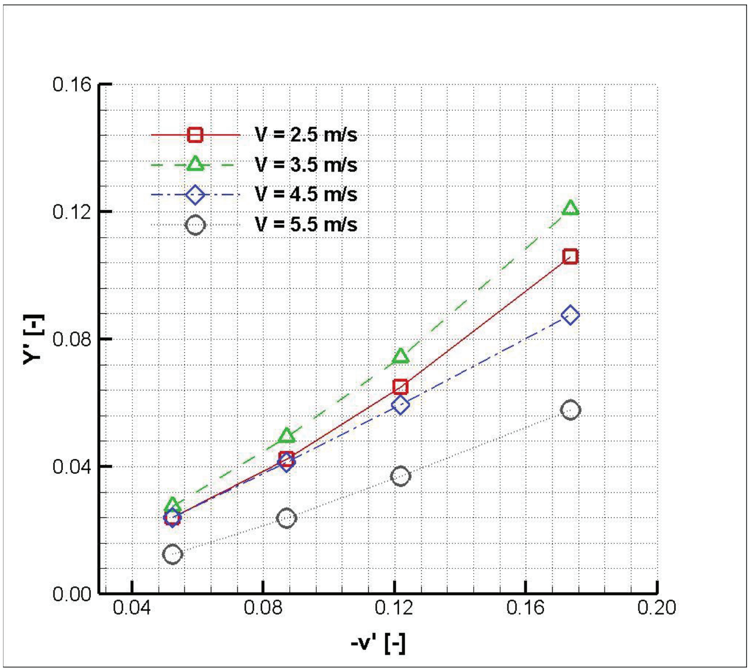

Figure 11. The non-dimensional sway forces for different forward speeds

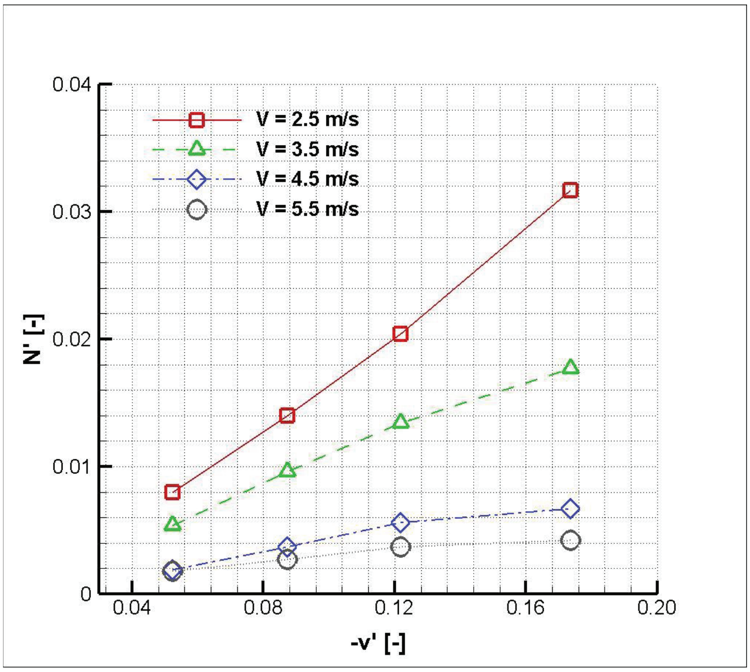

Figure 12. The non-dimensional yaw moments for different forward speeds

The effect of the forward speed on hydrodynamic derivatives is shown in Figure 13. It is obvious that the forward speed has a significant effect on hydrodynamic derivatives. The maximum changes in hydrodynamics derivatives are found to be 50%, 75%, 77% and 135% for Y_V', Y_{VVV}', N_V' and N_{VVV}', respectively. This shows that the hydrodynamic coefficients should be calculated for every different forward speed in pre-planing and planing regimes, unlikely to displacement type hulls (Yoon, 2009).

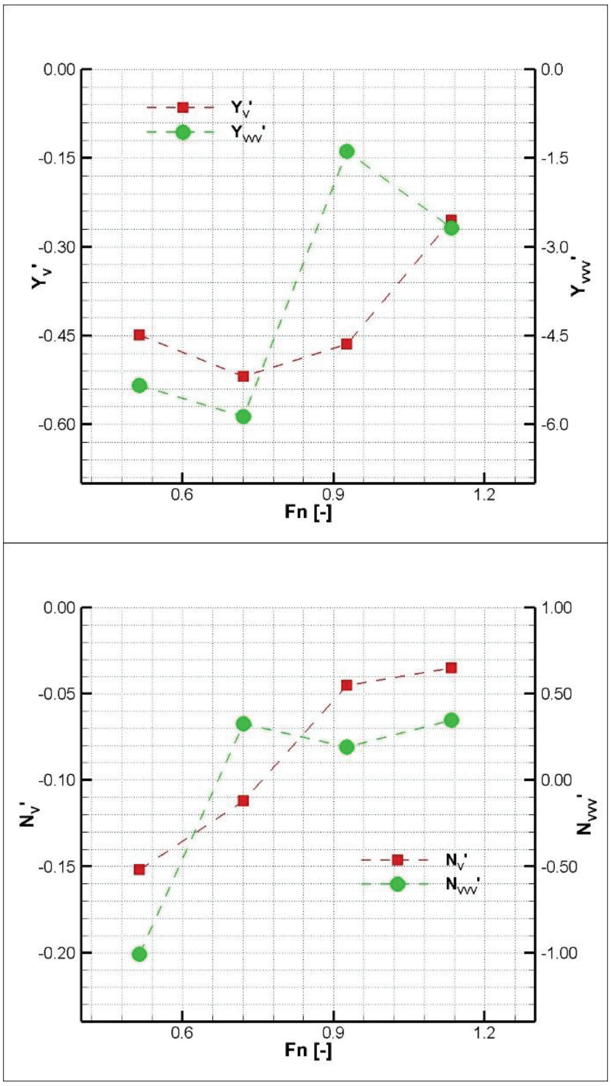

Figure 13. The change of the hydrodynamic derivatives with forward speed

5. Conclusions

In the present study, the effect of the forward speed on the forces and moments acting on the planing hulls in maneuvering was investigated numerically. Within this scope, the static drift analyses of a planing hull were conducted via the URANS approach in a wide range of forward speed. The validation and verification study was performed for resistance, trim and wetted area and a good correlation was found. The numerical analyses carried out in this study suggest some crucial results for the evaluation of hydrodynamic derivatives for maneuvering performance of planing hulls. The outcomes can be summarized by the following,

- The forward speed has a remarkable effect on both sway force and yaw moment in pre-planing and planing regimes.
- The hydrodynamic derivatives are strongly affected by the change of forward speed. Thus, the effect of forward speed should be taken into account for the calculations of hydrodynamic derivatives for the maneuvering performance of planing hulls.
- The results show that the mathematical models neglecting the forward speed may not be suitable for the accurate prediction of the maneuvering performance of planing hulls.

This study recommends that the mathematical model of maneuvering motion that is adopted for planing hulls should be reviewed by the researchers. Therefore, as future work, the effects of the forward speed on other hydrodynamic derivatives will be investigated with the aid of PMM analysis to reach a general conclusion.

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References

Abkowitz, M.A., 1964. 'Lectures on Ship Hydrodynamics Steering and Maneuverability Technical Report', Technical Report Hy-5. Hydro and Aerodynamic Laboratory, Lyngby, Denmark.

Brown, P.W. and Klosinski, W.E., 1994a. 'Directional Stability Tests of Two Prismatic Planing Hull', Stevens Institute of Technology, US Coast Guard, Hoboken, New Jersey.

Brown, P.W. and Klosinski, W.E., 1994b. 'Directional Stability Tests of a 30 Degree Deadrise Prismatic Planing Hull. Stevens Institute of Technology', US Coast Guard, Hoboken, New Jersey.

Çelik, I., Ghia, U., Roache, P., Fretias, C. J., Coleman, H. and Raad, P. E., 2008. 'Procedure for Estimation and Reporting of Uncertainty Due to Discretization in CFD Applications', J. Fluids Eng., vol. 130, no. 7, pp. 078001-078001–4.

De Luca, F. and Pensa, C., 2012. 'Experimental Investigation on Conventional and Unconventional Interceptors', Trans RINA Part B Int J Small Craft Tech, vol. 153, pp. B65–B72.

Duman, S. and Bal, S., 2019. 'A quick-responding technique for parameters of turning maneuver', Ocean Engineering, vol. 179, 189-201.

Ghadimi, P. and Panahi, S., 2019. 'Numerical investigation of hydrodynamic forces acting on the non-stepped and double-stepped planing hulls during yawed steady motion', Proc. Inst. Mech. Eng. Part M J. Eng. Marit. Environ., vol. 233, no. 2, pp. 428–442.

ITTC, 2011. 'Recommended Procedures and Guidelines - Practical guidelines for Ship CFD Applications'.

Judge, C., 2000. 'A theory for asymmetric vessel impact with horizontal impact velocity', University of Michigan, Ph.D. dissertation.

Kahramanoğlu, E., Çakıcı, F. and Doğrul, A., 2020. 'Numerical Prediction of the Vertical Responses of Planing Hulls in Regular Head Waves', J. Mar. Sci. Eng., vol. 8, no. 6.

Kahramanoğlu, E., Yıldız, B., Çakıcı, F. and Yılmaz, H., 2021. 'Numerical Roll Damping Prediction of a Planing Hull', Ships and Offshore Structures, vol. 16, no 4, 363-372.

Katayama, T., Kimoto, R. and Ikeda, Y., 2005. 'Effects of Running Attitudes on Manoeuvring Hydrodynamic Forces for Planing Hulls', International Conference on Fast Sea Transportation (FAST), St. Petersburg, Russia.

Katayama, T., Taniguchi, T., Fujii, H. and Ikeda, Y., 2009. 'Development of Maneuvering Simulation Method for High Speed Craft using Hydrodynamic Forces Obtained from Model Tests', 10th International Conference on Fast Sea Transportation (FAST), Athens, Greece.

Kazerooni, M. F. and Seif, M.S., 2017. 'Experimental evaluation of forward speed effect on maneuvering hydrodynamic derivatives of a planing hull', 49 Sci. J. Marit. Univ. Szczec., vol. 121, no. 49, pp. 40–53.

Kimoto, R., Ikeda, Y. and Katayama, T., 2004. 'Effects of Running Attitude on Hydrodynamic Forces for Oblique Towed Planing Craft', Proc. 2nd Asia-Pacific Workshop Hydrodynamics, pp. 115–122.

Larsson, L. and Zou, L., 2014. "Evaluation of Resistance, Sinkage and Trim, Self-Propulsion and Wave Pattern Predictions". In L. Larsson, F. Stern, & M. Visonneau (Eds.), Numerical Ship Hydrodynamics (pp. 17–64). Springer Netherlands.

Lewandowski, E.M., 1994. 'Trajectory prediction for high-speed planing craft', Int. J. Shipbuilding Progress, vol. 41, pp. 137–148.

Lewandowski, E.M., 1995. 'The transverse dynamic stability of hard chine planing craft' in: Paper Presented at: Proceedings of the Sixth International Symposium on Practical Design of Ships and Mobile Units, Seoul, Korea.

Lewandowski, E.M., 1996. 'Prediction of the dynamic roll stability of hard-Chine planing craft', Journal of Ship Research, vol. 40, pp: 144–148.

Mancini, S. 2016. 'The Problem of the Verification and Validation Processes of CFD Simulations of Planing Hulls', PhD Thesis, Universita Degli Studi Di Napoli Federico II, Italy.

Morabito, M.G., 2015. 'Prediction of planing hull side forces in yaw using slender body oblique impact theory', Ocean Engineering, vol. 101, pp. 47–57.

Mousaviraad, S.M., Wang, Z. and Stern F., 2015. 'URANS studies of hydrodynamic performance and slamming loads on high-speed planing hulls in calm water and waves for deep and shallow conditions', Applied Ocean Research, vol. 51, 222-240.

Norrbin, N.H., 1970. 'Theory and observation on the use of a mathematical model for ship manoeuvring in deep and confined waters' 8th Symposium on Naval Hydrodynamics, USA.

Plante, M., Toxopeus, S., Blok, J. and Keuning A., 1998. 'Hydrodynamic manoeuvring aspects of planing craft', International Symposium and Workshop on Forces Acting on a Manoeuvring Vessel, Val de Reuil, France.

Richardson, L. F., 1910. 'The Approximate Arithmetical Solution by Finite Differences of Physical Problems Involving Differential Equations, with an Application to the Stresses in a Masonry Dam.' Philos. Trans. R. Soc. Lond., vol. 210, 307-357.

Siemens PLM, 2019. 'STAR CCM+ User Guide', Version 14.02.

Stern, F., Wilson, R.V., Coleman, H.W. and Paterson, E.G., 2001. 'Comprehensive Approach to Verification and Validation of CFD Simulations—Part 1: Methodology and Procedures', J. Fluids Eng., vol. 123, no. 4, pp. 793–802.

Sukas, O.F., Kinaci, O. K. Cakici, F. and Gokce, M. K., 2017. 'Hydrodynamic assessment of planing hulls using overset grids', Appl. Ocean Res., vol. 65, pp. 35–46.

Tavakoli, S. and Dashtimanesh, A., 2018. 'Mathematical simulation of planar motion mechanism test for planing hulls by using 2D+T theory', Ocean Eng., vol. 169, pp. 651–672.

Yasukawa, H. and Yoshimura, Y., 2015. ‘Introduction of MMG standard method for ship maneuvering predictions’, J. Mar. Sci. Technol., vol. 20, 37–52.

Yoon, H., 2009. ‘Phase-averaged stereo-PIV flow field and force/moment/motion measurements for surface combatant in PMM maneuvers’, PhD Thesis, University of IOWA.

Yoshimura, Y., 2005. ‘Mathematical model for manoeuvring ship motion (MMG Model)’, In: Workshop on Mathematical Models for Operations Involving Ship-Ship Interaction, Tokyo, Japan, pp. 1–6.