The Influence of Sidehull Hydrodynamics on the T-Craft Seakeeping Motion

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ABSTRACT
In some papers, the hydrodynamic effects of sidehulls of surface effect ship (SES) are simply ignored with the prejudice that the displacement of sidehulls only takes a few proportions, e.g. 20% of the total displacement. To verify the conclusion, the seakeeping motions of a T-Craft together with hydrodynamic effect of sidehulls are investigated in this work. The transformable craft 'T-Craft' is a newly developed vessel by the Office of Naval Research (ONR) that could transform itself from ACV to SES or inversely. When operated in SES mode, T-Craft is mainly supported by the air cushion while partially supported by sidehulls. In this paper, based on linear potential theory, a numerical T-Craft (SES) seakeeping analysis method with consideration of sidehull hydrodynamics is firstly set up and validated by the model test results. Then by using the numerical method, the seakeeping performance of the T-Craft with various sidehull displacement ratios at low speed is investigated and compared with that of absence of sidehull effect. The investigation results suggest that the sidehulls could make significant influence on the T-Craft pitch motion, even when the sidehull displacement ratio is only 20% of the total one.

KEY WORDS: T-Craft, sidehulls, hydrodynamics, seakeeping, air cushion.

INTRODUCTION
Generally, the seakeeping performance of the air cushion assisted vessels such as Surface Effect Ship (SES) is affected by hydrodynamics of sidehulls and aerodynamics of air cushion. However, some papers found in public domain concerned about seakeeping performance of SES ignored the hydrodynamics of sidehulls (Kaplan, Bentson and Davis, 1981; Faltinsen, 2005; Dhanak, 2009; Dhanak, 2011). Although the sidehulls only support 20% of the SES weight in those cases, few public studies could support the standpoint that hydrodynamic effect of sidehulls could be neglected. To clarify the conclusion, a T-Craft (Hodges, Silver, Wieser and Adelsen, 2009) is taken as an example and the hydrodynamic effect of sidehulls on the motion response of the T-Craft is investigated in this work.

The T-Craft (Transformable Craft) is an innovative naval prototype developed by the Office of Naval Research (ONR). The T-Craft presents itself as a Surface Effect Ship (SES) for over-water transit and operations at the Sea Base, and with a deployable skirt system provides the amphibious capability as an Air Cushion Vehicle (ACV) to carry cargo onto the beach (Hodges, Silver, Wieser and Adelsen, 2009). To verify the influence of sidehull hydrodynamics on the T-Craft seakeeping motion, the T-Craft in SES mode is employed for investigation.

There exist several SES seakeeping analysis methods that could take the hydrodynamics of sidehulls into account. An efficient method is adding the constant hydrodynamic coefficients of sidehulls into the motion equations and then solving the equations in frequency or time domain. The hydrodynamics of sidehulls is individually calculated by empirical method (Wu, Yun and Cheng, 1987; Yun and Bliaut, 2000) or strip theory (Sorensen and Egelands, 1995). A more delicate method is to use nonlinear Rankine panel method for performing the hydrodynamic solution of sidehulls in each time step of numerical processing (Lin, Zhang, Weems, Huan and Whipple, 2010; Connell, Milewski, Goldman and Kring, 2011). The hydrodynamic model in the Rankine based seakeeping analysis method ‘ACVSIM’ (Connell, Milewski, Goldman and Kring, 2011) is a three-dimensional B-spline-based boundary element method for unsteady potential flow, which was originally developed to model the interaction between bodies operating on or near the free surface with incident waves. ACVSIM employs the three-dimensional, time-domain boundary element method to model incoming waves and the waves generated by the air cushion and sidehulls (Milewski, Connell, Wilson and Kring, 2007). CFD technique is also exploited to simulate the seakeeping motion of SES, where the hydrodynamics of sidehulls is considered together with dynamics of air cushion (Donnelly, 2010; Bhushan, Stern and Doctors, 2011). Both the methods based on the panel method and CFD have been demonstrated to give reasonable good results for T-Craft (in SES mode) at low speed, but showed poor agreements with experimental results at high speed.

Since there exist difficulties with high speed T-Craft seakeeping performance prediction and the main purpose of this paper is to validate the hydrodynamic effect of two sidehulls, the scope of current work is