Numerical Study on Hull Interference Resistance of High Speed Catamaran

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ABSTRACT

Flow field resistance interfaces of catamaran are produced between hulls at high speed, which are related to its speed and demi-hull spacing. In this paper, the RANS method is adopted to simulate the flow field around the catamaran, and an empirical model for predicting the resistance of the catamaran is constructed based on the regression method. The results show that the interference effect is obvious when the separation ratio is less than 0.5. The increase of the speed and the distance between the hulls will make the first dispersive wave intersection point of the catamaran move backward.

KEY WORDS: Catamaran; RANS; Interference factor; Regression analysis

INTRODUCTION

Compared with monohull, catamaran has more excellent performance in terms of rapidity, seakeeping, maneuverability, etc. The prediction and optimization of its hydrodynamic performance has attracted the attention of many scholars. Due to the interference of wave making and resistance between two hulls (Mandru,2020), the resistance of the catamaran during navigation is not twice that of a single hull. Therefore, it is necessary to study the interference effect between hulls of catamaran.

Some scholars have used numerical methods based on potential flow theory and experimental methods to study the interference resistance of catamaran. Lianen Zhao et al. (2006) proposed to replace the amplitude function of the actual ship type with the amplitude of Rankine function to determine the interference resistance factor between the twin hulls, to calculate the wave resistance of the catamaran. Xiaoyang Zhang et al. (2009) used the complex integral form of Michell integral to calculate the wave-making resistance of wave-piercing catamaran and the wave-making interference between two bodies. Dan et al. (2019) applied Sahoo’s method from the theoretical point of view, and carried out resistance tests with demi-hull and catamaran models. The difference between the theoretical and experimental results was compared. The results show that the accuracy of the theoretical method is poor at high speed. Riccardo Broglio et al. (2014) studied the influence of the change of catamaran spacing and Fr number on the interference effect through experiments.

The research shows that the interference effect is more obvious near $Fr=0.5$. Souto-Iglesias et al. (2012) studied the interference effect of 60 series models, and the results showed that the best interference factor appeared at $Fr=0.33$ and the separation ratio was 0.4.

CFD tools can be used to study the detailed information of the flow field between the catamarans. Based on the RANS solver, Doğru et al. (2021) studied the hydrodynamic performance of the Delft 372 catamaran in still water. The research shows that the numerical simulation of the flow field around the catamaran based on the RANS method has high accuracy in resistance, trim and heave. Based on the URANS solver, He et al. (2015) studied the influence of Froude number and demi-hull spacing on the resistance and navigation state of catamaran.

In recent years, regression analysis has been widely used in the field of ships: Shukui Liu et al.(2020)carried out regression analysis on the experimental data of wave added resistance in regular waves with arbitrary heading and established a semi-empirical formula; Jeong et al.(2020) used dimensionless regression to analyze the relationship between variables affecting ship resistance under floating ice conditions, and established a solid ice resistance prediction model; Xiaoying Xu et al.(2021)conducted multiple linear regression on the relevant data of 29 ships, and obtained the empirical estimation formula of single ship resistance coefficient with different Froude numbers.

In this paper, the computational fluid dynamics method based on RANS equations is used to simulate the flow field around the catamaran and predict the ship resistance and its components based on the numerical results of the flow field. Firstly, based on the numerical results of the same type of monohull and catamaran, the interference resistance of different resistance components of catamaran is decomposed. After that, according to the numerical results of the interference resistance of the catamaran with different speeds and different spacings, the law of the relevant interference resistance with respect to the speed and the spacing parameters is analyzed, and the mechanism of the relevant law is analyzed and discussed. Finally, an empirical model for predicting the resistance of catamaran is constructed based on regression method. The analysis of the law and mechanism of catamaran interference resistance and the established resistance prediction model have reference value for guiding the optimization of catamaran layout.