Analysis of the Seakeeping Performance of Icebreaker Based on Maxsurf

LI Xing-yu1,2,3, HE Yan-ping1,2,3*, CHEN Chao1,2,3
1. State Key Laboratory of Ocean Engineering, Shanghai Jiao Tong University
   Shanghai, China
2. Collaborative Innovation Center for Advanced Ship and Deep-Sea Exploration (CISSE), Shanghai Jiao Tong University
   Shanghai, China
3. School of Naval Architecture, Ocean & Civil Engineering, Shanghai Jiao Tong University
   Shanghai, China

ABSTRACT

As an indispensable tool for polar resource development, the research on the seakeeping performance of icebreakers becomes more necessary. This article takes the 153-meter icebreaker as the research object. The motion response of the icebreaker is calculated using Maxsurf software based on strip theory. The effect of different heading angles and sea conditions on the seakeeping performance of ship is analyzed. The calculation results show that the seakeeping performance is excellent and meets the demand of residential comfort. In addition, the dangerous heading angles during the navigation are also listed, which can help to improve the sailing safety.

KEY WORDS: Seakeeping, Maxsurf, motion response, short term prediction, strip-theory.

INTRODUCTION

The main function of the icebreaker is to serve as a tool for opening ice channels, science surveys and emergency rescue. Since icebreakers need to navigate in open water and ice areas, more factors need to be considered to ensure their navigation safety. Especially for countries far away from the polar region, their icebreakers need to sail in a variety of complex sea conditions, so good seakeeping performance is a key factor to ensure safe hull navigation. The seakeeping performance of a ship during sailing is determined by a variety of factors, including the movement of the six degrees of freedom and linear (accelerated) or angular (accelerated) speed of ship. In addition, when encountering severe weather incidents, some events such as the green water, slamming and emergence probability of the screw will also affect its seakeeping performance.

The theory of wave resistance of modern ships originates from the 1950s. Among them, the strip theory proposed by Korvin-Kroukovsky (1955) based on the slender body theory in aerodynamics has become an effective method for predicting the wave resistance of ships. In the subsequent development process, Korvin-Kroukovsky and Jacobs (1957) developed and perfected this theory, finally they proposed the ordinary strip method (O.S.M), which is the first theory that can effectively calculate the motion response of ships on waves, but it is only suitable for solving the heave and pitch motion responses in the head seas conditions. Later, Vossers (1962) and Joosen (1964) further reasoned the strip theory based on the slender body hypothesis. Gerrisma, J. and W. Beekelman (1967) proposed to use a modified slice theory (M.S.T) to perform theoretical calculations of ship motion on waves and wave loads. The calculated results are in good agreement with the experimental results in head seas conditions. Later, Tasai (1967), Grim and schenzle (1969) based on the slice theory to predict the lateral motion response of ship under inclined waves. Ogilvie and Tuck (1969) proposed the Reasonable Slice Method (R.S.T), which illustrates the slice theory through magnitude analysis, but it is also only applicable to heave and pitch responses. Salvesen, Tuck and Faltinsen (1970) proposed the STF theory, which can be used to predict the motion response of ships in five degrees of freedom (yaw, sway, pitch, heave, roll) other than surge. At the same time, this method is also suitable for solving the motion response in inclined waves. The strip theory is based on the assumption of low speed and high frequency, which is not suitable for the prediction of high speed ships.

Due to the high calculation efficiency of the strip theory, it has a good agreement with model tests at medium and low speeds, and it is still an important tool for studying the seakeeping performance of ships. Besides, its scope of application can be extended to many other complex conditions: Prediction of the seakeeping performance of ships with limited water depth; Prediction of ship motion response under complex boundary conditions (He, 1998).

In this paper, an icebreaker model was established based on relevant parameters and profile characteristics in Maxsurf. Not only the motion response of the ship in different wave directions and sea conditions is calculated using strip theory, but also some discussion about the criterion of the seakeeping performance is presented and the ship navigation stability was verified. Plus, as the ship anti-rolling tank was taken into consideration using the simplified method, this paper may have practical meaning for icebreakers carrying an special anti-roll devices.

CALCULATION METHOD

When consider a ship is moving at speed \( U \), it can be assumed that the coordinate system of ship is moving in the incident wave with a constant forward speed \( U \) as shown in Fig. 1, where \( A \), \( \omega \) and \( \beta \) represent the incident wave amplitude, frequency and heading angle,