Study on Under-Keel Clearance Algorithms for Very Large Ships in Restricted Waters

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ABSTRACT

Under-Keel Clearance (UKC) is one of the pivotal factors that ensure the navigation safety of Very Large Ships. Nowadays, the range of UKC is determined mainly based on pilots’ navigation experience gained in specific waters (restricted waters) without sufficient consideration of impacts of multi-variables, such as types and speed of VLCC, depth of water and situations of wind and wave. This paper will analyze the components and influencing factors of UKC, investigate the impacts of various variables and develop structural equation model for accurate estimation of UKC in practice. Due to the uncertainty estimates of UKC values in restricted waters, we will propose a dynamic calculation model for UKC estimation based on characteristics of Very Large Ships and navigation conditions in restricted waters. Meanwhile, the optimal UKC value will be estimated. The reliability of the proposed dynamics calculation model and estimated UKC value will be further validated by combining the reduced-scale Very Large Ships model experiment. Achievements of this proposal are of great significance in enriching the theory and skill for Very Large Ships maneuvering and pilotage, and guaranteeing navigation safety of VLCC in restricted waters.

KEY WORDS: Under-Keel Clearance; Very Large ships; multivariables; dynamics calculation model

INTRODUCTION

With the development of the recovery of the world economy and shipping industry, the tendency of large ships, and high speed are becoming more and more obvious, especially the oil tanker, bulk carrier, container ship. At present, the total number of Very Large Ships around the whole world has more than 400, accounted for about 64% of tons total of the world tanker truck. With the increase of ship traffic along with coastal waters, the risk of marine accidents is increasing. Therefore, ships navigation security has become the important topic of water traffic safety research, it is the key technology and bottleneck problem during the rapid development of industry. The domestic and foreign scholars, maritime safety administrations, shipping enterprises are also highly concerned about this hot and difficult problem.

Under-Keel Clearance (UKC) is a very important and contributing factor among many factors that influence navigation safety, especially in shallow waters and restricted waters. UKC is a water depth allowance must be retained below its bottom when ship is navigating, preventing the ship from dragging bottom and grounding (As shown figure 1). The factors that affect UKC include types of ship, navigation condition, speed, water depth, draught, wave, wind, flow, etc. Restricted waters is vary from different draught and breadth of ships in shallow or narrow waters and restricted waters. Because draught and breadth of Very Large Ships are large, it is prone to grounding when sailing in the restricted water. Because Very Large Ships has big inertia; rudder and steering response is slow; turning inertia is large and the effect of narrow channel and the influence of wind are significant, resulting in the determination of UKC become more complicated when it sailing in the restricted areas. Because of the different time and space constraints, the contribution of various factors of UKC is different and the interaction between different factors is also different. Namely the contributing factors of UKC have the feature of "space-time" which change with space-time. As for mathematics, it can be described as multivariate uncertainty, randomness and interaction effect of (coupling), which led to difficulties in calculating UKC. Determining UKC effectively and reasonably in the course of ships has become a bottleneck problem and key technology in the development of the industry.

Therefore, it is very necessary to use the new computer technology, system theory and modern mathematical method, combining the control characteristics of Very Large Ships and the condition of limited water area to calculate UKC effectively and reasonably.

With the development and wide application of the computer technology, system theory and modern mathematics theory and method, data processing method, experimental method, uncertainty and analysis and processing capacity of randomness problems have been greatly improved among transport engineering and marine science and technology field. Therefore, using computer application technology, system theory and the method of modern mathematics to study UKC in restricted areas can not only deal with interaction effect between multivariate uncertainty and randomness, contributing factors, sample data boundary problems well, but also to provide Very Large Ships with a good mathematical theory as support and reference to calculate UKC effectively and reasonably.

This paper is the innovation and application using computer technology, system theory and modern mathematics theory and method in the field of marine science and technology, as well as to study and solve the basic problem in the field to maneuver Very Large Ships. Results in the paper have important theoretical significance towards enriching large ship manipulation theory, promoting large ship maneuvering technology and advanced maritime technology. The application of the research results can not only guarantee Very Large Ships navigation.