ABSTRACT.

Due to the uncertainty of external environmental condition in the process of designing the ship, the ship’s performance may change and shift, or even fail during the ship operation. In order to reduce the influence of external uncertain factors on ship’s performance, the robustness of the ship is required as well as the performance in the process of hull form design. This paper presents an approach of robust optimization method, which analyzes uncertain factors in the process of the ship design, researches their analyzing approaches, constructs the model of robust optimization design on the above basis, to complete the robust optimization for typical ship hull form.

KEY WORDS: Uncertainty optimization; ship hull form; robust optimization design

INTRODUCTION

With the improvement of manufacturing technique, designers do not only pursue the high performance of the ship, but also higher robustness and reliability. However, due to the lack of knowledge and the uncertainty of external environmental condition in the process of manufacturing ship, the ship’s performance may change and shift, or even fail during the ship operating.

Therefore, in order to reduce the risk of malfunction of ships, various uncertain factors should be fully considered on the stage of general design. By optimization of design schemes, the performance of ships is optimized, while the sensitivity of system performance towards uncertainty and the probability of the malfunction are both reduced, thus the robustness and the reliability are improved.

Aiming at those demands above, ship optimization design based on uncertainty has been developed. Uncertainty optimization design is a methodology of searching optimized solution in the design space, according to the robustness and reliability (Oberkampf, et al., 2004; Sahinidis, N. V., 2004). Compared with traditional deterministic optimization method, uncertainty optimization of ships are mainly applied to solve two problems below:

1) Improve the robustness of ships, reduce the sensitivity of ship performance towards uncertainty, and remain ship performance stable.

2) Improve the reliability of ships, reduce the probability of malfunction and failure, and make the reliability of ships satisfy the expected demand.

According to those two objectives, uncertainty design methods are mainly divided into robust optimization design and optimization design based on reliability. The latter one is not discussed in this paper.

As for robust optimization design, where robustness refers to the insensitivity towards uncertain factors, in other words, ship performance does not fluctuate greatly when the environment or parameters of ship change. Therefore, robust optimization design is to pursue the optimization schemes with stability, which was raised by a Japanese scholar Taguchi in 1970s. By reducing influence of deviation factors on product performance, improved quality, stable performance, and low manufacturing costs are obtained.

Currently, in ship optimization design, traditional ship optimization design only considers the deterministic factors and ignores uncertain factors. Actually, the ship optimal scheme can be influenced by various uncertain factors, leading to the failure of optimal scheme or bad performance (Klasen, E., 2005; Good, N. A., 2006c). At present, ship robust optimization design mainly concentrates on the ship concept design (Vasconcellos, et al., 2011; Hannapel, S. E., 2012), rare researches discuss about ship performance.

This paper takes containership (KCS) hull form robust optimization design as the research object. Considering the influence of external factors on ships, the ISight platform is used, to integrate ship surface deformation, CFD (SHIPFLOW) calculation and robust optimization.

The paper is organized as follows. The basic theory of robust design is introduced first. Then analytical and numerical benchmarks for validation of the robust optimization design using radial basis function interpolation are presented, whereas conclusions are shown after that. Finally, references are given.