Cruise Engine Room Case Study: A Virtual Assembly Scheme for Ship Pipe Systems Based on Grey System Theory
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ABSTRACT
The application of virtual reality technology in ship piping assembly was of great significance to reduce the piping interference and optimize the piping installation sequence and spatial layout. In order to evaluate the virtual assembly scheme of piping system in all aspects and at multiple levels, combined actual installation technology and the possible installation problems, the evaluation index system of virtual assembly scheme was composed, which consisted of interference situation, process value, installation principle, pallet usage and maintainability. The analytic hierarchy process and entropy weight method were used to assign the weight of the system index subjectively and objectively. Based on the triangular whitening weight function, grey cluster evaluation model was used to evaluate the virtual assembly scheme.

KEY WORDS: piping virtual assembly; scheme evaluation; pipe system; Grey System Theory

INTRODUCTION
Similar to blood vessels, the ship piping system is responsible for connecting various ship equipment and completing the transmission of various resources between cabins, such as gas, water and oil. Therefore, the function and performance of ships are greatly affected by piping design. High-quality assembly scheme is of great significance for reducing rework rate, improving work efficiency and improving economic benefits of shipyards.

Ship piping design could be generally divided into five stages: preliminary design, functional design, detailed design, production design and system support information (Dong, Wang et al. 2022). The production and installation process of ship piping generally included six steps: pipe selection, pipe lofting, pipe processing, pipe accessories installation, pipe installation, pipe integrity and sealing test (Xu, 2010). The detailed process was shown in Fig. 1.

Piping lofting is the basis of various chart drawing, which provides support for piping production and installation. The processing efficiency of pipes is directly determined by the quality of the lofting. In modern shipbuilding, the quality of piping lofting is difficult to be judged. And the lofting process is only carried out around the principles of “first overall and then local”, “first large pipe and then small pipe”, “simple and beautiful pipe arrangement”, which lead to an inaccurate lofting result (Zhang, 2019).

In the narrow sense, piping assembly includes accessory installation and piping installation. Due to the cross operation of multiple types of work, the environment is harsh, and the construction conditions are difficult. In addition, the cabin is relatively narrow, and there are many equipment and pipelines, which results in complex layout constraints (Fan, 2007). In the actual assembly process, the installation and layout of the piping system is difficult to take into account, resulting in greater randomness. The collision phenomenon between the pipe and the hull structure, mechanical and electrical equipment is endless, resulting in the installation quality cannot be guaranteed.

Computer technology is widely used in the field of ships. Especially in recent years, assembly simulation technology based on virtual reality technology has been applied in the process of ship design and manufacturing, which has led to an effective transformation of ship