

# Optimization Design of Ship Rudder Steering Stability Optimization Control System

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**Abstract:** the Ship Rudder Control System Occupies an Important Position in the Ship's Power System, Which Can Ensure the Accuracy of the Ship's Navigation Direction and the Effectiveness of Navigation. However, Due to Various Factors, the Steering Stability of the Ship is Gradually Reduced, Which is Not Conducive to Improving the Safety of the Ship. Therefore, Based on the Analysis of the Ship Rudder Stability Optimization Control System, This Paper Studies the Optimization Design of the Ship Rudder Stability Optimization Control System from Three Aspects, in Order to Provide a Theoretical Reference for Improving the Ship's Comprehensive Performance.

## 1. Introduction

### 1.1 Literature Review

The stability of the ship's rudder is related to whether the ship can drive safely. Wei Dengming and Li Haiyan obtained the optimal model of the ship's motion model and the corresponding simulation experiments to obtain the optimal steady-turn diameter. In view of the low efficiency and large computational complexity of the calculation method, the optimal rudder parameter optimization method was proposed, which can make the ship's swing diameter. At best (Wei and Li, 2015). At present, in the ship's power system, the ship's rudder system plays an important role in ensuring the stability of the ship's navigation. Based on the optimization method of automatic ship rudder PID control, Yan Maozhen and Chen Ting have studied the method of improving the accuracy of ship rudder and deeply analyzed the application of PID in the synovial controller in the ship rudder system, which can significantly improve the ship rudder. Comprehensive performance (Ao and Chen, 2018). In order to improve the stability of the ship's operation, Liang Lihua et al. analyzed the ship's swing diameter and swing heel based on the maneuverability equation. Taking the turning diameter and the turning heel as the optimal design variables, the optimized design platform is used to optimize the design of the ship's rudder parameters, which can optimize the ship's rudder operation performance (Liang et al, 2013). The stability study of the ship is of great significance for the stable operation of the ship and can effectively guarantee the safety of the ship. Based on the problems existing in traditional ship rudders, Zhao Jing focuses on hull automatic rudder design and hydrodynamic optimization, establishes a stability model, and develops a new type of ship stability optimization control strategy, which is important for improving ship stability and improving ship stability. Meaning (Zhao, 2019).

### 1.2 Purpose of Research

In recent years, with the continuous development of the manufacturing industry, the world's ship capacity and quantity have increased significantly, and the resulting navigation safety issues have become more prominent (Zhou, 2005). Most shipwrecks are caused by poor steering of the ship's rudder. As the main operating point of the ship, the rudder maneuverability is mainly manifested in the maneuverability and stability of the hull movement (Li, 2014). The ship rudder is the main control device, which can effectively ensure the stability and operability of the hull in the actual application process. At present, in the background of the ship design industry not only in-depth development, the related scholars' research on the stability of the ship's rudder is also getting more and more attention. However, in the actual research process, no scholars have conducted in-depth

research on the ship rudder stability optimization control system, which can not provide theoretical support for the development of shipbuilding industry. Therefore, improving the steering performance of the ship and re-evaluating and optimizing the design has become an urgent need in the safety practice of maritime navigation. Based on the analysis of the ship rudder stability optimization control system, and optimize the design of the ship rudder stability optimization control system, it is of great significance for the development of shipbuilding industry.

## **2. Brief Introduction of Ship Rudder Steering Stability Optimization Control System**

As the main navigation equipment of the ship, the main function of the ship rudder is to control the navigation direction and ensure the stability of the navigation of the ship. Therefore, in the shipbuilding industry, the ship rudder is also known as the heading control system. In the ship rudder control system, it is mainly composed of a steering gear installed in the rudder nacelle and a steering instrument installed on the bridge, and the composition is relatively simple. Among them, the steering gear is mainly used as the actuator of the ship rudder and is controlled by the steering instrument. Currently, in the ship's rudder, the steering gear is mainly operated by hydraulic transmission. The operation of the steering gear is mainly controlled by advanced computer technology and electronic technology. Historically, the steering gear has mainly experienced three stages of development: mechanical automatic rudder, PID automatic rudder and adaptive automatic rudder.

In the actual application process, the ship rudder mainly adopts the two-side power supply mode, and mainly supplies power through the emergency switchboard in the ship. In the specific work, the ship's rudder mainly adopts continuous working system and has sufficient carrying capacity to block for one minute. Under normal circumstances, the ship's rudder is mainly controlled in two places, the bridge and the steering gear room, and is manually converted by the changeover switch.

In the development of shipbuilding industry, ship rudder control systems are mainly divided into three categories. They are direct control system, random control system and automatic steering control system. In the case of a direct control system, it is mainly used when the automatic steering system fails, requiring the driver to perform the rudder control in a short time. In the direct operation process, the driver mainly sets the steering point in the rudder cabin and the bridge, and encounters an emergency state, and can respond in the first time. The direct control of the ship's rudder is actually the direct control of the ship's hydraulic steering gear, and the bridge is only an electronic control method. In addition to the basic electronic control method, the ship's rudder can be directly operated by means of machine control. In the case of a stochastic control system, the stochastic control system is also used mainly when the ship's rudder enters or exits the port, or if the ship needs to be used on a narrow waterway basis, or if the automatic rudder operation fails. In the actual application process, the stochastic control system is actually a closed-loop control system of the rudder angle, which will move with the movement of the position, also known as the position random system. As far as the automatic steering control system is concerned, the system needs to maintain its operating state for a long time, and mainly plays an executive function during the navigation of the ship. For the construction of the automatic steering system, mainly using the current advanced intelligent technology and equipment, it can greatly reduce the actual range, has energy-saving effect, and can effectively improve the ship's aviation operational capability.

## **3. Optimization Design of Ship Rudder Steering Stability Optimization Control System**

### **3.1 Propulsion System Optimization Design**

In the ship rudder, the automatic propulsion system is mainly composed of a propeller, a controller, a motor driver and a motor, as shown in Fig. 1. Among them, the controller mainly issues corresponding instructions to publish relevant data information on the motor driver. Then, after receiving the information of the controller, the motor driver transmits the corresponding information command to the motor. Moreover, the motor driver performs the motor rotation according to the

command, and then converts the corresponding kinetic energy to the propeller, causing the propeller to generate the main thrust. During this process, the electrical drive returns relevant data to the inside of the motor driver during data transfer. At this point, after the motor driver receives the data, the system automatically performs data identification and processing, and then feeds the converted data back to the overall controller, thereby completing the entire propulsion system. In the propulsion system, different functional sections play different roles, and the relevant parts play their respective roles, thereby achieving the overall promotion of the ship's advancement and ensuring the effective operation of the ship.

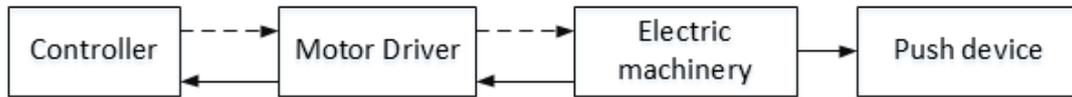


Fig.1 Propulsion System

### 3.2 Optimal Design of Steering Gear System

The structure of the steering gear system is relatively simple, mainly composed of three parts: controller, steering gear and rudder, as shown in Figure 2. In the specific work, the controller also issues corresponding commands in advance to transfer the command data to the steering gear. According to different data instructions, the steering gear regulates the direction of the ship and prompts the ship to sail in the specified direction to ensure the accuracy of the navigation direction. In this process, the steering gear is responsible for the ship angle adjustment, and the corresponding data is fed back to the controller according to the adjustment data. Then, based on the data behind the steering gear, the controller performs data recognition again and issues new instructions to ensure the timeliness of the release of the instructions, which is conducive to improving the accuracy of the navigation direction.

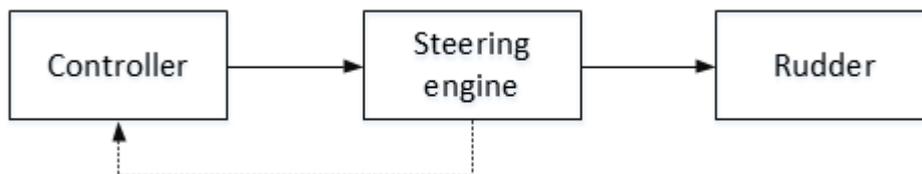


Fig.2 Servo System

### 3.3 Control System Optimization Design

In the process of ship rudder control, the control system plays a key role and is the key system for ship stability improvement. When optimizing the design control system, the self-propulsion model control system is adopted. The system mainly consists of two parts, which are the upper computer control system and the lower computer control system. Among them, the upper computer control system mainly realizes the hardware control of the whole system, guarantees the corresponding instructions, has corresponding operation equipment and plates, and improves the matching of the system. The lower computer control system is mainly composed of AVR microcontrollers, including Flash, I/O, COM and PWM. Among them, the role of Flash is mainly to store the relevant data of the operation of the lower computer system, and the storage of temporary data. I/O mainly performs input and output control, which is responsible for controlling the switches on different power supplies, and performs the operation of opening the device by outputting low power. COM is mainly responsible for the communication of the host computer, issuing corresponding instructions to the control system, and receiving the information of the sensor to ensure the effective flow of information in the system and improve the matching between different sections. At the same time, the serial port on the COM can control the steering angle and the motor speed according to the corresponding command while receiving the information of the upper computer, further improving the stability of the steering operation of the ship. The role of PWM is mainly to control the steering gear. In the actual working process summary, the PWM

mainly adjusts the angle of the ship by adjusting the duty cycle within the cycle. Moreover, during the navigation of the ship, the PWM can recognize the correctness of the ship's angle and make appropriate adjustments to achieve the purpose of the ship's angle control, which is conducive to improving the stability of the ship's rudder operation.

#### **4. Conclusion**

Aiming at the problem that the current rudder operation performance is gradually improved, this paper analyzes the ship rudder operation stability optimization control system, and then studies the optimal control of the ship rudder operation stability optimization control system from the three aspects of propulsion system, steering gear system and control system. Focusing on the internal execution function and internal operation mechanism of each system, on the basis of ensuring the normal running of the ship, the automation and comprehensiveness of the ship rudder operation is realized, which is conducive to the direction of accurate ship navigation and greatly improves the reliability and safety of the ship.

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