Overview of Ship Dynamic Positioning Control System

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Abstract: Ship dynamic positioning control system is one of the important technologies in shipping industry. With the continuous development of the economy, the requirements of ship field for dynamic positioning control system are higher and higher. This paper will briefly introduce the composition, working principle, controlling algorithm research progress and research status of ship dynamic positioning system.

1 INTRODUCTION

With the rapid development of global economy, the world's land resources are gradually in short supply. In order to obtain more abundant oil, rare metals and other resources, the human development field has been expanding to the ocean, promoting the development of ships and marine engineering, and the technology of dynamic positioning has been gradually developed. In recent years, with the continuous extension of marine engineering to the deep level, many kinds of ships emerge in an endless stream, and the ship's control system is also increasingly perfect. As one of the more advanced ship operation control system, the dynamic positioning system is more and more widely used in military ships, modern ocean platforms, scientific research ships, tugs and diving rescue boats. According to statistics, China's annual market demand for dynamic positioning control costs about 2 billion yuan, with more than 200 potential dynamic positioning control ships (Xiaobin Qian, 2018).

2 DYNAMIC POSITIONING CONTROL SYSTEM

Ship's dynamic positioning system is a typical closed-loop control system, including measurement system, propulsion system, power system and control system. Its working principle is to obtain the deviation between the current ship state and the expected state through the measurement system, and the control system processes and calculates the required thrust. The propulsion system uses multiple thrusters from multiple angles to provide the corresponding power, which is used to resist and eliminate the interference of wind, wave, current and other environmental forces in the ship operation, so as to make the ship stay in the designated sea area as much as possible. This system originates from offshore oil and gas platforms (Xiaobin Qian, et.al, 2017). The main functions of ship dynamic positioning control system include station keeping, auto pilot, joystick, heading control, follow target, auto track, etc.

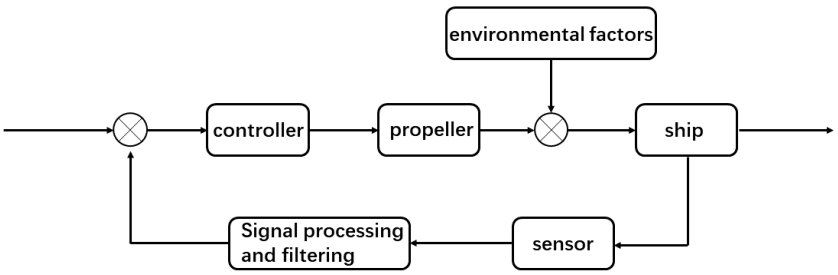

Figure 1: The structural diagram of the ship's dynamic positioning system.

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Compared with the traditional mooring system, the ship dynamic positioning system has the following advantages: High positioning accuracy, outstanding flexibility, higher safety and reliability, fast positioning, no seabed and water depth, etc. the limited cost is fixed, the cost of traditional offshore platform will not increase with the increase of water depth, the system has strong controllability, can effectively avoid the dangerous situation generated in the traditional anchoring process, and can produce rapid response to the interference of the environment (Minjie Zheng, 2018). The structural diagram of the ship's dynamic positioning system is shown in Fig. 1.

3 SYSTEM COMPOSITION

3.1 Measurement System

This system plays an important role in the precise work of the whole dynamic positioning system. It can be said that the measurement system is the performance guarantee of the dynamic positioning system. The measurement system is divided into two systems, reference system and sensor. The reference systems commonly used in dynamic positioning of ships are mainly satellite positioning, underwater acoustic positioning and tension locking systems.

3.2 Propulsion System

This system is the actuator of the dynamic positioning system. When the dynamic positioning system is started, the system will make a positive response to the command sent by the control system, and generate appropriate forces and moments to eliminate the interference of the surrounding environmental forces on the position of the ship. Maintain the running track or position of the ship.

3.3 Control System

The workload of this system is very heavy and it is the key part of the whole system. By measuring the deviation of the system to deal with the accurate calculation of the power distribution problem. The control effect in the control system is often reflected in the control technology. The ship's motion control technology has been constantly updated and improved. From PID control when the dynamic positioning system just appeared, it has experienced adaptive control, optimal control, robust control, to the most advanced and extensive English intelligent control. Intelligent control has gradually replaced the traditional control technology (Rong Zhen, 2012).

4 RESEARCH PROGRESS OF SHIP DYNAMIC POSITIONING CONTROL ALGORITHM

From the emergence of dynamic positioning technology now, the core of dynamic positioning control algorithm research and development can be divided into three stages. The first stage is to use the classical PID control algorithm to realize the control of the working ship, and to control the free degree movement of the ship in three aspects: sway, surge and yaw. In the second stage, the combined control method of filtering and optimal control is used. This method improves the security and robustness to a certain extent, and is widely used in modern commercial ships. However, this control method has large errors and the calculation process is too complex (Cong Liu, 2018). The third stage is to use the new intelligent control algorithm, including robust control, nonlinear model predictive control, neural network control and fuzzy control. They have higher positioning accuracy, can ensure the reliability of position information obtained by measurement, and make the ship gradually move towards intelligent development in the direction of dynamic positioning (Dandan Wang, 2010).

5 RESEARCH STATUS OF SHIP DYNAMIC POSITIONING CONTROL SYSTEM

5.1 PID Control Technology

In the early 1960s, dynamic positioning system was applied to the exploitation of marine resources. In 1961, PID control system was adopted by the first batch of ships with dynamic positioning system in the world. The system controls the three degrees of freedom of the ship and calculates the required thrust by measuring the deviation of the ship position and heading angle. The advantages and disadvantages of this method are very obvious. It has the advantages of good stability, high security, simple calculation and easy design. At the same time, it also exposes the disadvantages of the control function of the controlled object with variable parameters. When the ship and the surrounding environment change, the parameters of the PID control system must be reset.

5.2 Linear Optimal Control Technology

Due to the poor control effect of some parts of the PID control system, the research of linear optimal control technology is promoted. The system divides the mathematical model of a ship into high and linear optimal control technology, which can effectively solve the problem of phase lag in the first generation of a dynamic positioning system. Moreover, response speed and accuracy meet the requirements.

5.3 Nonlinear Control Technology

There are many non-linear factors that can't be liberalized in the process of ship's fixed force positioning. This technology can deal with the non-linear factors in the process of ship operation, and can deal with the non-linear problems directly. It is precisely because this feature can effectively improve the control performance and safety performance of ship positioning work, and has a considerable compensation for the interference in the external environment.

5.4 Intelligent Control Technology

In recent years, with the rapid development of computer related technology, artificial intelligence has rapidly entered human life, and the development of control theory has also been greatly promoted. Only control technology has the characteristics of imitating human to a certain extent, which has a good effect on solving the problem of difficult to establish a mathematical model. Because each intelligent control technology has its own advantages, how to use different intelligent control technologies together is also an important research direction nowadays (Yang Liu, 2013).

6 OUTLOOK AND SUMMARY

The control of the dynamic positioning system is always difficult to achieve perfectly, because of the nonlinear complexity of the ship system, the uncertainty of the parameters of the model and the external disturbance, and the change of the internal state is not easy to measure. How to effectively solve the above problems is an important research topic in the field of control theory.

Dynamic positioning system is widely used in ship control system. Compared with traditional anchoring positioning, it has obvious advantages and has gradually become a key technology in the field of deep-sea ships and offshore platforms. China is rich in marine resources and has an immeasurable prospect of exploitation and utilization. The only way to achieve sustainable development is to develop the dynamic positioning ship control technology at a high speed, which has important utilization value.

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