Research on Application of New Type Marine Intelligent Diesel Engine Control System

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Keywords: Intelligent Diesel Engine, Common rail technology, Electronically Control System, Reduce emissions.

Abstract. Nowadays, with the increasing cost of shipping and fuel oil, more and more countries pay attention to the energy saving and emission reduction of marine main diesel engine. The application of marine intelligent diesel engine is more and more extensive. This paper studies the common rail fuel system of intelligent diesel engine represented by RT-flex, and analyses the comparison between marine traditional diesel engine and marine intelligent diesel engine. Simultaneous analysis the advantages of intelligent diesel engine. Based on the characteristics of electronic control common rail of RT-flex diesel engine, the structure and principle of fuel common rail and servo common rail are analyzed. On this basis, the intelligent diesel engine control system is mainly studied. At the same time, the application of flex View software of control system is also studied.

Introduction

With the outbreak of the global financial crisis for a long time, the shipping industry has been at a low ebb, and shipping prices have been falling for several consecutive years. Shipping enterprises have been devoting themselves to the research of controlling the cost of ship operation. In addition, IMO has been stricter and stricter in controlling the emission of ship air pollution. Energy saving and emission reduction has become an important topic for the research of IMO and shipping enterprises in various countries.

At present, the focus of marine large low-speed diesel engine is how to reduce fuel consumption and harmful exhaust emissions. Traditional diesel engines, such as MC diesel engine of MAN-B&W company and RTA diesel engine of wartsila company, are controlled by traditional cam mechanism and electronic governor. This control mode can no longer meet the requirements of energy saving and emission reduction.

Intelligent diesel engines, such as RT-flex model designed and manufactured by wartsila company in Switzerland and MAN B&W ME model in Germany, have applied the common rail technology of EFI. Compared with traditional diesel engines, they have the characteristics of low fuel consumption, low emission and high reliability, and have gradually become the mainstream model of marine main diesel engines. Compared with the traditional diesel engine, the intelligent diesel engine uses the common rail technology of fuel and servo oil, cancels the traditional camshaft drive, and greatly improves the reliability and fuel economy.

Improvement of Intelligent Diesel Engine over Traditional Diesel Engine

Taking MC diesel engine of MAN B&W company and RTA main engine of wartsila company as examples, traditional cam control and electronic governor have encountered bottlenecks in reducing fuel consumption and harmful gas emissions. In recent years, MAN B&W and wartsila have introduced low-speed intelligent diesel engines. Compared with traditional diesel engines, these intelligent diesel engines have the advantages of low fuel consumption, low emissions, convenient maintenance and operation of equipment and high reliability. It is the best solution for energy saving and environmental protection of ships. Intelligent low-speed engines have unique advantages over traditional diesel engines in emission control. At present, the traditional diesel engine basically does
not meet the Tier2 standard, and the RT-flex and ME low-speed engines can meet the Tire2 regulation [1]. In the next few years, high-power intelligent low-speed diesel engine with low emission and good fuel economy will become the mainstream model of low-speed and high-power marine diesel engine. The original traditional model will be gradually replaced by RT-flex and MAN B&W ME models, which represent intelligent diesel engine.

**Structure and Control System of Intelligent Diesel Engine**

Before the advent of the intelligent diesel engine represented by RT-flex diesel engine, the application of intelligent control began with the intelligent governor. It introduced the real-time smoke exhaust temperature, oxygen content and speed signal of diesel engine into the control system. According to the deviation between the actual speed of the main engine and the given speed, the fuel injection was determined by synthesizing the boost pressure, smoke exhaust temperature and oxygen content. The injection quantity makes the diesel engine fully burn in the cylinder and achieves the goal of economy. However, in the actual work of marine diesel engine, there are many factors affecting its combustion adequacy, not only with the supercharger pressure and the amount of air input. At the same time, it is also related to the start time of fuel injection, the duration of fuel injection and injection pressure. In practical work, if the speed of diesel engine is different, the start time, start pressure and injection duration are also different. Therefore, the pure intelligent governor can not achieve the goal of real energy saving and emission reduction. We should improve the whole control system of intelligent diesel engine and seek a breakthrough to improve the economy and low emission requirements of the main engine. Wartsila first proposed common rail technology. Compared with the traditional Sulzer RTA diesel engine, abandoned exhaust valve drive device, camshaft, fuel pump, start-up air distributor, cam drive and other mechanisms were cancelled, and various key functions were changed from original mechanical control to fully electronic control [2].

In the operation of marine main diesel engine, in order to achieve high efficiency of diesel engine operation and reduce exhaust emissions, it is impossible to use traditional mechanical control. Intelligent diesel engine represented by RT-flex achieves the goal of high-efficiency fuel utilization and low emissions through the design of mechatronics control system. Intelligent electronic control diesel engine control means are flexible and changeable, and can adapt to the working conditions of different diesel engines. The main control system of intelligent diesel engine is based on the technology of mechatronics. It can effectively control each module and execution unit of the system by the technology of electronic control, which meets the requirement of optimizing the operation of diesel engine.

![Figure 1. Schematic diagram of electronic diesel engine structure.](image)

Compared with conventional diesel engines, the new RT-flex Intelligent diesel engine in Wartsila adopts electronically controlled hydraulic control technology, which cancels the traditional mechanical cam system and its transmission mechanism. It controls the valve opening and closing
and fuel injection of diesel engine by means of fuel and servo oil control. On the original RTA traditional diesel engine, fuel supply unit and common rail platform are added, and WECS-9500 control system is set up to control the action of main engine. Now WECS-9520 control system has been developed, as shown in Figure 1, which is the schematic diagram of RT-flex common rail control system.

**Intelligent Diesel Engine Control Module and Common Rail System**

As shown in Figure 2, the fuel supply unit is an important part of the RT-flex diesel engine system. Its action is driven by the gear at the output end of the diesel engine. The fuel supply unit provides fuel to the common rail tube through an efficient fuel pump, and the fuel pressure in the common rail tube can reach 1000 bar. The opening and closing exhaust valves and controlling fuel injection need to be performed by hydraulic servo oil in the common rail of the hydraulic servo system. The hydraulic oil is supplied by the axial piston pump, and its pressure can also reach 200 bar. WECS-9520 control system completes fuel injection and exhaust valve opening and closing by judging crankshaft position and piston position in cylinder. These actions need to be performed by WECS-9520 on the common rail platform to control the fuel ejector and the exhaust valve actuator respectively.[3]
read and write permissions. Classification is as follows: (1) Standard level, such personnel can check the system parameters, but cannot modify the parameters; (2) Operator level, such personnel can query the relevant parameters, but also can modify the user parameters in the operation of some ships, the marine engineers belong to such operators; (3) Operator level (detailed), the basis at the operator level. Up to the point where all user parameters can be modified.

Characteristics of Intelligent Diesel Engine in Ship Application

Compared with the traditional mechanical control system, the electronic control technology of intelligent diesel engine has a series of advantages. For example, the control precision is high, the control function is many, the adaptability is strong and the debugging is convenient. At present, the software of electronic control is also applied to the intelligent control of ships. Engine managers can use the software system to monitor and adjust the parameters of control system and actuator. Compared with traditional mechanical control diesel engines, intelligent diesel engines such as RT-flex have the following advantages [4]

Enhanced Operational Adaptability

Intelligent diesel engine represented by RT-flex has strong operational adaptability, which is mainly manifested in the fuel injection system of diesel engine. It mainly includes the following aspects:

1) The new fuel injection system can choose the injection pressure freely. In this way, the comprehensive performance of diesel engine can be optimized, and the fuel consumption (SFOC) of diesel engine under partial load can be reduced.

2) The new injection system can control the fuel injection more accurately, which can reduce the variation of the circulating fuel injection in the operating range. The application of the new system makes the fuel supply of each cylinder more uniform and the operation of the diesel engine more stable.

3) The use of independent control system to control fuel injection can make the fuel injection rule in diesel engine operation more ideal. With higher injection pressure, the power and economy of diesel engine can be improved. At the same time, the common rail system and control system can make the fuel combustion more sufficient. In addition, the control system can optimize the exhaust emission time to make the emission of NOx in the exhaust of intelligent diesel engine. It greatly reduces and better meets the emission requirements of IMO.

4) In the fuel selection of the main diesel engine of large ships, different fuels, especially inferior ones, will be used for the sake of economy. RT-flex diesel engine injection system can change fuel injection timing and valve timing through intelligent control according to fuel requirements. This greatly improves the applicability of the injection system for inferior fuel. This is difficult to achieve in the traditional cam drive mechanism.

Reliability Improvement of Diesel Engine

The reliability of diesel engine means that the engine has a longer life and maintenance cycle. The design of intelligent diesel engine electronic control system reduces the high wear rate of traditional mechanical mechanism control, reduces the failure rate of diesel engine in use, and has better maintenance performance. In addition, the concept of redundancy design is used in intelligent diesel engine, which makes the system more reliable. In terms of structure and control system settings, the fuel pump, servo pump and fuel pipe of diesel engine all adopt redundancy design, including electronic control system also uses redundancy technology. This design makes the main engine in operation, if a fuel pump or servo pump fails, it can still work at full load, and the bus between the electrical control unit and the system is redundant design, which makes the control system more reliable.

Using Multiple Modes of Operation

In ship navigation, the operation of RT-flex diesel engine can choose different operation modes. Operators choose the corresponding operation modes of diesel engine according to the navigation
conditions and operation conditions of diesel engine at that time. These operation modes include economic mode, low emission control mode, low load operation mode and so on. There are many options available. According to the requirement of working condition, this mode ensures that the engine is always in the optimal state. When intelligent diesel engine adopts low emission mode and economic mode, its fuel consumption under different loads is significantly lower than that of traditional single operation mode. Especially when choosing economic mode, the fuel economy of diesel engine is very obvious.

Have Perfect Condition Monitoring and Control System

Intelligent diesel engine has perfect condition monitoring and control system, which is incomparable with traditional diesel engine. Diesel engine can reasonably control fuel injection quantity and injection timing by integrated speed control equipment according to the detection of ship navigation dynamics and main engine operating conditions. Faults of diesel engine system and its components can be diagnosed by on-line diesel engine fault diagnosis system. In addition, the reliability of piston working in cylinder and combustion in cylinder of diesel engine can also be tested accordingly. These detection and control systems can effectively detect and optimize the operation of diesel engines. Through monitoring and control, the load of each cylinder is evenly distributed, and the overload of the engine is prevented. Before the malfunction of the diesel engine equipment and control system occurs, the system can alarm and start the processing program in the early stage.

Summary

In this paper, the application and control system of marine intelligent diesel engine are studied. Nowadays, more and more attention has been paid to energy saving and emission reduction of ships. Intelligent diesel engine will inevitably become the mainstream of marine diesel engine development. Intelligent diesel engine, represented by RT-flex diesel engine, is becoming more and more perfect in the application of electronic common rail technology, and its models are constantly updated. With more and more ships equipped with intelligent diesel engines, especially advanced ocean-going transport ships, the management level of marine engineers is becoming higher and higher. For marine engineers, it is necessary to understand and familiarize themselves with the technical characteristics of the main engine type RT-flex diesel engine of ship main engine in the future.

Compared with traditional models, because of the application of fuel common rail and servo high-pressure common rail technology, the oil leakage problem of common rail pipeline is more serious than that of traditional models. In addition, the electronic control system control unit module, information acquisition sensors and solenoid valves are prone to new faults, which are more complex than the mechanical faults of traditional diesel engines. This is also a test of the ability of marine engineers to analyze and solve faults. In the future, large intelligent diesel engines will be widely used in ships. While the hardware system is perfect, as a human-computer interaction control system software will become more and more important. Intelligent control software matched with intelligent diesel engine will make ship main engine monitoring and navigation management more intelligent and networked.

References