Analysis and Research on Energy Saving and Emission Reduction of Ships

Dong Xiaoliang1*

1 School energy and power engineering, Wuhan university of technology, Wuhan, Hubei, 430063, China

*Corresponding author’s e-mail: 1362100895@qq.com

Abstract: At present, China's marine industry is in a period of vigorous development, which means more and more ships are produced on the market. Ships are the main driving force for the development of the marine industry, but they also cause many problems, especially the marine ecological problem, marine pollution has become an important factor restricting the development of the marine cause. It is urgent to protect the marine ecology. In other words, to actively develop energy-saving and emission reduction technologies for marine diesel engines is in line with the long-term development needs of marine undertakings. For diesel engines that play a key role in ship driving, effective energy saving and emission reduction technologies are proposed from the aspects of improving the fuel combustion process, using alternative fuels, emission control and exhaust gas treatment, and comprehensive energy utilization, in order to truly realize the expected energy saving and emission reduction targets.

1. Introduction

Diesel engines have the characteristics of lower energy consumption, higher efficiency, larger power range, and simple application and maintenance. Therefore, many ships are currently inclined to use diesel engines. The application of diesel engines has greatly promoted the development of the shipping industry. However, due to inadequate combustion, marine diesel engines also emit more polluting gases, such as sulfur-hydrogen compounds, nitrogen oxides, hydrocarbons, and carbon monoxide, which cause greater pollution to the environment. For marine diesel engines to achieve sustainable development, it is necessary to continuously reduce fuel consumption and emissions and achieve green development. Therefore, the exploration of energy saving and emission reduction technology for marine diesel engines must have certain practical value and necessity.

2. Difficulties in the development of energy saving and emission reduction technologies for marine diesel engines

Sulphur-hydrogen compounds, nitrogen-oxygen compounds, hydrocarbons, and carbon monoxide are the main harmful gases produced by the combustion of marine diesel fuel. At present, carbon dioxide is also included in the control category. Sulfur compounds will be produced if the fuel is not fully combusted. If the sulfur content in the fuel is reduced, the amount of sulfur compounds formed will also be reduced. Nitrogen and oxygen in nitrogen oxides are also relatively common in the atmosphere. The reason why they produce harmful gases such as nitric oxide and nitrogen dioxide is because that the nitrogen component is in a high temperature environment, and when the temperature increases, the oxidation reaction rate Fast, the amount of nitrogen oxides will also continue to increase. The combustion of diesel engines has periodic characteristics. During combustion, it will continue to
undergo ventilation and exhaust links. Therefore, the cooling and heat transfer conditions of the combustion chamber are relatively good. Compared with the gas turbine temperature in continuous combustion mode, the diesel engine cylinder is higher. In order to improve and optimize the combustion, the diesel engine combustion has corresponding excess air. The high thermal efficiency of the diesel engine is due to its oxygen-rich and high-temperature environment. This is also the main factor in the formation of nitrogen oxides. To achieve the reduction of harmful gases. Through the formation principle of nitrogen oxides, it can be found that in order to achieve the reduction of nitrogen oxides, the combustion temperature and combustion speed need to be reduced, but this will reduce fuel economy.

At present, marine diesel engines can set the working mode to emission priority or economic priority through electronic control technology. In the marine environment, the economic priority mode is selected. When the ship enters the port and dock channel, the emission priority mode is adopted. Even though the fuel economy has decreased, the impact is not large because the operation time is not long. However, this mode of operation and management still cannot fully meet the needs of ecological development, especially after the need to control carbon dioxide emissions, the reduction in fuel economy will cause the increase in carbon dioxide emissions. Therefore, in order to achieve energy saving and emission reduction, it is necessary to further optimize the energy saving and emission reduction technology of marine diesel engines.

3. Improve the combustion process of fuel

3.1. Adopt high-pressure common rail fuel injection technology based on electric control
This technology mainly uses the high-pressure fuel pump to establish the fuel pressure, and then uses the common rail to accumulate the fuel pressure, and then uses the solenoid valve to control the fuel injection. Through the application of this technology, the pressure during fuel injection will not be restricted and affected by the pulsating characteristics in the past, so that the fuel supply and the fuel injection are truly independent, ensuring the accuracy of the fuel injection, and improving the combustion process. Ensure combustion efficiency, reduce the generation and emission of pollution and noise. In recent years, the common rail technology has developed rapidly, and the corresponding system structure is becoming more and more perfect. The common rail pipe is being replaced by a pressure accumulator to realize the pressure accumulating function.

3.2. High boost technology
In order to significantly increase the pressure of diesel engines and reduce fuel consumption, the supercharger is developing towards the high-pressure ratio or even the ultra-high pressure ratio. For now, the supercharged ratio of the mainstream products in the world has reached 5.2. However, increasing the pressure ratio does not contribute much to improving the performance of the unit, so further improvements should be made to the booster system. At this stage, the supercharging system that can play a role in performance improvement includes exhaust bypass, variable cross section, etc.

3.3. New gas technology
When diesel fuel is burned, almost all harmful substances need to meet a series of boundary conditions. Based on this, as long as these boundary conditions are strictly controlled, the goal of ultra-low emissions can be achieved. In this regard, many regions have successively carried out development research on new theories and new technologies, resulting in many new technologies such as homogeneous compression ignition and low temperature combustion.

Among them, homogeneous compression ignition mainly adopts methods such as low flame temperature and compression spontaneous ignition, while improving thermal efficiency and reducing emissions of substances such as nitrogen oxides. However, because diesel has a high viscosity, but the spontaneous combustion temperature and volatility are very low, it is the key to the special new technology to improve the mixing between air and fuel and slow down the combustion reaction speed.
Based on this, many new combustion modes have been generated, such as MK combustion and PCCI.

4. Improve the combustion process of fuel
The more commonly used alternative fuels now include: fuel cells, methane, organic fuels, which are secondary energy sources, have high reserves, and can also reduce pollution to the environment. The new models currently developed for this technology include: biofuel new energy engines, gas fuel new energy engines and dual fuel new energy engines.

Among them, dual-fuel new energy engines can alternately use diesel and liquefied natural gas. Compared with traditional engines that can only use diesel, they can increase the flexibility of fuel mixing and reduce pollutant emissions. Its flexibility in fuel blending can be reflected in all output ranges. The two modes of fuel and gas can be switched at will. The use of gas fuel new energy engines can greatly improve engine pollution emissions and adapt to the current regulatory requirements. However, due to the influence of fuel transportation and replenishment and safety, the commonly used models are still mainly It is a medium speed engine. For other types of new energy, such as wind energy and solar energy, although it cannot be the preferred fuel type for ships in a short period of time, a good supplementary energy can also achieve ideal emission reduction effects.

5. Emission control and exhaust gas treatment
The excess air coefficient of diesel engines used in ships is often large, so the combustion is relatively complete, and the amount of hydrocarbons and carbon monoxide in the exhaust gas generated will not be very large, so the pollutants are nitrogen oxides, sulfur oxides and PM mainly.

5.1. Sulfur oxide control
In the fuel of diesel engines, sulfur can be completely burned to generate sulfur dioxide and sulfur trioxide, and the amount of generated is directly proportional to the sulfur content in the fuel. Therefore, the actual emission level of sulfur oxides is directly affected by the sulfur content in the fuel. The method for reducing the production of sulfur and oxygen compounds is to use fuels with relatively low sulfur content, such as natural gas and biofuels, and post-treatment of sulfur and oxygen compounds produced by combustion, such as dry, semi-dry and wet desulfurization. For diesel engines used in ships, sulfur and oxygen compounds can be treated with the aid of a seawater washing system. The seawater of this system absorbs sulfur and oxygen compounds in flue gas. The principle is that carbonate and bicarbonate ions in seawater will react with sulfur and oxygen compounds. The entire treatment process does not require the addition of other chemical reagents, and the operation cost is very low. The product is mainly sulfate, which will not cause pollution to seawater, and is itself one of the components of seawater.

6. NOx
For nitrogen oxides, the following three methods can be used for control: first, pretreatment of fuel oil, such as direct use of low-nitrogen fuel, or emulsification of fuel oil; second, appropriate improvement or transformation of the structure of diesel engines For example, in-cylinder water spray technology, exhaust gas recirculation technology, scavenging air humidification technology, etc.; third, after-treatment of exhaust gas generated after combustion can be achieved using SCR technology and AR technology.

When using fuel emulsification technology, it can reduce nitrogen oxide emissions by 15% to 20%; when using DWI technology, it can reduce nitrogen oxide emissions by 50% to 60%; when using SCR technology, it can reduce 85% ~ Nitrogen oxide emissions of 90%; when using humid aerodynamic technology, it can reduce nitrogen oxide emissions by about 70%; when using CASS technology, it can reduce nitrogen oxide emissions by 50% to 60%.

Among them, fuel emulsification refers to the oil droplets that make the fuel oil into an emulsified state by the action of ultrasonic waves and mechanical agitation. After the oil droplets enter the combustion chamber, due to the absorption of a large amount of heat, a slight explosion will occur
inside and become. The smaller size oil droplets achieve an improvement in combustion. At the same time, because the water has the effect of heat absorption and dilution, it can also reduce the combustion temperature and reduce the emission of nitrogen oxides. SCR belongs to the dosage system. When the temperature is 290 ~ 350 °C, the reducing solution such as urea or ammonia gas is introduced into the exhaust gas, and the catalytic reduction of the nitrogen oxide compound based on the action of the catalyst eventually turns the nitrogen oxide compound into Water and nitrogen. The principle of EGR is to cool and filter part of the exhaust gas, and then re-introduce it into the intake pipe to reduce the total oxygen content in the cylinder before combustion. At this time, because there is carbon dioxide and water in the exhaust gas, because of its large specific heat capacity, it can reduce the combustion temperature. To effectively control the production of nitrogen oxides. For wet aerodynamic technology, it mainly uses humidified intake air to reduce the combustion temperature and control the production and emission of nitrogen oxides. At the same time, it can completely replace the cooler and effectively cool the air at the air inlet. Practice shows that by introducing this technology, it can reduce the emission of nearly 3/4 of nitrogen oxides. In addition, it also supports the use of seawater as a gas source, and uses waste gas to heat the boiler, which is extremely suitable for current ships.

7. Comprehensive utilization of energy
All the heat generated by fuel combustion, water and exhaust gas will take away 20% ~ 25%, 25% ~ 30%, respectively. If this part of waste heat can be fully recovered and utilized, energy consumption can be greatly reduced. Based on this, the idea of comprehensive energy utilization has emerged, that is, through the application of energy recovery and comprehensive utilization technologies, the actual utilization rate of all energy is increased, and the emissions generated by the ship's power system are reduced to the minimum level.

8. Conclusion
The energy saving and emission reduction of marine diesel engines conforms to the trend and needs of ecological and environmental protection. In order to achieve this goal, the combustion fuel can be improved and optimized to improve the combustion efficiency and the working efficiency of the diesel engine. Use high-quality new energy as much as possible and reduce the use of diesel to reduce pollutant emissions and achieve the goal of protecting the environment. The application of energy-saving and emission reduction technology in marine diesel engines promotes the better operating conditions of diesel engines and makes their operating results more ideal, which is conducive to the full combustion of fuel and reduces the production of nitrogen oxides, which can be reused for diesel engine operation. The heat generated at the time increases the energy utilization rate.

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