SCR Tail Gas Treatment of Marine Diesel Engine based on Optimization of Catalyst Structure

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Abstract. with the strict regulation of engine emission mandatory, the diesel engine exhaust emissions level put forward higher requirements, the domestic market sales of diesel engine must follow the upgrade. At present, Chinese has been in the country for the implementation of the national standards of vehicle emission regulations, with the engine at the same time, Beijing, Shanghai, the Pearl River Delta region has been implemented in the standard IV emission regulations, and soon in the nationwide implementation of China IV. For vehicle diesel engines, to achieve the National IV emission level technical route has two kinds, one is the use of exhaust gas recirculation EGR+ exhaust particulate trap, the other is the selective reduction of SCR exhaust emissions of processing. At present, most domestic and international automotive diesel engine enterprises adopt SCR technology roadmap to meet the requirements of National IV emission regulations.

1. Introduction

Because of its strong power and low fuel consumption, diesel engine has been widely used in medium / heavy duty vehicles, but the serious emission problem still restricts the rapid development of diesel engines. Diesel engine emissions of carbon monoxide and carbon oxygen compound CO CH gasoline engine is relatively much less, but NOX emissions and gasoline engine in the same order of magnitude, particle emission of PM to several times or more higher than the [1,2] gasoline engine, the emission control of NOX diesel engine is the key and PM (including soot). The emission of diesel engine and is an important source of pollution of the atmosphere, is considered to have high carcinogenicity and has become the main pollution source of suspended particles in the urban air, except for NOX induced human nervous and respiratory disorders are caused by acid rain and photochemical smog formation arch-criminal of a [3], however, the diesel engine emissions and NOX PM is not like the gasoline engine emissions of pollutants that can be effectively solved by using three way catalytic converter, the main reason is the high oxygen content in diesel exhaust, makes use of NOX to restore the reductive reaction difficult, engine exhaust and exhaust temperature of diesel engine was also lower than that of the gasoline engine, is not conducive to the post processing device in catalyst efficient [4]. As people put more emphasis on environmental protection, pollution of diesel vehicles have become more and more prominent, the heavy-duty diesel vehicles is particularly significant, data show that although heavy diesel vehicles accounted for about 15% of the total motor vehicle, but the NOX and PM emissions accounted for more than 60% of the total emissions of motor vehicles. Therefore, on the basis of developing new technologies for diesel engine emission control, [5] is the key to the development of diesel engine.

2. Current Diesel Engine Emission Control Technology Roadmap

In order to meet the national V, there are currently two relatively mature technology routes in the world. One is the EGR (Exhaust Gas Recalculation) +DPF route represented by American engine

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enterprises, and the other is the optimized combustion +SCR route represented by European engine enterprises.

2.1EGR+ DPF route

The EGR+DPF route is mainly based on EGR, reducing the oxygen content in the cylinder mixture, reducing the maximum combustion temperature in the cylinder, and inhibiting the formation of NOX. This will result in a significant increase in PM emissions from some operating conditions of the engine. PM is captured by the post emission treatment technology DPF to achieve NOX and CO2 emissions and to the extent permitted by the regulations. The advantages of EGR+DPF emission control route are: no need to add urea, low operating cost, and no need to build supporting facilities; no need to add blue cans; relative SCR system, light quality. Disadvantages: higher requirements for oil products, sulfur content country IV requirements below 50PPM, national V requirements below 20PPM; original machine changes greatly, high degree of enhancement requirements; cooling system design is difficult.

2.2 optimize combustion +SCR route

The optimization of combustion +SCR route is mainly to suppress the formation of PM in cylinder by means of internal purification technology, optimization of diesel fuel injection and improvement of cylinder combustion. However, the NOX emissions will increase accordingly, and NOX emissions can be reduced by SCR technology in the post treatment process, and the emissions of NOX and PM can meet the regulations.

Optimization of combustion advantages of +SCR emission control line: simple installation, no need to change the structure of diesel engine; combustion optimization, engine fuel economy can be improved by 5%~7%, after adding blue cost, can still be improved by 3%~5%; urea solution added safety, and low price, easy to obtain; the most important thing is not sensitive to sulfur, not high requirements for oil.

Disadvantages: the need to add urea, namely "Tim blue", for the construction of supporting facilities; the need to add Tim blue cans, increase the weight; to meet the country's V, to increase the NOX sensor to achieve closed-loop control, [9] high initial cost.

3. Realization of SCR technology for diesel engine

3.1 SCR Technology

Selective reduction of NOX catalytic reduction technology as an effective measure of post processing was first applied in the exhaust of fixed pollution source boiler, incineration and power plants to reduce emissions of NOX and climate components applied to the field of transportation, as one of effective measures to reduce emissions of NOX diesel engine. The principle is that ammonia (NH3) is used as a reducing agent, and the harmful component NOX in the diesel engine is converted into harmless nitrogen (N2) and water vapor (H2O) under the action of the catalyst. Ammonia itself is non-toxic, but it is a strong smell of gas, it is not easy to use directly in the car, so the use of the exhaust pipe to spray urea water solution to provide ammonia for the reaction required. A very significant advantage of the SCR technology is that the vanadium based catalyst is insensitive to sulfur in the fuel and does not cause serious poisoning.

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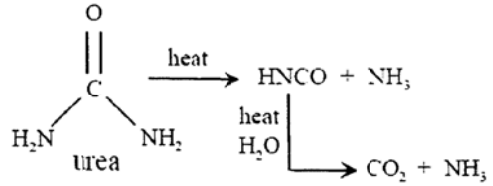
(1) The decomposition reaction of urea:



(1) Selective catalytic reaction of NH3 with NOX:

$$4NH_3 + 4NO + O_2 \rightarrow 4N_2 + 6H_2O$$

$$4NH_3 + 2NO_2 + O_2 \rightarrow 3N_2 + 6H_2O$$

$$4NH_3 + 2NO + 2NO_2 \rightarrow 4N_2 + 6H_2O$$

In the process of SCR reaction, more than 90% of NOX in diesel exhaust is in the form of NO, and the content of NO2 is less than 10%, so the reaction is the main reaction. If you want to do a quick reaction, you need to increase the amount of NO2 in the waste. Some studies can significantly improve the conversion efficiency of SCR system NOX Cuihua under low temperature, when the exhaust in a ratio of NO2 can significantly improve the conversion efficiency of SCR system catalyzed by NOX under low temperature, when the concentration ratio of NO2 and NO in the exhaust gas is 1:1 NOX, the highest conversion efficiency. Achieved by increasing the diesel oxidation catalyst between injection system and turbocharger wheel can increase the ratio of NO2 or NOX in the diesel engine, due to various operating conditions, NO2 and NO ratio control in the reasonable scope more difficult, one of the hot research. In addition, because DOC has strong oxidation, the oxidation of NO to NO2 at the same time the exhaust gas from fuel oxidation of lead sulfate, covered on the surface of the catalyst, if not promptly remove sulfate, sulfate accumulation long time operation leads to a decrease in the catalytic activity, thus affecting the normal operation of SCR system. Therefore, only when the sulfur content in the fuel is relatively low can DOC be used.

3.2 The development of SCR key technology

SCR catalytic converter mainly consists of three parts: handle catalyst, carrier and encapsulation. The catalyst is one of the core parts of SCR technology, the operation of SCR has a direct effect; the carrier is the supporting body, supporting the catalyst is mainly used at present, cordierite firing, automobile exhaust is through and attached to live on the surface of the catalyst carrier interaction, and accelerate the oxidation of NOX in the exhaust in order to achieve the purpose of purification of harmful components in the exhaust gas reduction reaction; catalyst carrier and package can be guaranteed within Shanghai better, play a role in sealing, by optimizing the internal structure with as much as possible to improve the urea droplets and exhaust mixed uniform condition, fully promote the decomposition of urea solution, and should effectively prevent the generation of urea solution deposition phenomenon. Typical catalytic converters are shown below:

Fig. 1 Effect diagram of catalytic converter

4. Summary

Through the optimization to reduce emissions of particulate matter in combustion machine, while using the machine post processing technique, through selective catalytic reduction (SCR) technology to reduce NOX emissions, so that the engine can meet the euro IV/V emission even higher emissions regulations. This technology needs to be improved through the following aspects:

(1) Increase the catalytic efficiency of the catalyst and increase the conversion efficiency of NOX at low temperature, so as to prevent the excessive exhaust emission caused by the low temperature of the catalyst.

(2) catalyst to improve the anti-poisoning ability and fuel quality, due to China's fuel sulfur content is relatively high, so it is easy to cause catalyst poisoning of SO2 catalyst poisoning can not achieve good catalytic effect, make the system conversion efficiency decreased.

(3) the increase of urea ("Tim blue") filling station, install the SCR system of the vehicle need to consume a lot of urea solution, therefore, the construction of "problem Tim blue" filling station is a key link of the whole SCR technology promotion.

In the future, the diesel engine with the gasoline engine incomparable advantages in power, economy and reliability, especially CO2 emission value is particularly low, power system it is no longer confined to marine and commercial vehicles, but has been gradually extended to all kinds of vehicles, diesel car share in the European market has reached 40%, while Germany is as high as 50%. At present, China is also developing diesel engines for vehicles with strict regulations on engine emissions. As a new post-processing technology, SCR can effectively reduce the emission of NOX in internal combustion engine. Most domestic large diesel engine plants reduce carbon smoke through internal purification, and then use the SCR system to reduce the NOX emissions to meet the national IV emission regulations limit the soot and NOX. Because of its low fuel consumption, strong adaptability, and good product platform, SCR technology has become the preferred technology for reducing the emission of medium and heavy duty IV diesel engines. Believe that in the near future, SCR technology in the application of the scope of further.

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