The Analyse and Research of New Controlling Technology of Motor Vehicle Exhaust

Tao-Ping YAN
HuaiYin Institute of Technology, Huai'an, Jiangsu, China, 223001
Ytp709803816@sohu.com

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Abstract. With the rapid development of modern economy and more attention people pay to the environmental quantity nowadays, the treatment of motor vehicle emissions is increasingly urgent. In this paper, a method of removing contaminants is explained by analyzing the operating principle of purifying motor vehicle exhaust using low temperature plasma. Then a method of cleaning motor vehicle exhaust is illustrated by studying the phenomenon that in a plasma fuel converter, when the measured air enters a plasma generator located downstream of the burner and is applied high voltage to, it can form a high-temperature plasma, which is then injected into the burner to ignite the fuel air mixture with high combustible components. Finally, in this paper the new technology of high-tech pavement material effectively purifying motor vehicle exhaust is deeply studied, which can solve the negative effects on the atmosphere caused by the motor vehicle exhaust to a greater extent.

Introduction

Along with the rapid development of automobile industry, vehicle inventory is increasing in our country, and the automobile exhaust emissions have gradually become the main sources of air. Especially large and medium-sized cities, which have developed economy, concentrated population, dense tall buildings, poor air flow, have suffered or are suffering from automobile exhaust pollution in recent years. None control will worsen environment severely, pose a great threat to people's physical and mental health. This paper mainly studies control principle and application of vehicle emissions control method by the low temperature plasma technology, plasma fuel converter technology, new technologies such as nano-materials technology[1].

The Low-temperature Plasma Technology to Purify Exhaust Gas

Low temperature plasma technology used to deal with pollutants, compared with the commonly used catalytic reforming process, has good treatment effect, wide processing range, can handle a variety of pollutants at the same time, purify thoroughly no secondary pollution etc, and is competitive in the field of waste gas treatment. Therefore, the low temperature plasma technology applied in automobile exhaust purification is bound to have very important practical significance and broad prospects.

The plasma, different from the three states of material (solid, liquid, gas), is the fourth kind of material existence form, is made up of a large number of positive and negative charged particles and neutral particles. The plasma can be divided into the plasma equilibrium and nonequilibrium plasma, according to the thermodynamic equilibrium of plasma. So-called plasma equilibrium on the macro is in thermodynamic equilibrium state, when the electron temperature Te and ion temperature Ti is equal. It is also called hot plasma due to the system temperature can reach tens of thousands of degrees. And the electron temperature Te of non-equilibrium plasma can reach more than $10^4$ K, when electronic temperature Te is greater than the ion temperature Ti, while the temperature of ion and neutral particles is only 300-500K. Therefore, the system's apparent temperature is very low, so it is also referred to the low temperature plasma.
In recent years, the low temperature plasma technology has been successfully used in solid waste, liquid waste and gas waste processing; its application in the field of environmental protection is becoming increasingly popular with people. In gas waste treatment, low temperature plasma technology in the industrial application of desulfurization and denigration of flue gas has been fairly basic, but the application in the automobile exhaust management research at present is still in the exploratory stage. Due to the treatment of gaseous pollutants generally require under the normal pressure, and only corona discharge and dielectric barrier discharge two forms can produce low temperature plasma under atmospheric pressure, the present study is given priority to with the two discharge modes.

Using low temperature plasma purifying automobile exhaust, the high-energy electron generated by discharge transfer energy obtained in the electric field to the surrounding atoms or molecules by collision to make them motivating, dissociating or producing active group. A series of gas phase chemical reactions take place between these active species and exhaust gas pollutants, so as to achieve the purpose of the removal of contaminants. The reaction process of plasma to purify automobile exhaust is very complex. The current literature is summed up a series of possible reaction pathways, remaining further experiment and theory validation.

It is seldom reported for the low temperature plasma purification of automobile exhaust reaction kinetics. Reaction kinetics study of plasma technology disposing of NO\textsubscript{X} have focused on qualitative research through the experiment in domestic at present, very few the quantitative analysis, although quantitative or semi-quantitative research of NO\textsubscript{X} conversion reaction kinetics have done on some abroad literature, but also have not formed mature theory, and the study of reaction kinetics in the automobile exhaust is very less[2,3].

Use Hydrogen to Reduce NO\textsubscript{X} and PM Threshold of Diesel Engine Exhaust Emissions

U.S. commercial automobile industry standards require existing diesel particulate and NO\textsubscript{X} emissions levels of diesel vehicle to reduce more than 90% in the near future. All kinds of innovative solutions and technology is developing aiming at application in passenger, heavy and light cargo cars of North America, Europe and Asia. One of these techniques is the use of hydrogen to reduce diesel engine exhaust emissions of PM and NO\textsubscript{X} threshold.

The goals of threshold of the vehicle emissions in the future is significantly reduce content of particulates or carbon smoke and NO\textsubscript{X} in diesel engine exhaust. Traditionally the problem is that in the exhaust gas after treatment systems, usually one’s volume of PM and NO\textsubscript{X} is reduced and the amount of another increased.

At present, most European truck manufacturer generate a few PM with design of engine, followed by using selective catalytic reduction technology to reduce NO\textsubscript{X} in the exhaust. This will sometimes need urea additives to restore NO\textsubscript{X} in catalytic converter. Urea additive also needs fuel low in sulfur. Sulfur will greatly reduce the service life of the catalytic converter material. Another way is by cooling exhaust gas and exhaust gas flow through the engine recirculation to more completely burning, in order to reduce the formation of NO\textsubscript{X}. And then capture PM in a particle trap. However, requires a continuous regeneration particulate trap, or trap is easy to be blocked by carbon smoke, then engine cease to work. For regeneration, by putting a diesel spray into the waste gas stream harmlessly burn carbon smoke particles in order to improve the exhaust gas temperature.

Therefore, the two plans above are difficult to avoid the traditional problems. According to exhaust system and axle manufacturers ArvinMeritor said, a method of the best of both worlds is to introduce plasma fuel converter into the gas stream. Soon, the new emission standards will bring even more stringent emission limits and new challenges. Plasma fuel converter may help to deal with the problem of more stringent emission limits. Plasma fuel converter produces a rich hydrogen gas from vehicular diesel or gasoline fuel, which can be used to start the exhaust control system. At present, the device is carried out on the heavy and light trucks, and buses loading tests. Expected the plasma fuel converter can be put into production in the near future.
The Main Stage of Clean Emissions "Hydrogen"

There perhaps be a lot of years before commercial practical stage of hydrogen fuel cell powered cars. But the role of the hydrogen is more than just as a fuel with the increasingly strict emission regulations. The latest technologies will use the hydrogen to simplify emissions control system in diesel engine in the coming years. ArvinMeritor have developed the new technology, which can narrow the gap between today's internal combustion engine and the fuel cell power system, and greatly promote the improvement of fuel economy.

Core technology of the new system of ArvinMeritor is a "low energy plasma fuel converter system", which produce hydrogen through the reaction of plasma cracking hydrocarbon gas and steam, without a separate hydrogen fuel supply system. The plasma fuel converter generates hydrogen according to the needs of vehicle for fuel, either gasoline or diesel oil, which can save weight and cost of a separate oil supply system. Due to the plasma hydrogen fuel converter is very effective for the birth of the hydrogen on the car, the technology can also be a transition for the development of fuel cell technology, as an important resource of internal combustion engine alternative fuel.

Working Principle and Effect of Plasma Fuel Converter

Plasma fuel converter is similar to strong continue "lighting", burn part of the air and hydrocarbon fuel (diesel or petrol) mixture. The air here is intentionally designed not to let it support combustion, instead of decompose the fuel and air mixture, forming a rich hydrogen gas. In diesel engine, the Rich hydrogen gas could help restore and improves the performance of the exhaust system, starting the other emissions system. In commercial vehicles, rich hydrogen gas can be used as a low cost, high efficiency, complete combustion, fast start trap regenerator of NO\(_X\) and PM, immediately can be applied to the diesel engine exhaust gas after treatment systems. In the long run, rich hydrogen gas may greatly improve the combustion efficiency of gasoline engines. Plasma fuel converter use electrical energy for about 100W, equal to a pair of traditional headlamps.

New plasma fuel converter of ArvinMeritor originally is designed for clean nitrogen oxides of regenerator of a commercial vehicle diesel engine exhaust emission system. Plasma fuel converter applied to automobile emission purification system. In principle active substance aid cover layer is formed on the surface of the system medium. NO\(_X\) in the exhaust gas is absorbed to avoid its emissions into the environment. In the traditional NO\(_X\) gas, diesel fuel is introduced as hydrocarbons. Its shortcomings include hard starting at low temperature, more fuel consumption, more not burning diesel emissions into the atmosphere. Using plasma fuel converter generate hydrogen through the low energy plasma cracking hydrocarbon gases and water vapor reaction, thus reducing emissions of NO\(_X\). Plasma fuel converter system can reduce NO\(_X\) and PM emissions both[4,5].

High-tech Pavement Materials Effectively Purify Automobile Exhaust

One of the new techniques of air pollution control is using nanometer material to purify automobile exhaust. Nanometer materials refer to materials at least one dimension in the nanometer scale in the three-dimensional space, which generally consists of the nanoparticles between 1-100 nanometer. Nanometer materials are widely used in a variety of special occasions because of its special physical and chemical properties, such as photocatalysis. At present, electrical semiconductor are widely used as light catalyst catalytic purification environmental pollutants, such as titanium dioxide, zinc oxide, cadmium sulfide, ferric oxide and tin oxide. While nano semiconductor catalyst has better catalytic ability, enough to put the oxygen reduction for lively hydrogen peroxide, or directly to put toxic high valence metal ions reduction for metal, which is a catalytic purification technology with great development potential pollutants.

At present, most of the research at home and abroad composite titanium dioxide nano photocatalytic materials in cement concrete matrix to make environmental protection cement concrete pavement materials, or nanometer photocatalytic materials are made of environmental
protection coatings on road facilities, purify automobile exhaust from the exhaust pipe under the irradiation of ultraviolet light to harmless CO$_2$ and inorganic salts etc of the human body.

The green car tail gas degradation technology is also used in the 2010 Shanghai world expo, in order to avoid the expo events' impacting on the surrounding ecological environment. Park surface coated with nano light catalyst coating in the periphery of the expo site, under the light, can quickly break down harmful substance in vehicle exhaust, make minimum damage of the fumes car produced to the environment.

Advanced air purification technology is taken to deal with the air pollutants at main road tunnel in Shanghai at the same time, carries on the comprehensive control of tunnel air. The system is a highly integrated engineering equipment of a concentration of high voltage electrostatic dust removal, carbon monoxide, hydrocarbons, nitrogen oxides and other gas pollutants high purifying in the integration. It is applied in road tunnel air comprehensive treatment, with a remarkable effect on the inhalable particles, carbon monoxide, nitrogen oxide, nitrogen dioxide, nitrogen oxides, total organic carbon and sulfur dioxide and other pollutants purification. The indicators are met or exceeded the similar level of pollutant purification technology. The system plays an important role in the expo the comprehensive control of air pollutants at main road tunnel in Shanghai during.

Polyphase photocatalytic process with semiconductor oxide as catalyst can spur the mineralization of organic pollutants directly under the action of light at room temperature. The technique, no secondary pollution, has become a kind of ideal environmental pollution treatment technology. It is a highly efficient, energy saving, green environmental protection technology with purify air, sterilization, deodorization, degradation of organic matter, self-cleaning surface and other special functions. Photocatalysis can make the pollutants oxidized to carbonic acid, nitric acid, sulfuric acid etc by photocatalytic ground material with the ground wash off, so as to purify the atmosphere. The core material of antibacterial ground material is nano silver antibacterial agent, which is a kind of efficient broad-spectrum antibacterial material. And the anion ground material release negative ions with nanometer tourmaline anion, so as to realize the function of antibacterial and cleaning the air[6,7].

**Summary**

It is given priority to the various purification technologies to improve engine combustion process throughout course of the human control auto emission pollution until the 70s. While these techniques has played a big role in reducing the exhaust pollution, but the effect is limited, and bring different degree of side effect of automobile performance and fuel economy. With increasingly strict emission regulations, people began to consider the low temperature plasma technology, plasma fuel converter technology. The successful development of new technologies such as nano-materials technology brings a breakthrough of vehicle emission control technology; reduces a lot harmful emissions of gasoline car.

**References**


