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METHODS OF DIRECT IMPACT ON THE WORKING PROCESS OF AN INTERNAL COMBUSTION ENGINE IN ORDER TO REDUCE HARMFUL EMISSIONS

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Abstract. The article analyzes changes in the characteristics of fuel supply and gas exchange, geometric dimensions, as well as the shape, material and state of the surface of parts of the gas exchange system, fuel supply and combustion chamber, leading to a change in the formation and decomposition of harmful substances during the working process. and, accordingly, to a change in the composition of the exhaust gases and proposed ways to improve the working process and design, contributing to the reduction of the formation of harmful substances.

Key words: harmful emissions, exhaust gases, individual pump section, pump injector, battery fuel system, exhaust gas recirculation.

Methods

Reducing emissions of harmful substances with the exhaust gases of the internal combustion engine is possible, whether directly in the process of formation, i.e. during the working process or due to the effect on the specified substances that are in the composition of the exhaust gases. In the latter case, it is appropriate to use additional devices such as neutralizers and particle filters.

General classification of methods for ensuring the environmental safety of a diesel engine given in the V.R. Buryachko's research is described below [1].

Any changes in characteristics of fuel supply and gas exchange, also geometric shape of gas exchange system parts surface's state and material will lead to a change in the formation and decomposition of harmful substances during the working process and accordingly to changes in the composition of the exhaust gases [2].

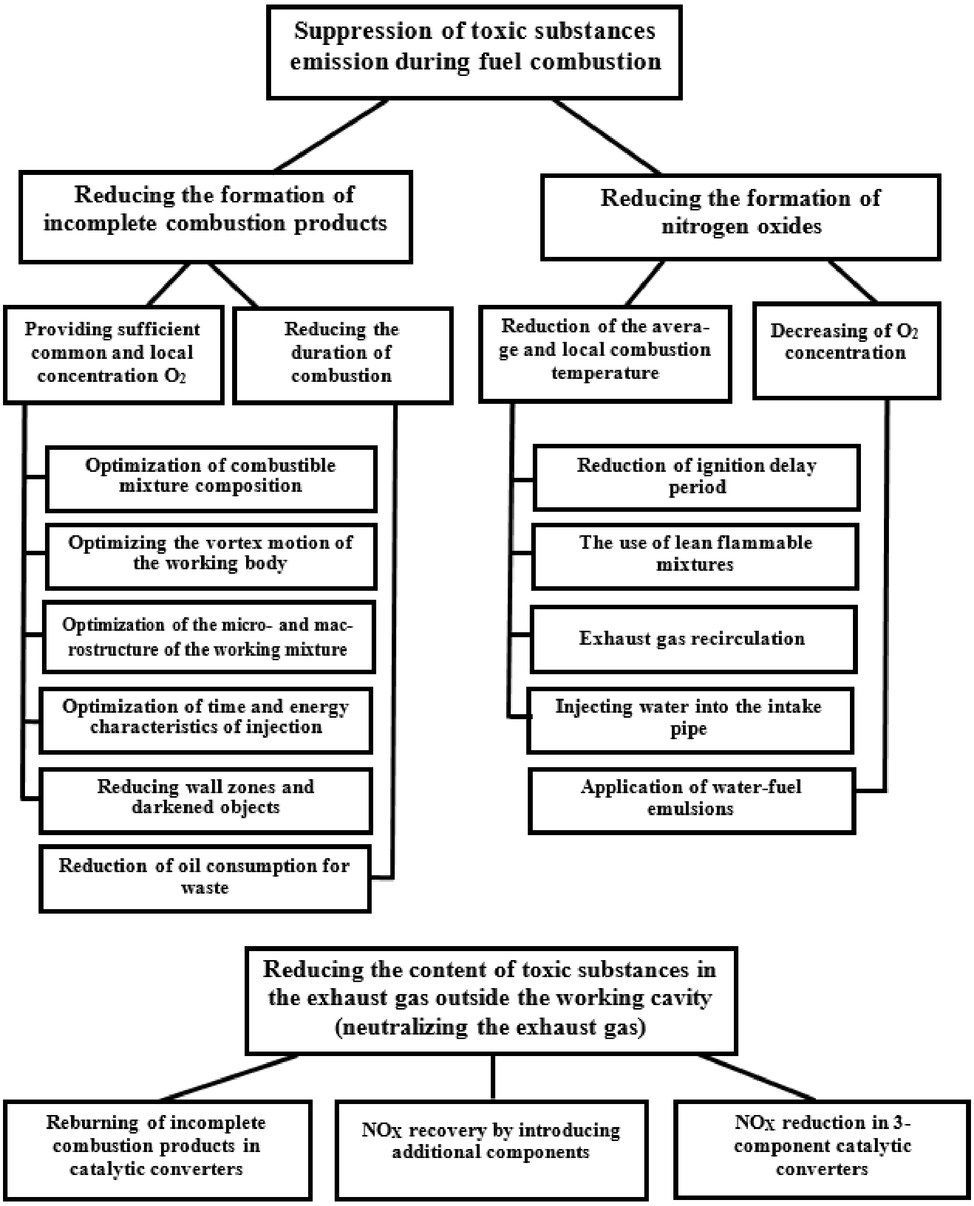
It is important to remember that the final conclusion about the certain measures effectiveness of improving the environmental performance of engines can only be made on the basis of tests carried out in accordance with the relevant standards (i.e., on the basis of standardized tests), but not based on the results of measurements on individual modes (i.e. based on research tests) [3, 12].

According to R.Bosch, the fulfillment of the standards of harmful substance emissions with the exhaust gases of automobile diesel engines Euro-3, Euro-4 in general was ensured by ten main measures, six of them related to fuel supply equipment. In this regard, it is possible to point out a number of directions for improving the fuel supply equipment of modern diesel engines. They cannot be considered as alternatives, but they are expensive and high-tech.

The individual pump section is a module consisting of a precision pair – a sleeve and a plunger with a pusher, which is installed in the bore of the crankcase and driven by an additional cam of the engine camshaft.

Results and discussion

The main positive property realized when using individual pumping sections instead of a block injection pump is the possibility of maximum spatial convergence of the section and nozzles. This ensures a reduction in the length and volume of high-pressure fuel lines, reduces the negative effect of elastic vibrations and wave phenomena that distort the fuel injection process. When using individual pumping sections, the injection pressure can be increased to 160 MPa. Until recently, section control was carried out by mechanical systems, which complicated the design and made it difficult to regulate the cyclic fuel supply. It turned out to be possible to use the advantages of individual pumping sections to the full when using electro-hydraulic control systems [4, 9].



The next step is unit injectors. In unit injectors, the pump section and the spray nozzle are combined into a single unit so that there is no high pressure pipeline between them. Pump injectors were widely used by GMC back in the 40s, and later were produced in the USSR for use on licensed two-stroke engines YAMZ-204 and 206. The use of original pump injectors from Cummins is also known. Even in those years, the injection pressure in the unit injectors increased to 150 MPa. Nevertheless, these designs have not received widespread use due to the complexity of the drive from the camshaft remote from them, as well as the difficulties of precise regulation of the cyclic fuel supply. The largest number of recent developments involves the use of electromagnetically-hydraulically controlled structures [5, 21]. This type of unit injector can generate injection pressures up to 200 MPa. However, the pump-injector drive operates under conditions of high contact voltages, which reduces its reliability and the prospects for increasing pressure. With this in mind, the design of pump injectors with a multiplicative servo drive and electrohydraulic control appeared.

The original fuel supply system with multiplicative unit injectors was developed by Caterpillar. This HEUI system uses oil pressure to drive the unit injectors, which is generated by a special oil pump and is held by a regulator at the required level in the pressure accumulator. This pressure is supplied to individual electrohydraulically controlled unit injectors, to the input of which fuel is supplied from the fuel tank using a fuel pump [5, 19].

The next type of injection molding systems is accumulator fuel systems. A distinctive feature of storage fuel supply systems is the asynchronous operation of the high-pressure fuel pump and injectors. In these systems, the fuel pump supplies fuel to a tank - an accumulator of a sufficiently large volume, the pressure in which is maintained by the regulating device at the required level. Normally closed injectors communicate with the accumulator, and their closing body is forced to open at the right moment for the required time. The cyclic feed in such a system is determined by the injection pressure and the duration of the open state of the nozzle, which creates great opportunities for multifactorial optimization of the process. It is also important that in this case the high pressure fuel pump is freed from the need to operate in a mode of extremely unequal torque. The first industrial prototype of an electronically controlled accumulator fuel system without pressure multipliers called Common Rail (CR) ("Common rail", ie a common line for injectors, accumulator), was a joint development of Robert Bosch GmbH, Fiat , Elasis, implemented in 1997. Currently, work on CR is being carried out in all firms - manufacturers of injection molding machines, and the range of completed developments is rapidly expanding. The principle of operation of the CR is similar to the electronically controlled gasoline injection system: the pressure in the accumulator is constant, and the fuel injection advance angle (UOVT) and the cyclic portion £ c are regulated by the phase and duration of the injector opening. However, the modes, operating conditions, requirements are different, and therefore, the design is much more complicated [7, 8].

An effective method for reducing NOx emissions is exhaust gas recirculation, which consists in returning part of the exhaust gases from the exhaust system to the diesel cylinders and mixing them with a fresh charge. The exhaust gas recirculation method is based on diluting the air entering the cylinders with chemically inert gases. The greatest effect during recirculation is provided by gases with an increased specific heat capacity, which include carbon dioxide (carbon dioxide) CO2, which is the main component of exhaust gas. In this way, exhaust gas recirculation provides the effect of diluting the air charge with carbon dioxide.

A decrease in toxicity during exhaust gas recirculation is due to both the impact on the working process and a decrease in the total mass of exhaust gases emitted into the atmosphere, since some of the gases are returned to the diesel intake. The mechanism of the effect of diluting the fresh charge with exhaust gases is that nitrogen dioxide NO2 contained in the exhaust gases, as well as the increased temperature of the end of compression, accelerate ignition (shorten the ignition delay period), and also, being a ballast component, reduce the heat of combustion, per unit mass of charge, which reduces the temperature level of the reaction, as well as the concentration of unbound oxygen. As a result of recirculation of exhaust gases to a level of 25 ... 45% of the mass of the cyclic charge, the content of nitrogen oxides decreases by more than 2 times at medium loads. Along with a decrease in NOx, exhaust gas recirculation also provides a decrease in aldehyde emissions [9, 11].

One of the main methods of optimizing the vortex movement of the air charge is also the transition to four-valve cylinder heads together with the use of throttle valves. Each of the two intake valves receives air from individual intake ports; one of them is tangential vortex-forming, and the other is straight, used as filling. Subsequently, a throttle valve is installed in it. The second throttle valve also regulates the air supply through both valves. Due to the automatic, electronically controlled control of these dampers, the vortex movement is optimized. If the throttle valve in the filling channel closes, the swirl movement is doubled due to 100% air passage through the tangential channel. This contributes to the best organization of mixture formation in the entire range of speed modes [10, 18].

The practical application of exhaust gas recirculation and the use of dampers in the intake ducts requires complex automatic control, therefore, the use of this technique should be considered as a scientific and technical groundwork for the future.

Injection of water into the intake system also has a positive effect on the environmental performance of diesel engines. The presence of water in the fresh charge leads to its rapid evaporation, and at the end of compression the fuel is injected into an almost homogeneous mixture of air with water vapor. In this case, the average and local temperatures of the mixture differ little from the temperature of the charge without the addition of water, since the volume of vapor is an insignificant fraction of the volume of air. Under these conditions, water vapor acts as an inert ballast with little effect on the ignition delay. A lower charge temperature and a decrease in the concentration of free oxygen leads to a decrease in NOx emissions. It has been established that the addition of 6% (by weight) water to the air entering the cylinders makes it possible to reduce the NOx concentration in the exhaust gases by 50% [11, 12].

The use of water-fuel emulsions. There are several hypotheses about the mechanism of the influence of water-fuel emulsions on the nature of combustion in diesel. One of the most widespread is the hypothesis of "microexplosions" of heated water droplets in an inverse emulsion when it is injected into the cylinder. Due to the intensive expansion of the vapor inside the fuel droplet, secondary atomization of the fuel and its mixing with air is provided. This results in a decrease in emissions of products of incomplete combustion [13, 20].

Recently, information has appeared that an improvement in the completeness of combustion is also observed when using direct emulsions. On this basis, a number of researchers believe that when entering a high-temperature environment, dissociation of water molecules occurs, followed by chemical interaction of radicals - products of decomposition of hydrocarbons with hydrogen and a hydroxyl group (OH) [14, 15].

The most probable is the existence of both mechanisms of the influence of water in the fuel. In addition, the evaporation of water leads to a decrease in the local temperature in the ignition zones, which causes a significant increase in the ignition delay. Hence, a dual effect of water in the fuel on the NOx emission is possible, an increase in the ignition delay, an intensification of the rate of pressure rise and average temperature, which increases the NOx emission, and a decrease in local temperatures due to the evaporation of water reduces it. Therefore, in some studies, either a weak effect of water addition on NOx emission was observed, or even an increase in the latter [16, 17].

However, the prospects for water injection and the use of water-fuel emulsions are controversial as they lead to many problems. For their implementation, a water supply is required (up to 20 ... 30% of the fuel supply). There are difficulties in preparing water-fuel emulsions and ensuring the stability of its structure over time, since water is released from the fuel over time and settles at the bottom of the fuel tank.

Conclusions

The operation of the fuel supply system with a water-fuel emulsion becomes problematic at negative ambient temperatures. Difficulties also arise with the anti-corrosion protection of parts of the fuel equipment and the engine itself. A rather sophisticated automation is required for dosing water added to the fuel.

Summarizing the above, we can conclude that in order to suppress the emission of toxic substances in the process of fuel combustion, it is necessary to ensure a sufficient total and local concentration of exhaust gases, reduce the duration of combustion, optimize the micro- and macrostructure of the combustible mixture, and reduce the average and local temperature of products. combustion. Ways to achieve these tasks are offered quite expensive and technologically complex. For example, such as the use of electronically controlled pump injectors, exhaust gas recirculation, the use of dampers in the intake ducts of the cylinder heads, etc. In many respects, such decisions are explained by the economic strategy pursued by foreign diesel companies, especially for fuel equipment and systems of automatic regulation. In this regard, it is necessary to make fuller use of the potential of traditional fuel and air supply systems, which are cheaper in production and operation.

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