

FEATURES OF THE ORGANIZATION OF THE WORKING PROCESS OF A GAS-DIESEL ENGINE

Doctor of Technical Sciences, Professor Manoylo Volodymyr Maksymovych
Graduate student Tyzhnenko Oleksandr Vyacheslavovych
Kharkiv National Automobile and Highway University
Master's student Eremenko Vladyslav Serhiyovych
State Biotechnological University

The use of natural gas as a fuel in gasoline engines has advantages compared to the operation of the engine on liquid fuel. The high octane number of gas fuel allows the engine to operate with an increase in the compression ratio by 15-20%. The wider limits of flammability of gas fuel allow operation on lean mixtures ($\alpha=1.4...1.7$), which provide an increase in the fuel efficiency of engines provided that stable and uninterrupted combustion is ensured.

Effective combustion of the gas-air mixture at such values of the excess air coefficient can be carried out at high values of the compression ratio, which are characteristic of engines with ignition of the combustible mixture from compression, that is, in diesel engines.

Thus, despite the advantages of using natural gas to power engines with positive ignition, the use of natural gas to power diesel engines allows for more efficient combustion of gas-air mixtures. There are several ways to adapt piston truck engines to power natural gas. The first is to convert already manufactured and operating engines powered by liquid petroleum hydrocarbon fuels by retrofitting them with a system for storing, supplying and dosing gaseous fuel, as well as making the necessary changes to the engine control system and ensuring an effective mechanism for the formation of a gas-air mixture.

Examples of such engines are engines that are converted for the purpose of conducting experimental studies of working processes, the results of which are given in the scientific and technical literature.

The second method is to organize mass production of engines originally designed to run on natural gas, both compressed and liquefied. Currently, there are some engine manufacturing companies that have in their line of assembly-line models designed to run on natural gas.

When converting spark-ignition engines to natural gas, no major changes to the design of the power plant are required. In addition, the transfer from one type of fuel to another can be carried out without stopping the engine, which is an important advantage. In most cases, positive-ignition engines converted to operate on natural gas fuel operate on stoichiometric and near-stoichiometric fuel-air mixtures. With this organization of the working process, an increase in the average temperature values per cycle is observed, and there is also a possibility of detonation.

It is worth noting that when carrying out a work process with external formation of a gas-air mixture, a phenomenon such as backfire may occur, when the fuel-air mixture ignites in the intake manifold.

The conversion of diesel engines to natural gas power is carried out in two ways, which differ in the method of ignition of the gas-air mixture and the number of simultaneously used types of fuel. In the first case, a work process is organized with the ignition of the gas-air mixture from a spark plug, in other words, the engine is transferred to work according to the Otto cycle.

At the same time, the standard diesel fuel equipment is dismantled, its place is set by the ignition system. The engine no longer has the ability to operate on diesel fuel, it becomes completely gas. To ensure the effective course of the ignition processes and detonation-free combustion of the gas-air mixture, the compression ratio of such an engine is reduced to values that are slightly higher than those in gasoline engines, which is due to the physicochemical properties of the gas.

Typically, reducing the compression ratio is accomplished by changing the volume and shape of the combustion chamber in the diesel engine piston.

The disadvantage of this conversion method is a significant change in the design of the basic diesel engine, which means high costs for re-equipment, as well as the possibility of operating on diesel fuel.

The second method of conversion consists in equipping the engine with a system for storing, supplying and dosing gaseous motor fuel, as well as making changes to the electronic engine control system. In this case, the standard system for supplying the engine with diesel fuel is preserved.

With this method of conversion, the advantage of the working process of diesel engines associated with maintaining high values of the compression ratio is realized. As noted above, with such values, it is possible to carry out effective combustion of the lean gas-air mixture, which has a positive effect on the fuel economy of the converted engine.

Diesel fuel acts as the source of ignition of the gas-air mixture with this method of conversion, that is, the engine becomes dual-fuel. This method of converting part of the operated fleet of diesel engines to operate on gas fuel has received the widest application.

When converting a diesel engine to operate with a gas-liquid cycle, in most cases one of two schemes for obtaining a gas-air mixture is used. In the first case, external mixing is used, when natural gas is fed into the intake manifold and together with air enters the cylinder on the intake stroke, where they are mixed due to the vortex motion of the air charge. In this case, natural gas is fed in a gaseous state, which ensures excellent mixing and a homogeneous fuel-air mixture throughout the volume of the combustion chamber. In this variant, the engine performs mixed mixing: at the first stage, an external formation of a homogeneous mixture of natural gas and air is carried out, and then an internal formation of a heterogeneous mixture of an ignition dose of diesel fuel with a homogeneous gas-

air mixture. In the second case, the gas engine fuel is injected directly into the cylinder in a liquid state under high pressure in order to ensure fine atomization, rapid evaporation of the fuel, and good mixing with air [1].

The use of natural gas injection directly into the combustion chamber involves the installation of an expensive and technologically complex storage and power supply system on the engine, which makes this scheme of organizing the work process less rational from an economic point of view and complicates the design of the engine. However, research into the work process using direct injection of natural gas is currently being conducted, and the results of individual works are being implemented in new products that are being introduced to the consumer market [2].

When switching to a gas-diesel cycle, the primary goal is to minimize the ignition dose across the entire load and frequency range of the engine [3]. Reducing diesel fuel consumption allows for increased economic efficiency of a dual-fuel engine through fuel price differentiation, as well as reducing the content of suspended particles in exhaust gases.

Despite the advantages of using natural gas to power compression ignition engines, there has been a gradual abandonment of the use of gas-diesel engines. This is due to the fact that the previously used diesel fuel supply systems and engine control systems did not provide the necessary level of environmental safety. This was the main reason for the abandonment.

Currently, the problem of reducing harmful emissions during the transition to a gas-diesel operating process needs to be solved.

This assumption is confirmed by the number of scientific publications devoted to improving the environmental safety of internal combustion engines operating on a gas-diesel cycle. However, an effective approach to solving this problem has not yet been found. When converting a diesel engine to operate on a gas-diesel cycle, the control unit for the engine's natural gas supply system receives information from engine sensors and from the main electronic control unit (ECU).

With such a scheme, there is no feedback with the control unit for supplying the ignition dose of diesel fuel. In this regard, it is necessary to develop a system where a single control of the supply algorithms for each fuel will be implemented depending on the operating mode and on the values received by feedback from all engine systems

Reference

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DIRECTIONS FOR IMPROVING THE CHARACTERISTICS OF PISTON INTERNAL COMBUSTION ENGINES

Candidate of Technical Sciences, Associate Professor Shevchenko Ihor Oleksandrovykh;
Master's student Shubnyy Vladyslav Vitaliyovych
State Biotechnological University

Improvement of internal combustion engines continues in traditional directions – increasing efficiency, reducing emissions, improving adaptability.

Progress in three directions is provided by new technical solutions in the design of fuel and air supply systems, in the design of friction pair elements, in the control of the combustion process, and the design of anti-toxic system components. Let us consider a specific recent example - the development by the Weichai company from the People's Republic of China of the WP 13H560E65 serial diesel engine with a record effective efficiency of 50.26 %. This efficiency value corresponds to the minimum effective specific fuel consumption of 167.04 g/kWh. The authors of the achievement report on five key technologies implemented in the development: coordinated combustion technology, which allows to increase the combustion rate by 30 %; coordinated design technology, which increases the strength of the engine structure at increased combustion pressures; exhaust gas energy distribution technology, which optimizes the processes of converting harmful substances in the catalytic converter and ensures high turbine efficiency in a wide range of operating modes; zoned lubrication system technology, which reduces friction losses by 20 %; intelligent control technology, which uses accurate algorithms for predicting changes in engine parameters.

Increasing the effective efficiency to 50 % from the previous achievement of 46 % provides a reduction in fuel consumption (and a reduction in carbon dioxide emissions) by 8 %. At the same time, the new engine meets the Euro-6 requirements for limiting emissions of harmful substances.

The following modern levels of parameters of diesel engines that meet Euro-6 standards can be determined: effective specific fuel consumption – less than 190 g/kWh; liter power – more than 30 kW/l; the beginning of the frequency range of maximum torque – below 1000 min⁻¹.

It is obvious that these levels will be improved in the near future. Weichai announced that it intends to begin work together with partners to achieve an effective efficiency of 55 %.