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REDUCTION OF TOXICITY OF BURNT DIESEL GASES WITH THE ADDITIONAL FEEDING SYSTEM

Statement of the problem in general. As a result of the introduction of new environmental emission standards, manufacturers of motor vehicles and fuels have to use a variety of technologies, systems and units to reduce harmful substances in the exhaust gases of diesel engines. Modern development of automobile internal combustion engines takes place in the following directions: increase of fuel economy and ecological purity; sub-increase of unit power and weight reduction; creation of hybrid power plants with an internal combustion engine (ICE); dieselization of transport; increasing reliability of work and resources; use of alternative fuels (gas, hydrogen); control of internal combustion engines with the help of microprocessor technology. One of the ways to solve the problem is to develop technologies related to the installation of additional equipment on an existing engine in order to reduce harmful emissions into the environment.

Analysis of recent research publications.

It should be noted new development and use of theoretical insights in the field of alternative fuel combustion, both for stationary combustion (gas turbine, rocket engines) and for non-stationary combustion at variable volumes and pressures (combined reciprocating engines). [1–3]. This has already allowed to obtain much higher efficiency output (efficiency), and the utilization of exhaust gases - to reduce significantly the content of harmful impurities, i.e. to partially solve the environmental problem [4,5].

The task of burning highly viscous fuels is complicated by the fact that their thermophysical parameters differ significantly in relation to traditional fuels, which requires a careful approach to assessing the formation of the fuel mixture - spraying, evaporation and mixing with an oxidant [6]. In addition, the high sulfur content poses additional challenges, especially for exhaust gases to become environmentally-friendly.

The theoretical preconditions for increasing the rate and completeness of combustion of high-viscosity fuels are determined by the following considerations.

Combustion of high-viscosity fuels in stationary combustion chambers puts forward requirements for the processes of decomposition of the jet or veil into droplets, evaporation and mixing with the oxidant (air). The rate of combustion or the rate of propagation of the flame front is determined by the values of micro- and macroturbulence, the degree of dispersion of the distribution of droplets on the flame front and the spray quality.

Fractional composition of high-viscosity fuel and thermophysical parameters of its components are particularly important parameters. One of the most important arguments that determine the rate and completeness of combustion is the coefficient of excess air, temperature and rate of heat release.

Statement of the problem. The listed arguments and parameters at the correct and scientifically substantiated combination give the chance to optimize process of burning from economic and ecological points of view, and reasonable use of free and forced micro-and macroturbulence - to find ways and methods of real increase of speed and complete combustion of viscous fuels.

Hence the tasks of scientific research on fuel combustion are formulated: first, economic, i.e. increasing the efficiency of power plants; secondly, ecological - obtaining the cleanest, without harmful carcinogenic components of exhaust gases; thirdly, reducing the cost of technologies and increasing their reliability in operation with any type of fuel.

These tasks are especially gaining value nowadays with a large shortage of energy resources, which in the nearest future, even if it does not increase, still will not weaken the relevance of these tasks.

Presentation of the basic research material. We offer the solution of these problems by using an additional power supply system in the form of a vortex evaporator-mixer, which works on the energy of exhaust gases or a gas turbocharger, to use cheap fuel (stable gas condensate) and increase the thermal efficiency of the diesel engine (Fig. 1).

The use of low-cetane and high-viscosity fuels for diesels puts the problem of dividing the supply into two parts: the first, as the main, through the vortex system and the second, as the ignition dose, which is injected by standard fuel equipment [7]. The vortex evaporator-mixer runs on the energy of the exhaust gases and allows the use of cheap, relatively standard, low-cetane fuels, such as stable gas condensate without processing.

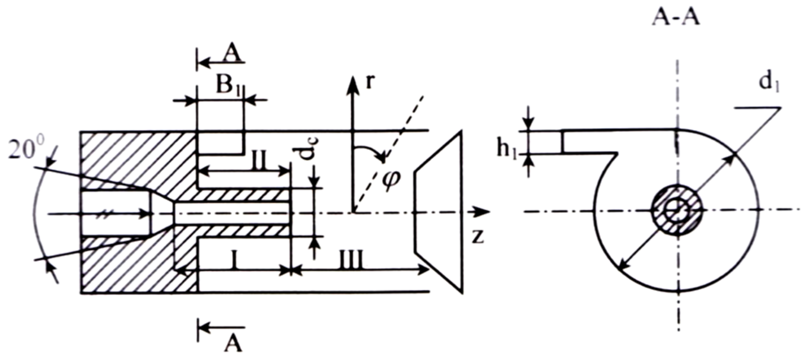

Fig. 1. Scheme of an additional diesel power supply system engine: I - zone of free vortices, II - zone forced vortices; III - zone of potential vortices

Using the thermal energy of the exhaust gases with an additional power supply system (part of the thermal energy is used with a significant decrease in ambient temperature) to heat the fuel, and using the kinetic energy of the exhaust gases to spray the heated fuel, eliminates the above disadvantages of the diesel engine . The ratio of recirculated exhaust gases to fresh air is chosen so that the combustion of low-cetane fuels is detonation-free at all fast and loaded modes of operation. An additional supply system is a straight-flowing Ranque tube with a forced vortex flow in the nozzle inlet, in which the fuel atomizer is placed (Fig. 1). This design allows you to use an aerodynamic method of spraying with the formation of fuel droplets with a diameter of 5-40 microns, which satisfies the combustion mode in terms of burnout speed and completeness at any speed of the engine.

According to the functional diagram of the device for preparation for combustion of low-cetane fuel in a diesel engine, the fuel pump 3 supplies fuel from the tank 2 to the evaporator-mixer 1 and the high-pressure fuel pump 9 (Fig. 2). Prepared for aerosol mixture of fuel and exhaust gases through pipelines 8 enters through the intake manifold 5 to the diesel engine 6, and clean air through the air filter 4. Selection of exhaust gases is carried out to the muffler 7 through the pipeline 11, which supplies them in the evaporator-mixer 1. Thus, the depleted working mixture of clean air, exhaust gases and low-grade fuel enters the diesel engine through the intake manifold, and the ignition of the same fuel is fed through the high pressure pump 9 according to the usual diesel scheme, through the pipeline high pressure 10 and nozzles 12.

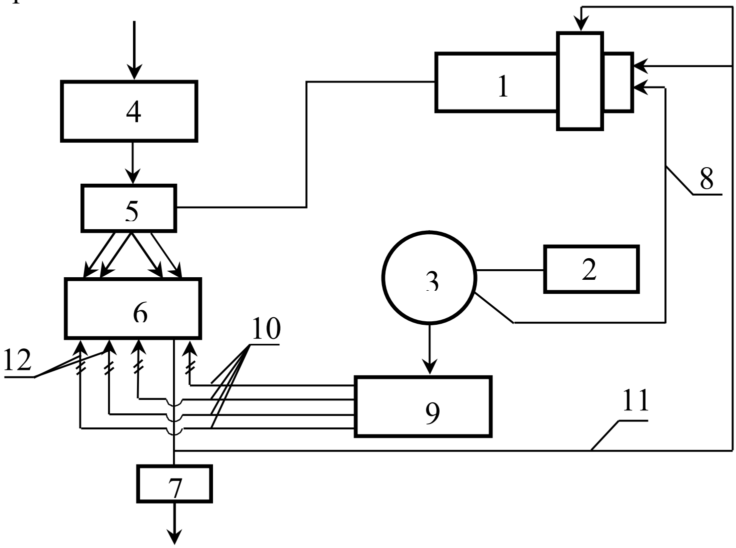

Fig. 2. Scheme of the power supply system of the diesel engine: 1 - evaporator-mixer; 2 - fuel tank; 3 - fuel-sensitive pump; 4 - air purifier; 5 - suction manifold; 6 - diesel engine, 7 - muffler; 8 - fuel line; 9 - high pressure fuel pump; 10 - high pressure fuel line; 11 - gas pipeline, 12 - injectors

The presence of exhaust recirculation gases in a mixture with air and low-cetane fuel reduces the likelihood of detonation combustion due to the presence of water vapor and hydrocarbon oxide, and improves the quality of preparation of low-cetane fuel by aerodynamic spraying and evaporation в Ranque tube increasing the speed and completeness of fuel combustion which significantly reduces the release of toxic components into the atmosphere.

The geometric parameters of the vortex evaporator-mixer (width b1 and height h1 of the tangential inlet, inner diameter d1, diaphragm diameter dc) are selected by the air flow of the diesel for the maximum power mode Nemax and the speed of the crankshaft nmax (Fig. 1) for complete evaporation is selected by the viscosity of the fuel used, for example, in a standard supply system, the droplet diameter is 30 μm, at the parameters of the end of compression, the fuel completely evaporates in a stable medium for a range of 0.15-0.18 m In a vortex evaporator-mixer, the way of the mixture, which passes from the inlet to the outlet (assuming the presence of non-evaporating droplets), with a vortex diameter of 0.08 m, with a vortex frequency of 12000 *1/min* is within hundreds of meters, based on which to obtain aerosol fuel in the vortex flow l_T *must be about (7 - 10)* d_T.

Studies on the use of an additional power supply system in the form of a vortex evaporator-mixer have shown that the toxicity of CO is reduced by 17%, and NOx - by 8%.

Conclusions and prospects for further research. An additional power supply system has been developed in the form of a vortex evaporator-mixer, which uses the energy of exhaust gases and allows the use of low-grade cheap fuel. It has been proved that the process of mixture formation in the additional power supply system of a diesel engine can be close to ideal, and the mixture can be obtained close to stoichiometric regardless of the thermophysical parameters of the mixture.

Based on experimental data, the possibility of using alternative fuels in internal combustion engines, such as gas condensate and its products, has been stated. Tests of diesel engines operating on stable gas condensate according to the specified scheme allowed to prove qualitative improvement of complete combustion processes and diesel start-up at low ambient temperatures (over -20^0 C). The studied principle of using vortex processes in the additional power supply system with the division of mixture formation into primary and basic ones at forcing diesel engines is the most advanced for carburetor and gas engines.

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АНОТАЦІЯ

Запропоновано вирішення задачі оптимізації процесів горіння з економічної та екологічної точок за допомогою використання додаткової системи живлення у вигляді вихрового випаровувача-змішувача, який працює від енергії відпрацьованих газів або газотурбонагнітача, для використання дешевого пального (стабільного газоконденсату) та збільшення термічного ККД дизеля. Доведено, що процес сумішоутворення у додатковій системі живлення дизельного двигуна можна наблизити до ідеального, а суміш отримувати близькою до стехіометричної незалежно від теплофізичних параметрів суміші. На підставі експериментальних даних доведено можливість використання у двигунах внутрішнього згоряння альтернативних палив, наприклад газоконденсату та продуктів його переробки. Випробування дизелів, які працювали на стабільному газоконденсаті за вказаною схемою, дозволили довести якісне покращення процесів згоряння за повнотою та запуском дизеля при низьких температурах навколишнього середовища (понад –20^0 С). Токсичність відпрацьованих газів по CO знизилась на 17%, а по NO_x – на 8%