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STUDY OF THE INFLUENCE OF IMPROVED POWER SUPPLY SYSTEM, BY THE APPLICATION OF GAS INTAKE DEVICE, ON THE GAS DIESEL ENGINE INDICES

The paper gives data on the efficiency of the gas intake device application in gas-diesel engines. Mathematical calculations of the cycles are presented for diesel and gas-diesel engines with gas intake device and without it.

Keywords: *gas-diesel engine, natural gas, power supply system, carburation, gas intake device.*

Reduction of operating costs is one of the tasks in the creation of new transport means or in modernization of the existing ones. Experts believe that one of the trends towards operating cost reduction is application of cheaper alternative fuel types. Natural gas is a real alternative to the liquid motor fuel [1].

Application of natural gas as a motor fuel will make it possible not only to realize the required number of transportations without changing operating costs but also to save a considerable amount of liquid fuel to be used for other needs of the country.

Natural gas application as a motor fuel in spark-ignition engines does not require design modifications but causes its power reduction, which is unacceptable for transport means.

Natural gas is the most expedient to be used in the vehicle diesel engine but the temperature of natural gas ignition is higher than that of diesel fuel, which requires either installation of an additional ignition system, which causes engine design modification, or supplying an inconsiderable amount of diesel fuel as ignition dose to the cylinders.

The second method is more expedient to be used as its implementation does not require engine design modifications while the engine maintains the ability of adequate operation only on a liquid fuel.

The analysis of the existing diesel gas supply systems with external carburation has shown that vehicles equipped with diesel power system, where gas is supplied to the inlet manifold under excessive pressure, have higher dynamic, economic and ecological indicators compared to the vehicles equipped with the diesel power system where gas is supplied to the inlet manifold of the engine under vacuum.

The main disadvantage of the existing diesel power system with gas supplied to the inlet manifold of the engine under excessive pressure is the difficulty of providing homogeneity of the gas-air mixture and also its uneven distribution between engine cylinders. Therefore, to solve this problem, it is necessary to improve gas fuel power supply system of the engine in order to provide better carburation process in the inlet manifold of a gas-diesel engine.

Carburation process has significant influence on the engine power cycle [1]. Its improvement results in the increased fuel combustion speed, higher combustion efficiency and, consequently, in the increased economic efficiency of the cycle. This is achieved by means of engine cylinders receiving ready homogenous mixture. Therefore, no time is needed for mixing air and gas in the cylinder itself, which will increase the speed and completeness of the chemical reaction of gas-fuel mixture combustion.

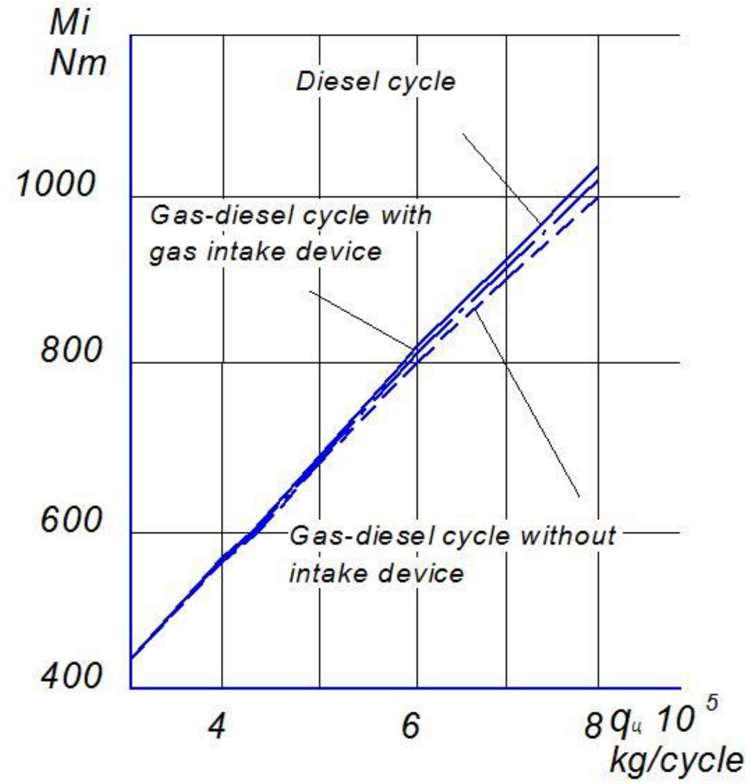
It should be noted that unburned methane is found in the products of incomplete combustion rather than carbon oxide. 1 % natural gas content in the natural gas combustion products is determined by heat losses caused by about 10% chemical incompleteness of q_3 combustion [1].

When considering the issue of mixing gas and air in gas diesel engines, the theory and practice of gas combustion in burners and furnaces of industrial plants was used. The form of inlet manifold is identical to that of the furnace burner mixer, and so the actual mixing processes could be considered to be identical. Hence, the methods used for burner devices in order to improve carburetion could be also used in internal combustion engines.

The research has proved that carburation quality is influenced by a number of various factors that were taken into account in development of the procedure for determining the minimal zone of mixing gas and air in the inlet manifold of a gas-diesel engine [4]. The developed gas intake device is proposed to be used instead of the common nozzle for supplying gas to the inlet manifold. The analysis of the research results has shown that for complete mixing of gas and air at the minimal distance in the inlet manifold of gas diesel engine ЯМЗ-238 it is necessary to use a gas intake device having four openings with the diameters of 7.4 mm located one opposite to another. Such number and diameter of the gas nozzles provides uniform distribution of the natural gas both between the units of the gas-diesel engine and between the cylinders, mixing zone being 270 mm instead of 1356 mm (almost 4 time reduction). This allows application of the proposed power supply system in the transport means without design modifications of the engine intake system. The proposed procedure makes it possible to determine special features of the gas supply nozzle and installation place of the device for supplying gas to the inlet manifold of the gas-diesel engine.

For checking operability of such arrangement experimental studies of the improved power supply system with gas intake device have been performed using gas diesel engine ЯМЗ-238.

During the experiment performed in accordance with ДСТУ 14846-81 [2] external and partial speed as well loading characteristics of the engine were registered for diesel and gas-diesel cycles operation.



-------------- - diesel cycle; - - - - - - - - gas-diesel cycle;

-- -- -- -- -- -- - gas-diesel cycle with gas intake device

Fig. 1. Dependence of the indicator torque M_i of gas diesel engine ЯМЗ-238ГД on the total cyclic fuel supply

As far as engine loading characteristics are concerned, during their investigation the values of the indicator torque *Mi* were calculated for the determined rotation speed of the crankshaft of the gas diesel engine, which were in the range of the engine speed modes. The analysis of loading characteristics shows that indicator torque of the engine with the proposed power system is up to 2,8 % higher than that of the engine with the existing power system depending on the total cyclic fuel supply q_{total} (Fig. 1).

During experimental studies second stage of the low-pressure reducer was set for the initial pressure p_{2in}=104 KPa [4]. Total cycle supply q_{total} of gas and diesel fuel was adjusted so that nominal power of the gas diesel engine would be equal to the power of the base diesel ЯМЗ-238.

Ignition dose of the diesel fuel was taken to be 30 % from the nominal diesel fuel supply during gas-diesel engine operation according to diesel cycle as this value provides stable diesel fuel supply at low rotation speed of the engine crankshaft.

Characteristic of the indicator torque *Mi* of the gas-diesel engine during gas-diesel cycle operation with gas intake device was approximated by the polynomial of the third degree:

$$M_i = 96.7757448+104.2831671q_c + 5.7450358q_c^2 - 0.5299496q_c^3;$$

where q_c – per cycle fuel supply.

Temperature *Tr* of the exhaust gases coming out of the left and right cylinder block remained almost the same during experimental studies, which indicates a uniform natural gas distribution between cylinder blocks of the gas-diesel engine by the gas intake device.

Temperature characteristic of the exhaust gases of the gas-diesel engine during gas-diesel cycle operation with gas intake device was approximated by the polynomial of the second degree:

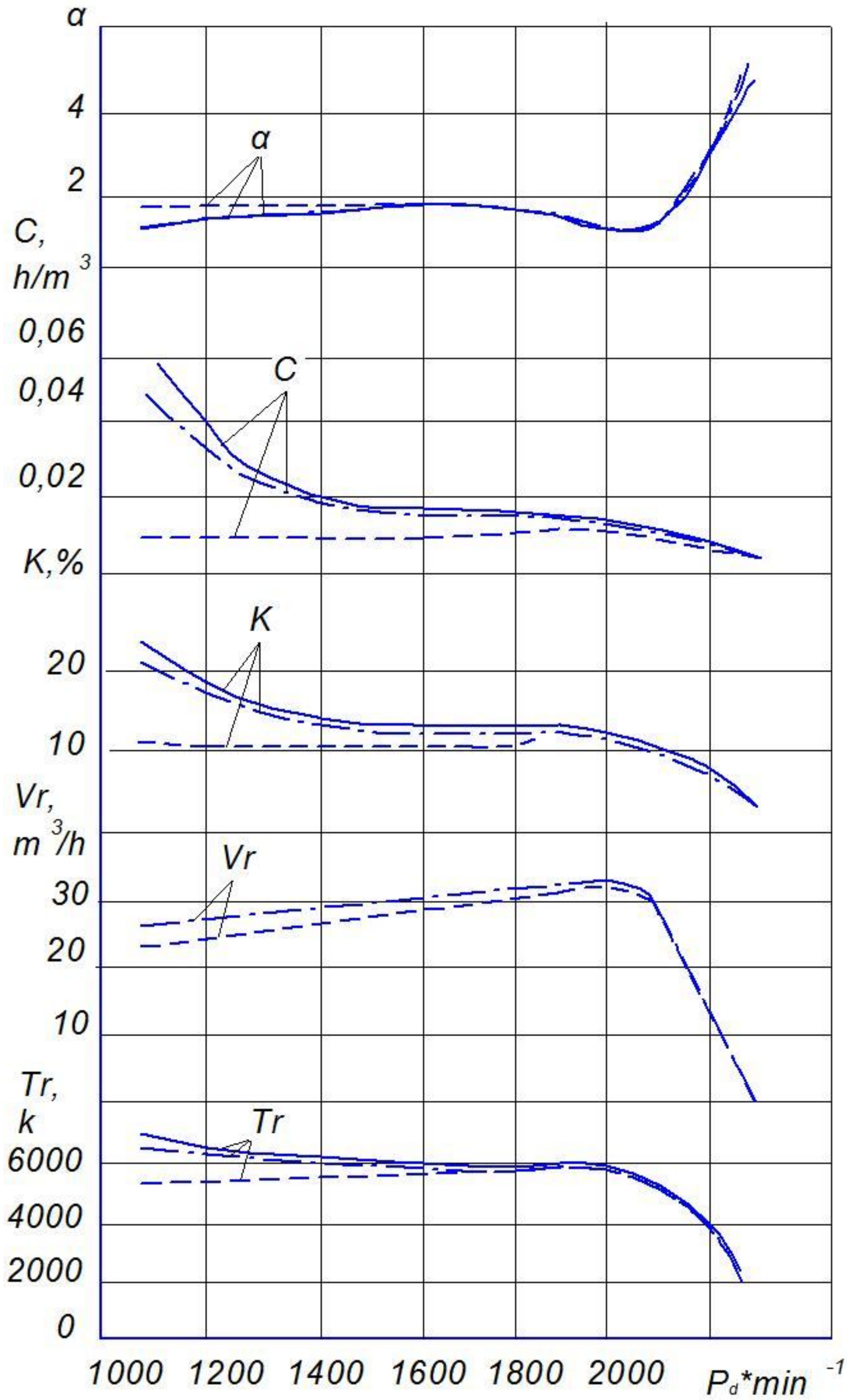
$$Tr=432.3274+0.30225n_{eu}+10.47061q_{total}-0.001n_{eu}^2-0.09027q_{total}^2+0.000617n_{eu}q_{total};$$

where q_{total} – total cyclic fuel supply; n_{eu} – rotation speed of the crankshaft.

These equations were used in the mathematical model of the “vehicle – environment” system based on the mathematical model of the “driver – automobile – road – environment” system [3]. Mathematical model of the “vehicle – environment” system makes it possible to investigate both engine operation indicators and vehicle speed indicators in operating conditions as well as to study the influence of the modernized power supply system on dynamic, economical and ecological performance of the vehicle.

Main difference of the “vehicle – environment” system mathematical model from the mathematical model of the “driver – automobile – road – environment” system is as follows: to the mathematical model of the subsystem “gas-diesel engine with crankshaft rotation speed control system” the obtained equations were introduced: of the exhaust gas temperature *Tr*, indicator torque *Mi* of the engine, empirical equation of the metering valve flow coefficient as well as a unit of determining the minimal air-gas mixing zone in the inlet manifold of the engine. This makes it possible to investigate dynamic, economic and ecological performance of the vehicle with the improved power supply system.

Analysis of the computational research results has shown (Fig. 2) that application of the improved engine power system of natural gas supply with the gas intake device provides 4.2 % reduction of natural gas consumption compared with that without gas intake device, power indicators being the same. This leads to 4.2 % increase of the air excess factor and to 3.4 % increase of the air excess factor in the mixture with diesel fuel, which results in 1.9 % reduction of the exhaust gas temperature, 6.7 % reduction of its smokiness and 12.8 % reduction of soot concentration.



– – – – –– diesel cycle;

————– gas-diesel cycle without gas intake device;

- - - - - - - – gas-diesel cycle with gas intake device

Fig. 2. Dependencies of the excess air factor α, smokiness K and soot concentration in the exhaust gas *C*, exhaust gas temperature *Tr* and gas consumption *Vg* on the crankshaft rotation speed n_d of gas-diesel engine ЯМЗ-238

Investigation of the dynamic performance of the vehicle with a gas-diesel engine has proved that when a car is accelerated to the speed of 60 km / hour on the road with asphalt concrete pavement fuel consumption for the car with the mass of 16 000 kg is reduced by 4.3 %, acceleration path is reduced by 4.5 %. Environmental indicators have been improved by 4.6 % on the average.

Energy and economic indicators of the vehicle gas-diesel engine were improved due to the better power cycle indicators, which is the result of the increased completeness of mixing gas and air in the engine intake manifold.

Thus, on the basis of the obtained results we can draw a conclusion that traction-dynamic, economic and ecological performance of the vehicles with a gas-diesel engine equipped with the power supply system that includes gas intake device can be improved.

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