

# Level Recession Of Emissions Release By Motor-And-Tractor Diesel Engines Through The Application Of Water-Fuel Emulsions

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**Abstract.** The paper is dedicated to a problem of environmental pollution by emissions of hazardous substances with the exhaust gases of internal combustion engines. It is found that application of water-fuel emulsions yields the best results in diesels where production of a qualitative carburetion is the main problem for the organization of working process. During pilot studies the composition of a water-fuel emulsion with the patent held is developed. The developed composition of a water-fuel emulsion provides its stability within 14-18 months depending on mass content of components in it while stability of emulsions' analogues makes 8-12 months. The mode of operation of pilot unit is described. Methodology and results of pilot study of operation of diesel engine on a water-fuel emulsion are presented. Cutting time of droplet combustion of a water-fuel emulsion improves combustion efficiency and reduces carbon deposition (varnish) on working surfaces. Partial dismantling of the engine after its operating time during 60 engine hours has shown that there is a removal of a carbon deposition in cylinder-piston group which can be observed visually. It is found that for steady operation of the diesel and ensuring decrease in level of emission of hazardous substances the water-fuel emulsion with water concentration of 18-20% is optimal.

## 1. Introduction

The most powerful sources in atmospheric air of hazardous substances are vehicles, including the cars and tractors using traditional hydrocarbon fuel. The emission of hazardous substances with the exhaust gases in the atmosphere is a result and a necessary condition of normal functioning of internal combustion engines. In Russia diesel is recognized as the most dangerous engine from the ecological point of view and in traditional completeness doesn't meet the modern requirements for an emission limitation of hazardous substances with the exhaust gases.

Considerable part of trucking facilities and practically all agricultural vehicles are completed with diesel engines. The world park of mobile farm vehicles contains more than 100 million units which are releasing annually more than 300 million tons of total number of hazardous substances with the exhaust gases. In all cases these emissions exert negative impact on working conditions, farmlands and products received from them.



In use technical condition of tractors, as a rule, worsens: energy consumption increases, indicators of working capacity, technical and ecological safety decrease. The fact that in Russia there are more than 50% of tractors which are over 10 years old and most of them operate strained to the limit of technical capabilities aggravates considerably an ecological situation.

In spite of the fact that the modern diesel is the efficient and long-life engine now, there is a possibility of further improvement of its characteristics by updating of operating process which quality depends on many factors: a gasdynamic condition of an air charge, parameters of the fuel equipment, quality of carburation, conditions of pressurization, physical and chemical indicators of fuels and so on, which opportunity is used not completely. Besides the formation of carbon dust in diesel causes introduction of the intensive radiation heat exchange increasing heat release rate of the engine's details.

Being adsorbents and further carriers of many substances, harmful to live organisms, the carbon dust particles which are present at the exhaust gases exert negative impact on health of the person and ecology of the environment.

Ecological and economic indicators of diesels in many respects depend on quality of carburation behavior and combustion. One of the directions of further development of diesels is increase in their specific capacity and decrease in harmful emissions in case of buildup in mean effective pressure and crankshaft speed that is connected with updating of engine cycle.

Thus, the solution of the main problems of diesel engine manufacturing (improvement of economic and ecological indicators, increase in specific capacity) requires improvement of quality of fuel combustion process. Therefore researches in this field are of current interest.

Application of alternative types of motor fuel for the purpose of increase in ecological safety of diesels' operation is the most effective now. The water-fuel emulsion belongs to one of them [1-7]. The best results are yielded by application of water-fuel emulsions in diesels where receiving a qualitative carburetion is the main problem for the organization of working process [8].

The water method of application in the form of an emulsion with the diesel fuel and various additives improving its properties is the simplest, cheap and available. This method allows saving diesel fuel to some extent doesn't require considerable costs for introduction of constructive changes and additions in diesel and can be realized for the engines which are already in operation. Most intensively, the researches connected with using water-fuel emulsions are conducted in two directions: 1) injection of water in the combustion chamber just before fuel inflaming; 2) preparation of a water-fuel emulsion with in advance selected optimum composition of water and fuel [9].

But, despite satisfactory indicators of operation of the engine on a water-fuel emulsion, mass application of emulsions is interfered by their insufficient stability that is they are inclined to breakdown to diesel fuel and water eventually. The main reasons are complexity of selection or high cost of development of emulsifiers and difficulties at the choice of a mode of emulsions' processing.

## **2. Methodology**

Increase in stability of a water-fuel emulsion that is prevention to breakdown to diesel fuel and water was one of research problems for a long time. To estimate efficiency of the developed emulsion it is necessary to make comparative tests of operation of the diesel engine.

Therefore the general technique of pilot studies included:

1. Development of a water-fuel emulsion composition (selection of surfactants, water addition; test procedure of influence of surfactants for stability of a water-fuel emulsion);

2. Pilot studies of operation of the D-243 diesel engine using diesel fuel and a water-fuel emulsion.

Installation of equipment and devices, tests of the engine and the analysis of the exhaust gases were carried out taking into account requirements of state standards. At test procedure diesel fuel of the L-0,5 brand name, the M-10-G2 engine oil, surfactants and industrial water were used.

Frequency of carrying out experiments equaled to five.

For the purpose of increase in stability of a water-fuel emulsion the composition of the water-fuel emulsion containing diesel fuel, water and emulsifiers which remains stable within several months [10] was developed. Results of tests of stability of a water-fuel emulsion are presented in tab. 1.

Table 1 – Composition of a water-fuel emulsion and results of tests of its stability

Component of emulsion and its indicator	Content of a component, masses. % in emulsion			
	1	2	3	4
Diethanolamide of oleic acid	1.640	1.640	3.120	4.230
Diethanolamine soap of oleic acid	0.500	0.770	0.960	1.420
Diethanolamine	0.850	1.440	1.500	2.030
Monoester of oleic acid and diethanolamine	0.800	1.200	1.250	1.570
Oleate of sodium	0.190	0.150	0.100	0.080
Water	10	15	20	25
Diesel	The rest			
Stability, month	18	18	15	14

At the first stage there was an emulsifier preparation. Further process of its mixture with diesel fuel and water, and then treatment in a homogenizer. After that monitoring of stability of a water-fuel emulsion as by a visual method, and by means of devices was performed. The analysis of dispersion of a water-fuel emulsion under a microscope was made once a week. The water fuel emulsion was considered stable if its dispersion made 3-5 microns.

Dedication of components of an emulsion: diethanolamide of oleic acid is surfactant and provides droplet breakup; diethanolamine soap of oleic acid regulates optimum hydrophilic and lipophilic balance of emulsifier; diethanolamine facilitates receipt of a microemulsion; monoester of oleic acid and diethanolamine improves stability of an emulsion, reduces an emulsifier consumption; oleate of sodium is surfactant and increases stability of an emulsion.

The developed composition of a water-fuel emulsion provides its stability within 14-18 months depending on the mass content in it of components while stability of emulsions' analogues makes 8-12 months. It is noted that application of homogenizers for treatment of emulsions gives considerable effect concerning receiving high-disperse phases in comparison with mechanical treatment.

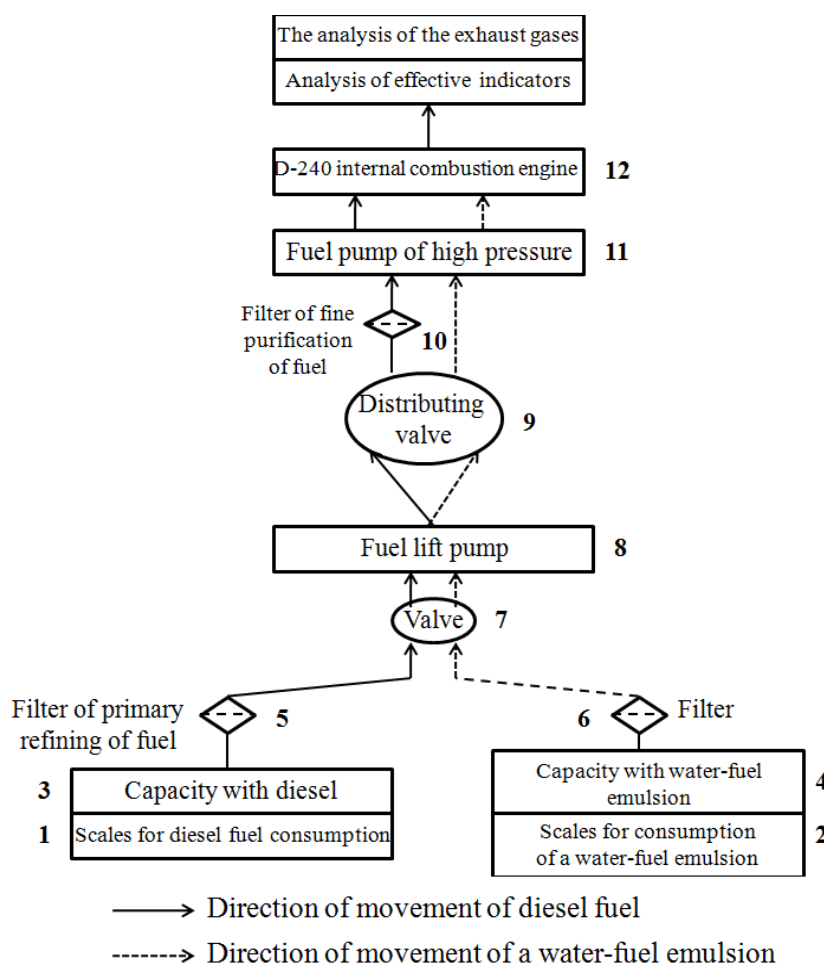
Pilot studies were conducted for the D-243 diesel engine of the Minsk motor plant (Belarus) which is widely used in cars and tractors (tab. 2).

Table 2 – Specification of the engine D-243

Indicator	Value
Type	Four-stroke, no turbo-supercharging
Number of cylinders	4
Location of cylinders	In-line, vertical
Displacement volume, l	4.75
Capacity, kW (hp)	60 (81)
Rotary speed, min <sup>-1</sup>	2200
Torque capacity, Nwm	258
Mass, kg	448

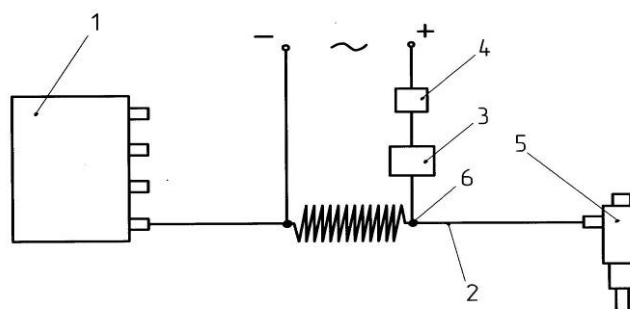
On the diesel engine installation for delivery of a water-fuel emulsion was mounted. The schematic diagram of experimental installation is submitted in fig. 1. From capacity 3 with diesel fuel the fuel moves the fuel lift pump 8 via the filter of primary refining of fuel 5, the valve 7, the distributing valve 9 and the filter of fine purification of fuel 10 to the fuel pump of high pressure 11 (fig. 1). The discharge rate of diesel fuel is determined with the help of electronic scales 1. Further from the fuel pump of high pressure 11 diesel fuel moves in the engine 12.

The engine gets warm up till the operational temperature using clean diesel fuel. Then, there is a measurement of effective indicators with the simultaneous analysis of the exhaust gases and their smokiness. Then by means of the valve 7 and the distribution valve 9 the engine 12 is taken over to a water-fuel emulsion which is delivered from capacity 4 via the filter 6, the valve 7 and the distribution valve 9 to the fuel pump of high pressure 11 and further to the engine 12. The consumption rate of a water-fuel emulsion is determined by means of electronic scales 2. Similar to work on diesel fuel, there is a measurement of effective indicators with the simultaneous analysis of the exhaust gases and their smokiness. Upon termination of an experiment for washing of a fuel system the engine 12 is taken to diesel fuel.



**Figure 1** – Scheme of experimental installation

For additional treatment of a water-fuel emulsion in fuel system of diesel engines the device with the patent [11] held is developed. The general scheme of the device is presented in fig. 2. The fuel system of the diesel contains the fuel pump 1 of high pressure connected to a nozzle 5 by means of the fuel-supply line 2 of high pressures including a heating element 6. The heating element 6 is connected to the regulator of temperature of heating 3 and a preventer 4. The device consists of the fuel-supply line of high pressure 2 made in the form of a spiral, which is wrapped up by the isolating material 7 in which the heating element 6 included in an electric chain with the regulator of heating temperature 3 and a preventer 4 is located.

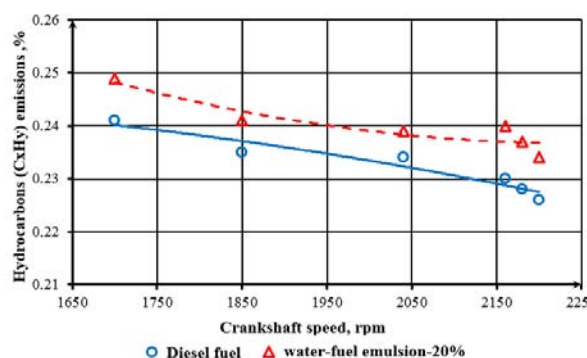


**Figure 2** – The scheme of fuel system of the diesel with the developed device for processing of a water-fuel emulsion

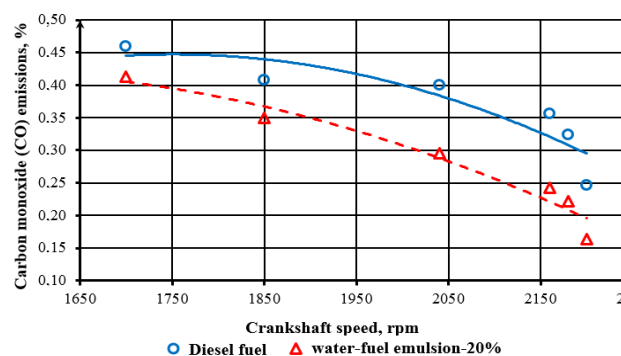
Work of the device is carried out as follows. The water-fuel emulsion moves the fuel pump of high pressure 1 in a nozzle 5 via the pipeline of the high pressure 2 having the spiral form (the number of spiral turns depends on properties of a water-fuel emulsion). The water-fuel emulsion passing on a spiral is warmed up by a heating element 6 up to the required temperature at the exit and moves in a nozzle 5 (temperature of heating depends on properties of a water-fuel emulsion). In order to avoid an overheat of a water-fuel emulsion the electric chain with a heating element 6 has switched on the regulator of heating temperature 3 and a preventer 4.

### 3. Results and analysis

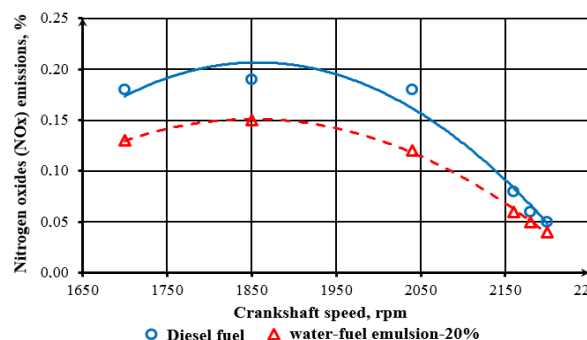
Results of tests of the diesel D-243 during the work using diesel fuel and a water-fuel emulsion of the developed composition with concentration of water 20 % are presented on graphic curve (fig. 3-6).



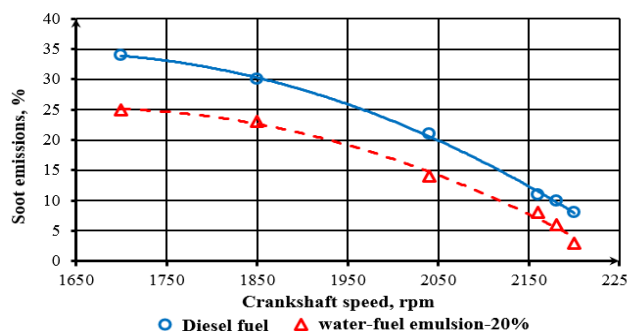
**Figure 3.** Change of level of hydrocarbons' emissions



**Figure 4.** Change of level of carbon monoxides' emissions



**Figure 5.** Change of level of nitrogen oxides' emissions



**Figure 6.** Change of level of the exhaust gases soot emissions

In the combustion chamber after warming up of the sudden fracture of globules, splinters of sinking fractions (asphaltogenic), being moved with a high speed intensively interact with oxygen of an air charge, burn down almost completely, that is without formation of a varnish. The water phase which is in composition of the emulsified fuel, partially dissociates during fuel oxidation, then, in process of temperature increase, reaction of dissociation of water is sharply accelerated. The excess of atoms of hydrogen formed at dissociation reacts with atoms of oxygen and as a result, burning process is sharply accelerated.

In the course of burning of a water-fuel emulsion in a combustion chamber of diesels there is a conversion of the gas fractions formed as a result of phase transformations; the diesel fuel burning with a water vapor is enriched with hydrogen, and burns up with generation of additional energy almost completely with sharp reduction of hazardous emissions. At the same time the component wear of cylinder-piston group decreases significantly, and the group of the gas-removing channel is less exposed to abrasive wear, and, as a result, reliability of the fuel equipment as there is no coking of holes of injector spray nozzles increases.

The shift of the engine from diesel fuel to a water-fuel emulsion allows reducing considerably smokiness of the exhaust gases, emissions of nitrogen oxides and carbon. Emissions of hydrocarbons, on the contrary, are increased in all range of rotation frequencies of a crank shaft of the engine. Emissions of carbon oxides during the operation of the engine with heavy load are almost identical.

#### 4. Conclusions

In the conclusion it should be noted that the water-fuel emulsion is an effective mean of improvement of carburetion quality and an intensification of burning process of fuel in diesels, especially in engines with unsatisfactory technical condition.

Application of a water-fuel emulsion allows improving ecological indicators of the diesel, reducing the content of harmful substances in the exhaust gases, thermal stress of details of cylinder-piston group, discoking of spraying nozzle holes, reducing waste of grease oil and temperature of the exhaust gases to improve resource indicators of the diesel.

The water fuel emulsion burns up quicker than diesel fuel. Processes of burning because of finely dispersed composition of an emulsion increase in a surface of burning of particles and good mixing with air are changed in a quality manner. Reduction of drops burning time of a water-fuel emulsion improves completeness of combustion of fuel and reduces carbon deposit (varnish) on working surfaces.

Partial dismantling of the engine after its operating time during 60 engine hours has shown that there is a removal of carbon deposition in cylinder-piston group which can be observed in the visual way.

As a result of the conducted researches it is found that for steady operation of the diesel and ensuring decrease in level of emission of hazardous substances the water-fuel emulsion with concentration of water in it 18-20% is optimum.

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