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FUME EMISSIONS IN INVESTIGATIONS OF EXPLOITATION OF DIESEL ENGINES

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Abstract

The results of the investigations of exploitation emissions the harmful components of the fumes of diesel engines were introduced in the work. Obtained results were subjected to a statistical study according to new computer procedures. Qualitative and quantitative reports were established for the level and kind of emission in reference to the changes of the state of studied engines.

Keywords: combustion engines, toxic fume components, exploitation investigations, environmental protection

1. Introduction

The assumption for researches of this work was the performance of the analysis influence of engine warming on the harmful emission at these states of engine's work, especially concerning climate conditions in Poland. In the range of researches, the analysis of the emission of harmful compounds was performed during the warmed up engine in the neutral race at different temperatures of the environment.

The conducted considerations indicate that researches of the work of high-pressure engines of different destination in the conditions of exploitation take place usually in changeable unsettled conditions, or are a majority of its working time, which considerably influences the general emission of harmful components of fumes.

The contribution of harmful components of fumes diesel engines into total atmosphere pollution is as follows: there are mostly solid particles (PM) and nitro oxides (NOx) in fumes, whilst in smaller amounts there is carbon oxide (CO) and not burned hydrocarbons (HC).

The results of realized in exploitation tests on a chosen group of diesel engines allow to determine, practically and cognitively, important premises in the field of toxic effects of diesel engines on the environment.

2. Research objects

The researches of his work, in the field of recognizing toxic components generated by diesel engines for different technical states and change able external temperature, were performed on a engine S-359. Results of these researches in the range of quality changes of the toxic components of fumes in operation conditions was performer during 2 years of exploitation on the group of 20 vehicles with such engines. The units of the investigative position were showed on Fig. 1.

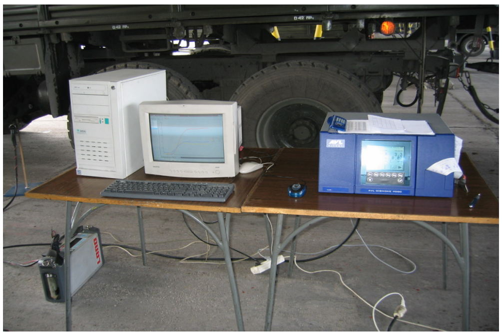

Fig. 1 General view of test stations

The object of research in this work was S-359 engine with self-acting fusion whose basic technical data is presented in Table 1. It is an engine of a wide practical application, and characterized by small unitary fuel use, good dynamic characteristics and small damageability.

Tab.1. Basic technical data of the engine S- 359 [105]

Cylinder formation	row, vertical
Number of cylinders	6
Cylinder diameter	110 mm
Piston stroke	120 mm
Swept capacity	6,842 dm^3
Compression degree	17
Order of cylinder work	1-5-3-6-2-4
Maximum Power	110 KW with 2800 min^{-1}
Maximum turning moment	438Nm with 1800-2100min^{-1}
Minimum unitary fuel use	224 g/kWh
Statistical angle of pumping beginning	18,5^{0}OWK before GMP
Injection system	Direct
Injection pump	P-76G10
Injection pressure	22MPa

The engine is a running unit for trucks: Star 200 – street, Star 266 – cross-country, produced in Factory in Starachowice (at present: Star Trucks Sp.z o.o). These cars are widely used in the national industry, as well as military service.

The tested combustion engines belong to the group of exploitation objects, used in difficult training conditions of military service. Large and changeable loads of engines implied by inexperienced drivers diversified their technical state, which for the researches of his work posed a challenge in the range of preparing the experiment, its proper realization, and careful concluding and statistical work.

3. The conditions of exploational investigations

It mattered considering the acquisition of different temperatures, in which the engine S-359 was thermally stabilized, and considering the temperature of the air used for running the engine.

Before proceeding with the tests, the following were checked and regulated:

a. technical state of the engine,
b. injection pump at the probing station type PW-8, predestined for testing fuel equipment of high-pressure engines with regard to dosage, performing, according to BN-88/1301-16 velocity characteristics of fuel injection,
c. injectors used for the tests were checked and regulated on an injector probe type PRW-3, performing the evaluation of pressure of the injector’s opening, tightness and trickling of the sprayer, and the correctness of fuel spraying,

d. suction and exhaustion valves – according to the manufacturer's suggestions.
e. During the test, the following were registered:
f. multicomponent composition of exhausted fumes of the engine,
g. smoking of fumes with a smokemeter AVL.

Fume tests with respect to the quantity of toxic substances were performer with the use of a multicomponent analyzer of fumes LANCOM, whose general image is presented on the Fig. 2. The analyzer LANCOM enables the measurements of: CO, CH, NO_x, SO_2, fumes temperature and environment temperature.

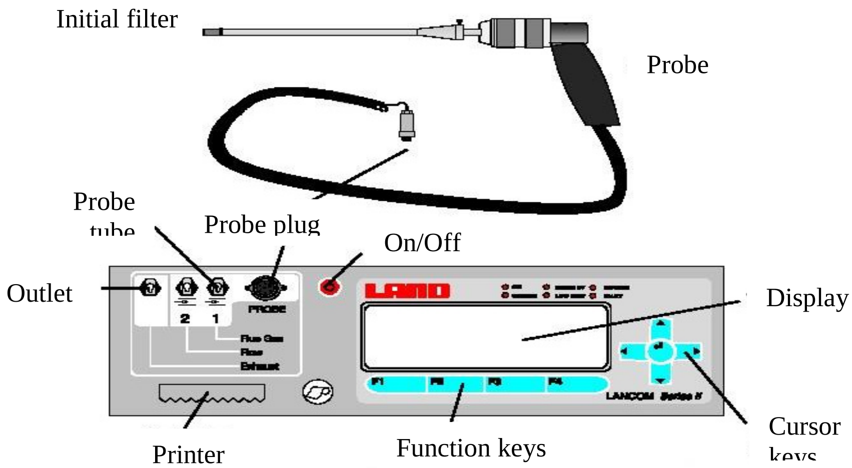

Fig. 2. General image of fume analyzer LANCOM with fume acquisition probe

The measurements of smoking degree of fumes diesel engines were performer with the use of a smokemeter AVL-4000 for the need of further statistical processing, the measured values were saved in a sheet (Excel). Exploitation tests were performed in real conditions on the group of 20 vehicles.

3.1 Testing conditions

The engine, before each test, was subjected to thermal stabilization, thanks to which all elements of the engine and exploitation liquids and exhaust system had the same temperature (for every test) equal to the environment temperature. Environment temperature and motor oil temperature were measured directly prior to each measurement, and if the temperature differences did not exceed 1°C, the measurement began. Also performed were tests in the conditions of a hot start-up. i.e. during a start-up of an engine beforehand warmed up to a normal temperature (oil temp. 80°C) in certain environment conditions. During the measurement, registered were (LANCOM, AVL) the contents of carbon oxides (CO), hydrocarbons (HC), nitro oxides (NO_x) in fumes, motor oil temperature, rotational speed of the crankshaft, environment temperature, and fumes smoking.

Exploitation tests were realized in real conditions on a group of 20 randomly chosen vehicles with the engine S-359 throughout the period of 2 years in a military facility. The tests on toxic substances emission in fumes (CO, HC, NO_x and PM) of diesel engines during a hot start-up (oil and cooling liquid temperature – 70-80^{o}C) were performer at different environment temperatures, with a special consideration of run kilometers of vehicles, and operation-maintenance actions carried out during breaks in tests.

Average daily run of each car was about 70km, which with sustaining the regime of car operation suggested by the manufacturer gives on average about 14000-16000 km per car yearly.

3.2 Exploitation tests results

From the general number of 20 cars subjected to exploitation tests, 10 cars were chosen for the initial analysis, for which checked was the effect of the quantity of emissions of toxic fume components as well as the degree of smoking in relation to run kilometers in the testing period.

The chosen vehicles (num.4) were evaluated in respect of the contents of CO, HC, NO_x in fumes, and smoking of the hot engine, which is shown as an example in the Fig. 3.

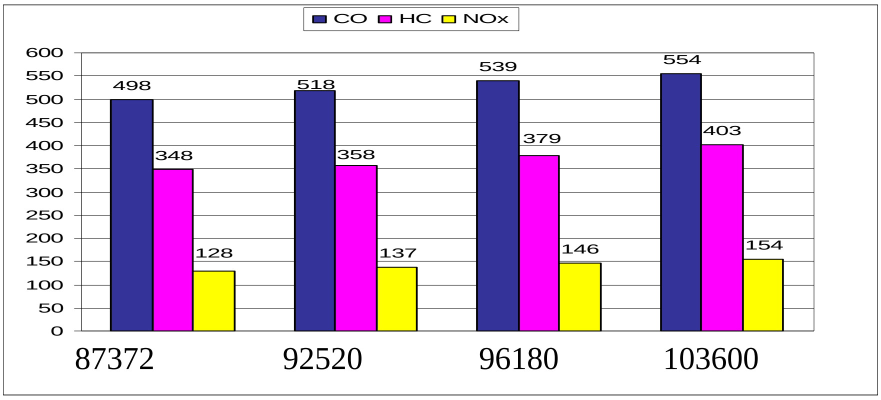

Fig. 3. Overall values of CO, HC, NO_x emissions engine 4 in relation to run km

The following Fig. 4 presents the juxtaposition of values of engine (vehicle num.4) fumes smoking for different km runs of the car.

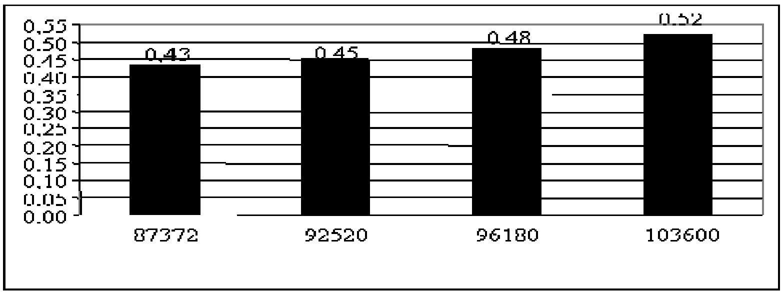

Fig.4. Smoking of 4 engine fumes depending on the km run

The vehicle (num.10) were evaluated in respect of the contents of CO, HC, NO_x in fumes, and smoking of the hot engine, which is shown on the Fig. 5.

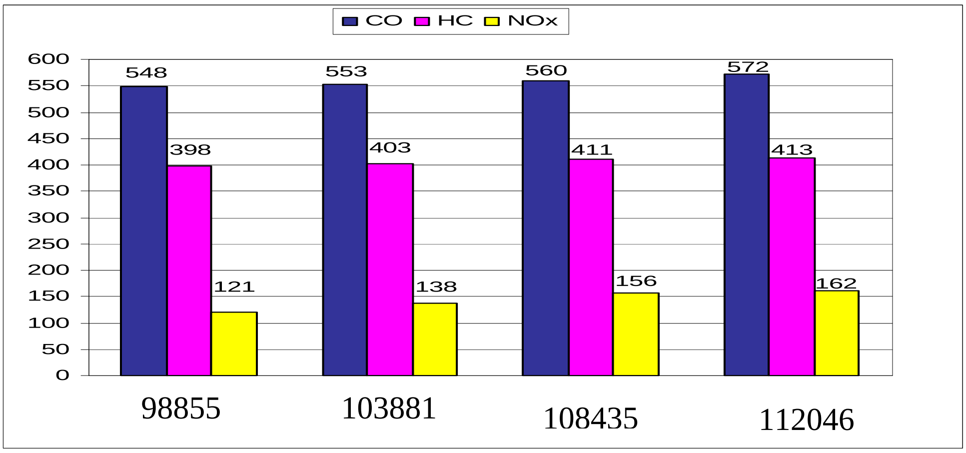

Fig. 5. Overall values of CO, HC, NO_x emissions engine 10 in relation to run km

The following Fig. 6 presents the juxtaposition of values of engine (vehicle num. 10) fumes smoking for different km runs of the car.

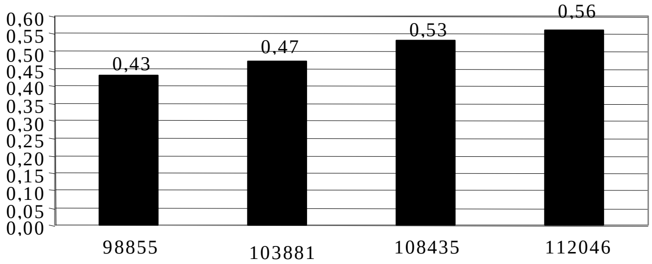

Fig. 6. Smoking of 10 engine fumes depending on the km run

Even brie analysis of the presented results of these tests indicates a visible increase of toxic fume components and engine smoking together with increasing mileage of the car. Other test results of the whole group of 20 cars confirm it visibly. It can be stated that together with the increase of the number of run kilometers, the quantities of carbon oxide (CO), hydrocarbons (HC), nitro oxides (NO_x), and smoking go up.

3.3 Results investigations regress for the exploational investigations

Analysis of the regress for results got in exploational investigations 10 cars were conducted stay for selected about the largest course. Put given these in the Tab. 2 and Fig. 7 represents the results of polynominal regressions, together with coefficient R^2.

Tab. 2 The results of exploitation investigations for chosen 10 vehicles

PARAMETR / NR VEHICLES	CO	HC	N_{OX}	k
1	0,567	0,797	0,978	1,010
4	0,141	0,135	1,000	0,945
5	0,096	0,151	0,389	1,000
8	0,053	0,101	0,153	1,000
9	0,064	0,132	0,101	1,000
10	0,311	0,638	1,000	0,989
11	0,169	0,191	0,311	1,000
15	0,021	0,056	0,044	1,000
18	0,059	0,156	0,250	1,000
19	0,173	0,195	0,461	1,000

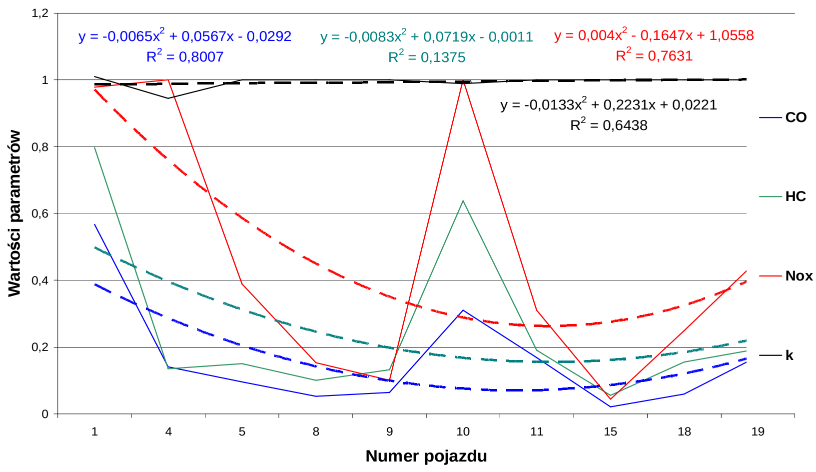

Fig. 7. The date for the polynominal regressions analysis of the studied group of cars

4. Fume test results for engine run on BIO-D10

The possibilities to satisfy increasingly strict regulations force vehicle manufacturers to search new solutions. One of the ways is looking for new, ecologically purer, fuels, among which galenic fuels begin to play a dominant role.

Vegetable oils in their pure form, also colza oil, are not suitable for engines with self-exciting fuse, mainly because of their increased density and viscosity, low cetane number, and insufficient immunity to low temperatures. These disadvantages are absent in products of chemical processes of vegetable oils, called methyl esters, which, combined with diesel oil in appropriate proportions, are called Bio-diesel.

Taking the above into account, quality comparison between diesel oil (ON) and the oil BIO-D10 was carried out during test realization. The comparison of qualities of BIO-D10 fuels with ON, used for tests, is shown in the Table 3. The characteristics of BIO-D10 fuel, produced in refinery Trzebinia are included in the certificate No. 5100634 from 7.10.2005, issued by the manufacturer.

Tab. 3. Comparison of chosen characteristics of test fuels of the engine S-359

Characteristics	Unit	Diesel Oil	BIO-D10
Density at temp. 15°C	g/m^3	0,836	0,841
Kinematical viscosity at temp. 40°C	mm^2/s	2,76	2,82
Fuse temperature	°C	63,5	72
Cetane number		51,1	52,4
Sulfur contents	mg/kg	6,9	4,8
Temperature of cold filter blockage	°C	-30	-25
Remains after incineration	%(m/m)	0,002	0,003
Water contents	mg/kg	68	93

Juxtaposition for easier comparison of emissions of toxic fume components of diesel oil and BIO-D10 during cold and hot start-ups of the engine in diversified environment temperature is presented in the following figures.

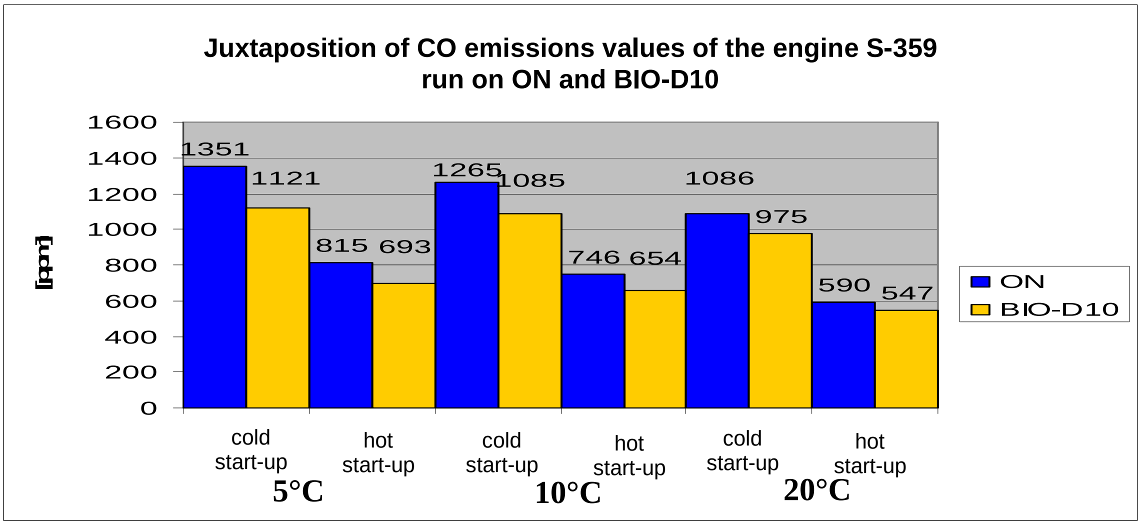

Fig. 8. Juxtaposition of CO emissions values of the engine S-359 run on ON and BIO-D10

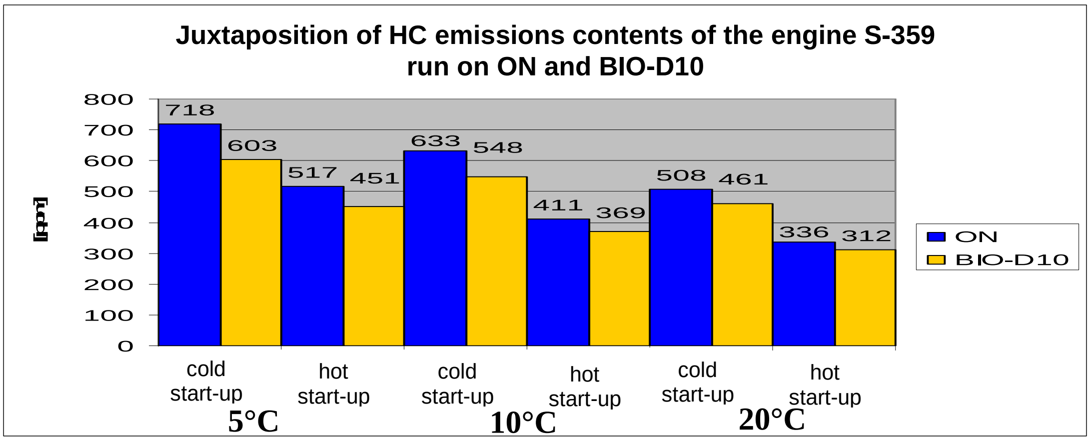

Fig. 9. Juxtaposition of HC emissions contents of the engine S-359 run on ON and BIO-D10

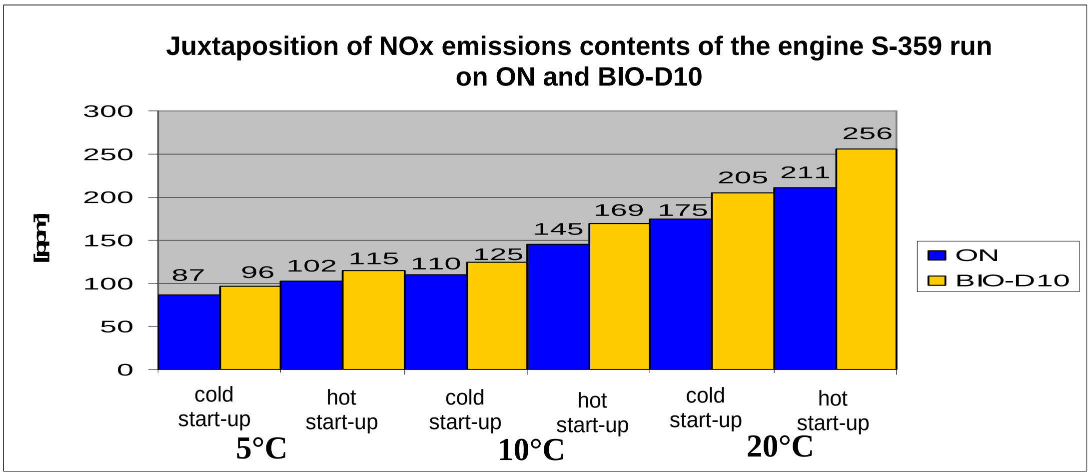

Fig. 10. Juxtaposition of NO_x emissions contents of the engine S-359 run on ON and BIO-D10

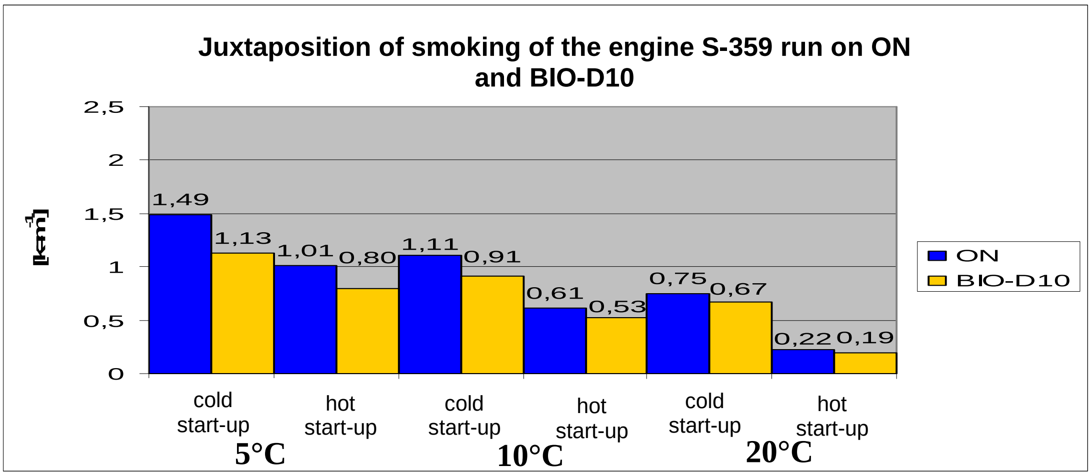

Fig. 11. Juxtaposition of smoking of the engine S-359 run on ON and BIO-D10

As the result of performed tests and result analysis, it was concluded that using the fuel BIO-D10 instead of diesel oil at cold engine start-up, at environment temperature of 5°C, causes the decrease of emissions of CO with 16%, HC with 13% and smoking with 6%. Whilst the emission of NO_x grows with 10%.

It can also be stated that with the use of BIO-D10 at cold and hot start-ups at environment temperatures of 10°C and 20°C, the contents of CO, HC and smoking in fumes decreases. Whilst the contents of NO_x go up.

The presence of oxygen in the fuel causes the increase of nitro oxides with simultaneous decrease of carbon oxide and hydrocarbons, thus giving easier possibility to regulate toxicity of fumes by delaying the angle of fuel injection initiation. Steering the combustion process can be performer in a much wider range.

5. Summary

The need for detailed analysis of phenomena changes of state destruction of the examined engines, with a vast number of measuring data, requires the use of specialized methods of statistical concluding. The presented results were submitted to statistical analysis, where the methods OPTIMUM and AVD were used, as well as correlation and regression methods. It gave the possibility of quality and quantity comparison of results of fumes contents from stationary tests and exploitation researches. The results of this research allow a model (mathematical relations) determination of relations between smoking and the quantity of toxic fume components of a high-pressure engine.

The performed tests and analyses in his work's researches indicate to the conclusions:

1. In the engine of self-acting fuse (ZS), the emission of carbon oxide (CO), hydrocarbons (HC) and smoking are considerable, especially during start-up and engine warming.
2. Along with the decrease of environment temperature, the emission of CO, HC and smoking increase, whilst the quantity of NOx goes down, providing premises confirming the specified regulations of forming dangers on the side of engine fumes emission.
3. The phases of start-up and warming up of the ZS engine are characterized by increased fuel usage and increased emission of carbon oxide – CO, giving information and sensitizing vehicle users to these harmful for the engine working conditions.
4. The influence of environment temperature on the emission and smoking of fumes during hot start-ups is weaker than during cold start-ups.

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