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# EVALUATING PERFORMANCE OF CLEANING THE DIESEL ENGINE LUBRICATION SYSTEM FROM POLLUTION

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## Abstract

This study was carried out in the laboratories of Federal State Institution "all-Russian Research Institute for using machinery and petroleum products in agriculture", Tambov at 2020. The results showed the following by using diesel engine by adding 2% of monoethanolamine's weight and 2% of isopropanol's weight to the used M-10G2K motor oil, followed by the deposition of contaminants in the field of gravitational forces for 7-8 hours, provides a satisfactory quality basis for flushing oils. The content of insoluble sediment in the waste oil, the resin is reduced from 0.9% to 0.01%, the color of the oil changes from 9 to 5 points in units of the color on colorimeter. At the next stage, dimethyl sulfoxide, potassium isopropylate, and diesel fuel, 3% by weight of each of the additives, are added to the purified used motor oil. A decrease in the amount of deposits under the influence of the experimental composition of flushing oil from 7 g on plastics to 1 g was established. As a result of bench tests of the composition of flushing oil in the D-240 engine, an increase in the content of insoluble sediment in oil from 0.01% to 0.16% was determined, which indirectly characterized by reasonably high detergency properties of the experimental composition of flushing oil. Compression in engine cylinders increased by 8 to 10%; fuel consumption decreased by 4%
***Keywords***: diesel engine, flushing oil, lubrication system, pollution, fuel consumption.

## Introduction

One of the effective ways to extend the service life of tractor engines and increase their service life is the periodic flushing of the lubrication system from contamination. The main reasons for the formation of pollution are high loads, technical faults in the engine, and the low quality of used petroleum products, there is practically no flushing of the lubrication system, . the technological process of flushing the lubrication system using waste motor oils and detergent additives is being developed at the Federal State Budgetary Institution named "All Russia", especially in agricultural field during the maintenance of tractors and other machine as harvesters, in Agriculture" during the operation of diesel internal combustion engines, tarry deposits may form on the bottom of the crankcase, in oil channels, on parts of the cylinder-piston group, which reduce the efficiency of tractor engines, also tar deposits are formed under the oil scraper and compression rings that can reduce their mobility, thereby degrading engine performance. These facts are primarily due to several technical condition such as engines, high loads, properties of motor oil and the quality of the diesel fuel used. One of the most effective measures to reduce the contamination of engine parts is to flush them with special oils, in the practice of cleaning engines from hard and greasy deposits, there are conflicting approaches based on the recognition of the need to flush of internal combustion engine from pollution.

Using the flushing with lubrication systems of tractor engineshas not found wide application and distribution in agricultural production. One of the most important reasons for refusing these maintenance operations is the relatively high price of flushing oil with the required significant amounts of oil for flushing the diesel engines of tractors and combines.

An assessment of the contamination of tractor engines depending on the influence of various factors in real-life conditions showed that most often contaminants and resins are formed due to unsatisfactory technical condition of the engine (high wear of cylinder and piston group parts, interruptions in the operation of fuel equipment) and poor quality of used motor oil (Figure 1)

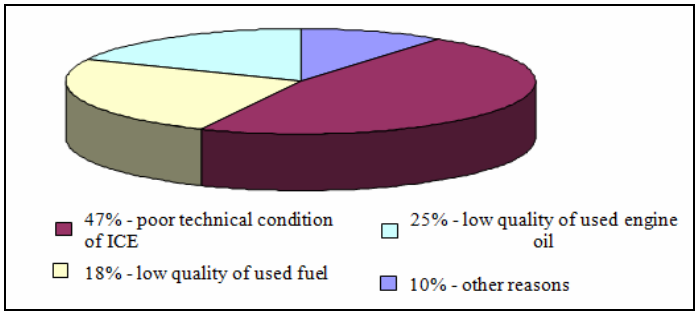


**Fig. 1 :** Contamination parts of engines

Noveltly of using this method to obtaining the base of flushing oil is substantiated, the dependences of changes in the properties of used engine oil in the process of their purification and enrichment with additives are established. The rational characteristics of the composition of flushing oil based on used motor oil are determined.

5 tractors (MTZ) were selected for analysis of technical conditions and contamination. To the evaluate such indicators as compression in the cylinders, fuel consumption and engine power characteristics. After that disassembling the five engines, the mobility of the piston rings, the contamination of the parts, the analysis of the used motor oil, the assessment of the physicochemical parameters of the used diesel fuel were examined. Based on a comprehensive analysis by specialists of the engineering services of the

repair and technical enterprise, with the specialists of the Federal State Budget Scientific Institution VNIITiN, a conclusion on the degree of contamination of the engine and the causes of pollution. The result, it was very challenging to unequivocally state that one factor is the cause of high engine pollution. As a rule, a particular relationship of factors was viewed. Analyzing the changes in the formation of deposits in the grooves of the piston rings of the piston of the D-240 engine, which worked for 250 hours on oil M-10G2K with unsatisfactory characteristics, in comparison with oil that have the requirements of GOST, the dependence of the growth of the formation of deposits on the operating time was established (Figure 2).

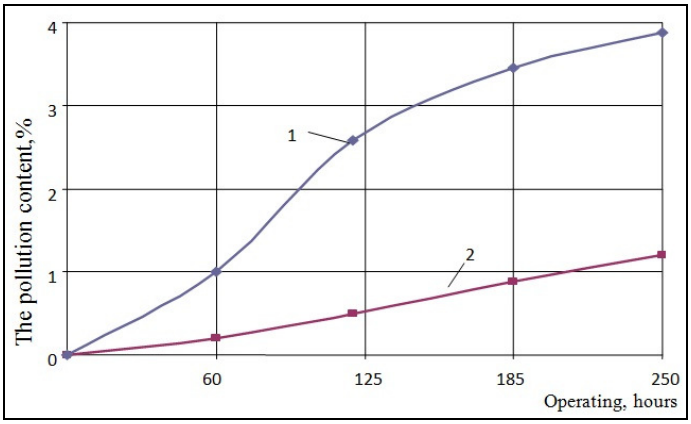


**Fig. 2 :** Dependence of the rate of formation of deposits in the channels of the piston rings from the operating time

A significant effect of the properties and qualities of the starting oils on the amount of formation of deposits has been established. Deposits were a greasy structure relatively easy to remove. The study aim to increase the operational characteristics of tractor engines and reduce the cost of maintenance of machines through the development and use of the technological process of cleaning engine parts from contamination with flushing oil based on used motor oil.

## Materials and Methods

The studies were carried out at the Federal State Budget Scientific Institution VNIITiN. After draining from the crankcase of a tractor engine, the spent oil was used to determine viscosity, flash point, alkaline and acid numbers, and insoluble sediment content, then oil was cleaned from resins, asphaltenes, carbenes and carbides by physicochemical methods. At the same time 2% of the mass of monoethanolamine and 2% of the mass of isopropanol were introduced into the oil. As beside as the mixture was stirred and heated in a reactor to a temperature of 130 °C. Further, the resulting suspension settled for 8 hours with a gradual decrease in temperature to 40 °C. Additives are added to the settled oil at a concentration of 1-5 % of the mass to increase the washing properties of the oil. This mixing is carried out by a gear pump for 15 minutes. The resulte of oil composition is analyzed for alkaline and acid numbers; kinematic viscosity is determined at 100 °C, flash point and oil color in points. CNT. After that the oil is refilled in the D-240 engine, which has previously worked in bench conditions for more than 200 hours. The elemental composition of the oil is analyzed before and after the test to determine the content of Al, Fe, Cr, Cu, etc. Consequently comparative analysis of the content of insoluble sediment and the color change of the oil is also carried out, at the next stage of development of the composition of the flushing oil, special additives were added to the refined used engine oil in a percentage ratio of 3 to 9% of the masses, which increase the washing properties of the oil.

These additions are (Dimethyl sulfoxide and Potassium isopropylate to increase the efficiency of dissolving resins, varnish deposits in the oil were also added diesel fuel 1 to 5%. To assess the dissolution efficiency of resins, the formation of deposits in the internal combustion engine was simulated. In a glass with a diameter of 60 mm and a height of 10 mm was placed spent engine oil M-10G2K drained from the crankcase. The glass was installed in a muffle furnace, where oil was heated for 1 hour at a temperature of 200 °C. The stripe formed after heating and burning oil was considered as greasy deposits and contamination of the lubrication system. Next, oil with various component composition of additives was refilled in a glass, then container was closed and shaken for 15 to 60 minutes. After which the oil was drained, the process of drying, weighing and visual assessment of the washed surface of the glass was carried out.

## Results and Discussions

The results of table 1 showed that the consumed engine oils have several advantages over the base oils used in flushing oils and the used oil contains about 20-30% of non-working detergent-dispersing, anti-wear additives, has a satisfactory viscosity. therefore, it can be assumed that the flushing time of the lubrication system can be increased and led to an increasing the cleaning efficiency and temperature operation in the engine. At the same time, used motor oil contains a significant amount of contaminants, resins, asphaltenes, oil oxidation products, and fuel combustion, which makes it unsuitable for use as a base for flushing oil, and this physical cleaning methods does not allow soluble impurities to be removed from the oil. this use of well-known physico-chemical methods of cleaning increases the cost of cleaning, as it involves the use of sophisticated technological equipment that is not accessible to the main mass of agricultural enterprises. Based on previously developed methods of purification of used motor oils such as indicated by (Ostrikov *et al*., 2017), studies have been conducted to simplify the purification process to obtain a cleaning product that meets the requirements for base oils, also table 1 showed the physico-chemical characteristics of the original spent engine oil M-10G2K used in the development of a new cleaning process.,consumed engine oil was placed in a heat-insulating container with electric heating elements, then the oil was heated to 100 °C, and then monoethanolamine 2% of the mass and isopropanol 2% of the mass into it. After that, the oil temperature increased to 130 ° C, and further heating ceased.

**Table 1 :** Physico-chemical characteristics of the used engine oil M-10$G_{2K}$

| No. p/p | Indicators | Value |
|---|---|---|
| 1. | Kinematic viscosity, mm² / s, at 100 °C | 10,6 |
| 2. | Alkaline number, mg KOH / g | 2,5 |
| 3. | Acid number, mg KOH / g | 1,6 |
| 4. | Flash point, ° C | 198 |
| 5. | The content of insoluble precipitate,% | 0,9 |
| 6. | Colors on the CNT colorimeter | 9,0 |

As beside as, the diagram 1 showed the dependence of the change in the content of insoluble sediment in the oil at the time it settles, it should be noted that after 6 hours of deposition of coagulated contaminants, their concentration decreased by more than ten times such as the following diagram.

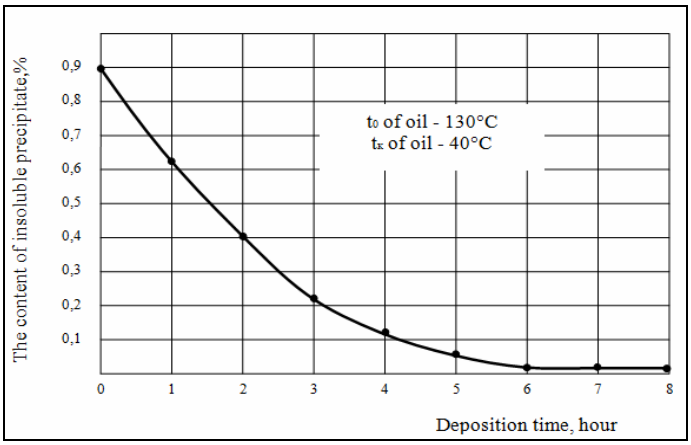


**Diagram 1 :** Dependence of changes in the content of insoluble sediment in the mass at the time of the deposition process

The results of table 2 showed that the viscosity of the oil and the flash remained virtually unchanged and were at the level typical for motor oils used in agricultural machinery engines as such the alkaline number increased due to the presence of monoethanolamine in the oil, which should be regarded as a positive fact, indirectly indicating an increase in the washing properties of the oil, and the color of the oil changed from black from used to light brown from refined which the value of 5 in points of CNT units in the oil after cleaning corresponds to some types of commercial motor oils, but higher than most washing oils. It can be concluded that the waste oil refined using simplified technology meets to a first approximation the requirements for oils used to flush the lubrication system from pollution such as indicated by researchers (Adkins, 1982; Nikolaenko *et al*., 1986).

**Table 2 :** Presents the physico-chemical characteristics of the engine oil after completion of the settling process in the tank.

| No. p/p | Indicators | Value |
|---|---|---|
| 1. | Kinematic viscosity, mm²/s, at 100 °C | 10,0 |
| 2. | Alkaline number, mg KOH / g | 3,1 |
| 3. | Acid number, mg KOH / g | 0,6 |
| 4. | Flash point, ° C | 201 |
| 5. | The content of insoluble precipitate,% | 0,01 |
| 6. | Colors on the CNT colorimeter | 5,0 |

Analyzing the obtained research results noted that the lowest detergency of the considered compounds has purified motor oil without additives this was indicated by (Ostrikov *et al*., 2017; Nepogodyov *et al*., 1990) the highest is pure diesel fuel. However, diesel fuel should not be considered as a detergent, but only as additives. At the same time, commercial washing oil had relatively low washing rates such as reported by (Grigoriev *et al*., 1983). In particular, the pollution content decreased from 7 g to 2 after one hour of washing. Experimental formulations results were found by (Ostrikov *et al*., 2019; Kartoshkin, 1984; Nikolaenko *et al*., 1984) based on refined used motor oil reduced the content of contaminants on the surface of the glasses from 7 to 1 gram, studies were conducted to determine the washing properties of the experimental composition and the efficiency of removing contaminants on a full-size D-240 engine, and then the engine worked for more than 200 hours, also assessment of the state of contamination of parts and assemblies was carried out by partial disassembly and photography. Through which it was evaluated the technical condition based on the definition of compression in the cylinders, fuel consumption, and oil pressure in the lubrication system.

Diagram 2 flushing oil was prepared by cleaning the used M-10G2K engine oil by the addition of dimethyl sulfoxide, potassium isopropylate, and diesel fuel. The rational concentration of each of the additives is taken to be 3% by weight of each component, and it was done the efficiency of removing contaminants from the lubrication system was determined basis on periodic analysis of the physicochemical characteristics of the flushing oil.

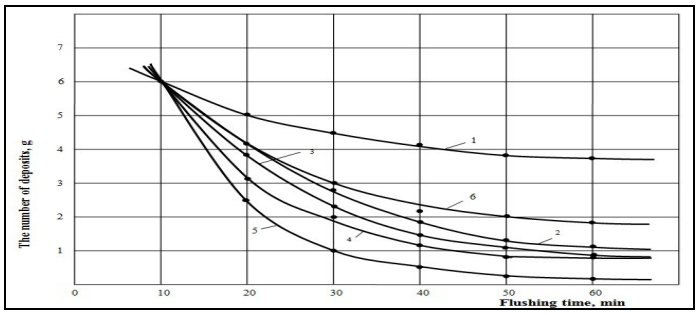


**Diagram 2 :** Dependence of the change in the number of deposits on the time of washing the contaminated surface

Diagram 3 showed dependence of the change in the content of insoluble sediment in the experimental flushing oil on the engine operating time. As intensive accumulation of contaminants, resins in oil was noted in the first 30 minutes of engine operation, then the process stabilizes. That is, a rational washing time, in a first approximation, should be considered 30-40 minutes. The increase in the flushing time of the lubrication system in comparison with the accepted and recommended for well-known flushing oils because the of the basis of the experimental composition obtained from used engine oil.

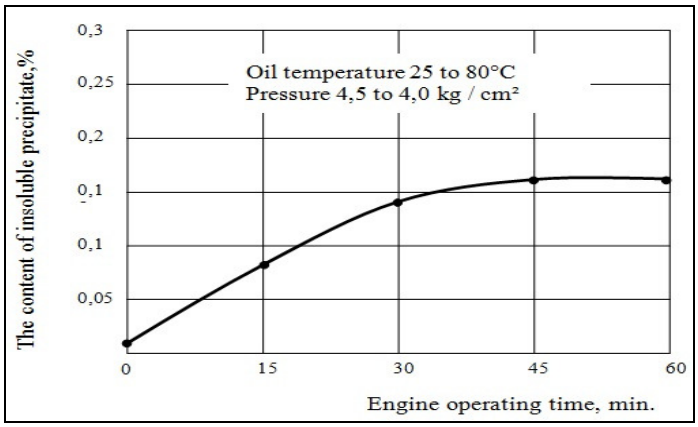


**Diagram 3 :** shows the dependence of the change in the content of insoluble sediment in oil on the time of engine operation.

Table 3 showed the analyzing the change in the elemental composition of the washing oil before and after the washing operation of the lubrication system such as table 3, it was found that the developed composition allows removing not only resins but also wear products, also the determination of compression in the engine cylinders after the completion of the washing operation showed an increase of this indicator by 8 to 10% compared with the initial state. Fuel

consumption decreased by 4% such as indicated by (Kolpakov, 1986).

**Table 3 :** The Change in the elemental composition of the washing oil

| Element | Flushing oil sample | Concentration | |
|---|---|---|---|
| | | mg /L | p.p.m. |
| Fe | Original sample | 26,04 | 28,64 |
| | After flushing | 58,97 | 64,87 |
| Al | Original sample | 1.09 | 1,19 |
| | After flushing | 3,21 | 3,52 |
| Cr | Original sample | 2,57 | 2,83 |
| | After flushing | 4,19 | 4,60 |
| Cu | Original sample | 1,10 | 1,20 |
| | After flushing | 3,81 | 4,19 |

## Conclusion

1- From the results was found that the used motor oils as the basis for flushing oils. Oridinary motor oil in comparison with the base oils used for the preparation of flushing oils, has higher detergent with anti-wear properties and removing resins and oxidation products from used motor oils allows them to be recommended as a base for flushing oil.

2- The addition of dimethyl sulfoxide, potassium isopropylate and diesel fuel to the waste oil purified from contaminants improves the washing properties of the purified oil.

3- As a result of testing the experimental composition of the flushing oil in the lubrication system of the D-240 engine an increase in compression and a decrease in fuel consumption were found.

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