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Research Article

Determination of Process Parameters For Removing Impurities from Motor Oils for Their Use as The Basis of Working and Preservation Fluids

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ABSTRACT

Motor oil that has spent a certain period of time in combined engines has a reserve of operational properties and can be considered as a basis for the preparation of working and conservation oil when storing equipment for a long period of storage [1].

1. INTRODUCTION

Physico-chemical analysis of viscosity, base number, flash point allows us to state that, according to the oils used in combine engines (Table 1) are superior to the I-20A base oil in terms of the content of additives (including antioxidant, anti-corrosion, anti-wear). Oils have a higher viscosity, which creates conditions for the formation of a more "strong" film on metal surfaces, which reduces corrosion and mechanical wear when cranking engines during storage. The disadvantages of motor oils used in engines, as mentioned earlier, include their contamination with mechanical impurities, resins, and asphaltenes. these characteristics, the motor oil is superior to the I-20A base oil (Table 1).

TABLE I. COMPARATIVE CHARACTERISTICS OF USED MOTOR OIL AND COMMERCIAL OIL I-20A.

Indicators	**Used motor oils in internal combustion engines**	**Industrial base oil I-20A**
Kinematic viscosity at 100°C, mm^2/s	13-16	10
Base number, mg KOH/g	3.5-4.5	0.1
Flash point, °C	> 200	> 200

2. RESEARCH METHODOLOGY

At this stage of research, the possibility of removing contaminants and oxidation products from motor oils used in engines was assessed. Simulation of the process of removing contaminants was carried out in laboratory conditions using oils drained from the engines of combines in the first year of operation and with a service life of more than 10 years. Motor oil with varying degrees of contamination was considered as a base. The basis for the developed method for used mineral oils was the purification methods previously developed by the Federal State Budgetary Institution VNIITiN [2].

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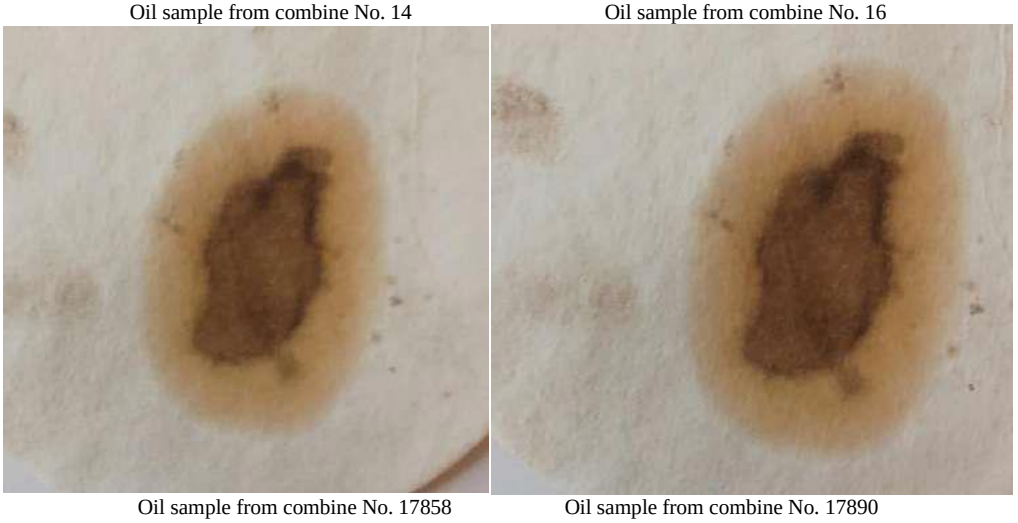
3. RESULTS AND ITS DISCUSSION

The fundamental aspects of developing a new method for removing contaminants from used motor oils was to reduce the cost of purification technology in order to adapt it to the modern conditions of the agro-industrial complex. Namely, the exclusion of the cleaning technology of the use of special cleaning equipment (units for oil purification).

Figure 1 shows the contamination of source oils determined by the drop method. Urea, ammonium hydroxide, monoethanolamine and isopropanol in various concentrations at different temperatures and settling times were considered reagents that ensure the process of coagulation of contaminants.

Oil sample from combine No. 14 Oil sample from combine No. 16



Oil sample from combine No. 17858 Oil sample from combine No. 17890

Fig .1. Appearance of oil samples based on drop contamination analysis

Figures 2 show some results of studies to determine the rational composition of reagents and the concentration of their application. It has been established that adding a mixture of urea and ammonium hydroxide can reduce the content of contaminants and resins from 0.65 to 0.15...0.25%. The oil-settling time was 12 hours.

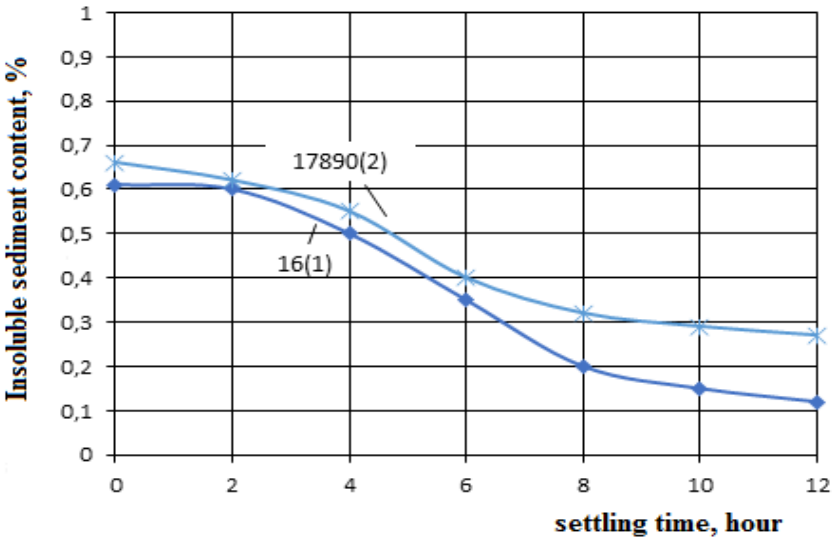


Fig .2. Change in the content of insoluble sediment in the oil depending on the settling time (coagulant composition: 2% urea, 2% ammonium hydroxide, oil temperature 100°C): 1: motor oil M-10G2 (combine No. 16); 2: engine oil M-10DM (combine No. 17890).

During the research, the ambient temperature was 20...25 °C. The oil was heated to a temperature of 100 °C, then the heating was turned off, and the processes of coagulation and settling continued gradually with a constant decrease in temperature to room temperature, that is, to 20...25 °C.

According to the second known method, the working oils were heated to 80 °C, and then 2% of the mass of isopropanol was added to them. The mixture was stirred and heated to 120 °C. Then, as in the first case, the oils were left to settle for 12 hours (Figure 3).

When using this composition of coagulants, after 12 hours of oil settling (with gradual cooling to 20–25 °C), the content of insoluble sediment was 0.13% in the M-10DM engine oil, and 0.05% in the M-10G2 oil.

This fact can be explained by the high residual content of dispersing and stabilizing additives in the M-10DM motor oil compared to the M-10G2 oil. Micrographs of drop samples show a decrease in contamination, and residual elements of dissolved resins are observed after 12 hours of settling (Figure 4).

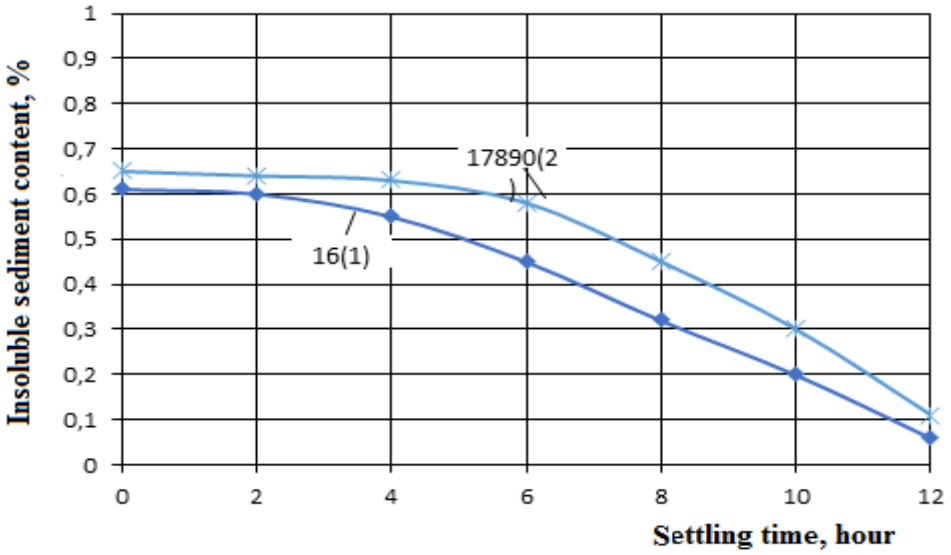


Fig .3. Change in the content of insoluble sediment in motor oils depending on the settling time (composition of coagulants: 2% by weight mono-ethanol amine, 2% by mass of isopropanol): 1: motor oil M-10G2 (combine No. 16); 2: engine oil M-10DM (combine No. 17890).

Sample No. 16 after settling the oil for 12 hours (oil M-10G2)

Sample No. 17890 after settling the oil for 12 hours (oil M-10DM)

Fig .4. Image of drop samples of oil after settling

Analyzing the research results, it was found that the use of various simplified cleaning processes does not completely remove resins from used oils. This fact is explained by the fact that without the use of oil filtration means, after the contaminants enlarge, the process of removing impurities slows down significantly. The slowdown is also explained by the fact that in the approach under consideration, the temperature of the oil during the deposition process is much lower, which also slows down the process of particle enlargement and their subsequent precipitation.

At the next stage, the possibility of changing the combination of reagents used and increasing the settling time was considered. It is proposed to use ammonium hydroxide, urea and mono-ethanol amine as components. The refusal to use isopropanol is explained by the fact that its addition to used motor oil leads to a decrease in the flash point of the oil by 15–20 °C. Urea in the composition of the reagents allows not only to activate the coagulation process, but also, as established in studies previously conducted by the Federal State Budgetary Institution VNIITiN, increases the anti-wear properties of purified oil.

It is suggested that residual urea elements dissolved in the oil can increase the adhesive properties of the oil used as a base for the preparation of working and preservation oils. The studies were carried out using the same oils drained from combined engine crankcases. The used oils were heated to 80 °C and then 1% monoethanolamine and a solution of 1% urea in 2% ammonium hydroxide were added to them. The resulting mixture is heated to 100 °C and left for 24 hours.

Figure 5 shows the dependence of the change in the content of insoluble sediment at the time of deposition of contaminants (in two oils, M-10G2 and M-10DM) drained from the engine crankcase of a combine with a significant service life and a combine in its first year of operation.

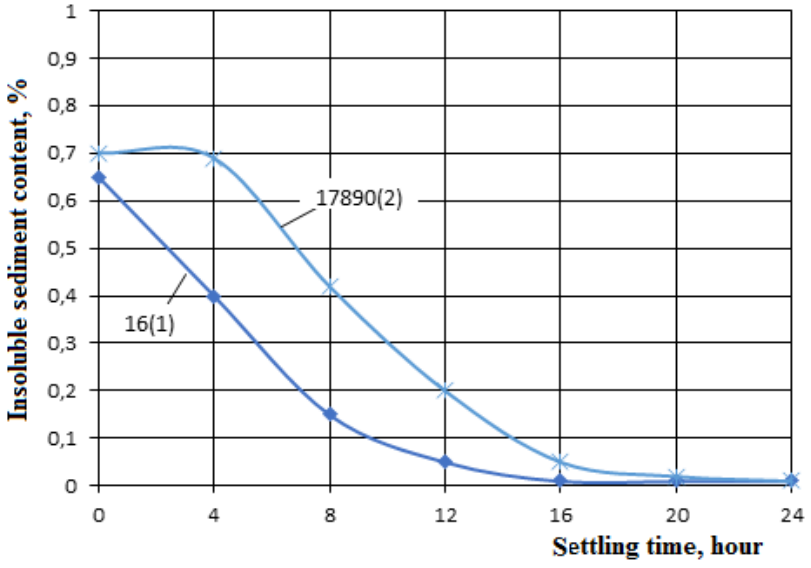


Fig .5. Dependence of changes in the content of impurities in motor oils on settling time, taking into account changes in the composition of reagents.

The working M-10G2 engine oil after 16 hours of sedimentation in the field of gravitational forces contained practically no resins (insoluble sediment content). Oil M-10DM showed a virtual absence of contaminants after 20...22 hours of settling.

Figure 6 shows droplets of purified oils.

Oil sample (combine No. 16) after sedimentation for 16 hours (M-10G2)

Oil sample (combine No. 17890) after sedimentation for 22 hours (M-10DM)

Fig .6. Image of drop samples of oils M-10G2 and M-10DM after implementation of the proposed cleaning method.

In appearance, the stain is yellow without any streaks or traces of dirt. Based on the results of physicochemical analysis of samples of refined oils (5 combines), it was found that the viscosity of the oil remained virtually unchanged, the base number decreased by 0.3–0.5 mg KOH/g, and the flash point increased by 5–8 °C. The acid number of oils decreased by 35...40%.

At this stage of research, it can be argued that purified oils have higher performance properties compared to their original state; the oil is functional for further use in internal combustion engines for a period of at least 50 engine hours.

A comparative analysis of the characteristics of purified oils with commercial industrial I-20A [4-7], used in the preparation of working and conservation oils, showed the advantage of purified motor oils.

As a result of research, it has been established that motor oils after operating in combine harvester engines for 150–200 hours have fairly high physical and chemical characteristics, except for the presence of mechanical impurities and resins in them, which limit their further use in internal combustion engines.

Table 2 shows the results of determining the wear scar diameter. It should be noted that the anti-wear properties of M-10G2 and M-10DM oils, despite their fairly high contamination with mechanical impurities (more relevant to oils that have worked in machine engines with a significant service life), have unsatisfactory anti-wear properties - possibly due to the large number of top-ups oils for burning. Removing impurities using the proposed method makes it possible to improve anti-wear properties to the level of commercial motor oils (Table 2).

Returning to the justification for the need to remove contaminants from used motor oils during the harvest season and the proposed cleaning method, it should be noted that the cleaning productivity is reduced by 50–80% compared to the use of special installations.

TABLE II. RESULTS OF DETERMINING THE ANTI-WEAR PROPERTIES OF OILS.

Sample oil	**Anti-wear properties of oil, D, mm**
Commercial oil M-10G2 original	0.32
Engine oil M-10G2 from the engine of combine No. 14 - after completion of work - after cleaning according to the proposed method	 0.41 0.28
Engine oil M-10G2 from the engine of combine No. 15 - after completion of work - after cleaning according to the proposed method	 0.48 0.30
Engine oil M-10G2 from the engine of combine No. 16 - after completion of work - after cleaning according to the proposed method	 0,39 0,26

Commercial oil M-10DM	0,27
Engine oil M-10DM from combine engine No. 17890 - after completion of field work - after cleaning according to the proposed method	 0.36 0.25
Engine oil M-10DM from combine engine No. 17890 - after completion of field work - after cleaning according to the proposed method	 0.43 0.27

4. CONCLUSION

However, in our case, productivity is not a fundamental characteristic, since after completion of field work, combine harvesters are sent to the off-season parking site for a period of 10 months or more, and the farm engineering services have enough time to carry out work on cleaning the oil in order to use it for its intended purpose or to obtain working and preservation oil. Based on the research results, a patent for invention No. 2773468, Method for Purifying Used Motor Mineral Oils, was received.

Conflicts Of Interest

The author declares no conflict of interest in relation to the research presented in the paper.

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