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Research Article

Assessment of Changes in The Characteristics of Motor Oils in Grain Harvest Engines

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ABSTRACT

The period of use of grain harvesters is short and amounts to 1.5 – 3 months a year. The operating time of the internal combustion engine most often does not exceed 200 hours. At the same time, engines operate in harsh conditions of high temperatures, significant loads, and high dust levels in the air. As has been established, the engines of domestic combines and combines of the Republic of Belarus use M-10G2 and M-10DM motor oils.

1. INTRODUCTION

To date, the literature has provided insufficient information on changes in the properties of oils during the harvesting campaign [1, 2]. The established time for changing motor oils is regulated by the manufacturer of combine engines and is 250 operating hours. In fact, during the harvesting campaign, depending on working conditions, operating hours rarely exceed 200 hours. Due to high loads, insufficient equipment of the material and technical base, and the high degree of wear of the bulk of combines, waste and topping up in the engines of the Don and Polesie series combines may vary. The oil "ages" more intensively towards the end of its service life. And by the time of replacement, it has either already exhausted its operational properties or has not reached its rejection values.

2. RESULTS AND ITS DISCUSSION

As established at the stage of analyzing the state of the issue, before storage, engine oil is not drained from engines and preservation operations are not carried out. In some cases, based on insufficient operating time, having completed the harvesting season and a period of downtime (more than 10 months), the combine can continue to be used for some time without changing the oil in the next harvesting season. This approach is based not on physical and chemical analysis of oil properties, but on the conclusions of specialists from farm engineering services, which jeopardizes increased wear of engine parts, reduces their service life, etc.

Research was carried out on Polesie combines in the period 2021-2022 at JSC Prigorodny Plant, Tambov region. Both combines with a service life of 10–15 years and new combines were taken under observation. All combine engines used Russian-made M-10G2 and M-10DM engine oils. Kinematic viscosity changed slightly over the operating period of 150-200 hours (Figure 1).

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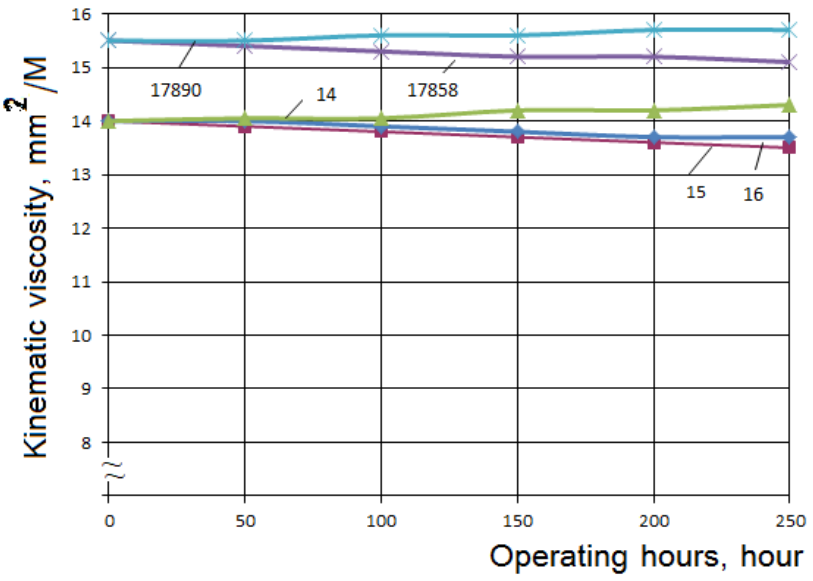

Fig .1. Dependence of changes in the viscosity of motor oils on operating hours: 14 – Polesie combine harvester (M-10G2 oil); 15 – combine harvester "Polesie" (oil M-10G2); 16 – combine harvester "Polesie" (oil M-10G2); 17890 – combine harvester "Polesie" (oil M-10DM), 2021 release; 17858 – combine harvester "Polesie" (oil M-10DM), 2021 release.

The operating time of all combines at the end of harvesting grain crops (wheat, barley) ranged from 170 to 200 hours. The oil viscosity in new combines is slightly higher than in combines with a long service life, since the viscosity of the original M-10DM oil was initially higher.

The slight decrease in viscosity of combine No. 15 is explained by wear and tear of the fuel equipment and other internal combustion engine parts from the combine. The alkaline number of motor oils M-10G2 and M-10DM changed depending on the operating time in the normal mode. With increasing operating time, the alkaline number (an indicator of additive content) decreased (Figure 2).

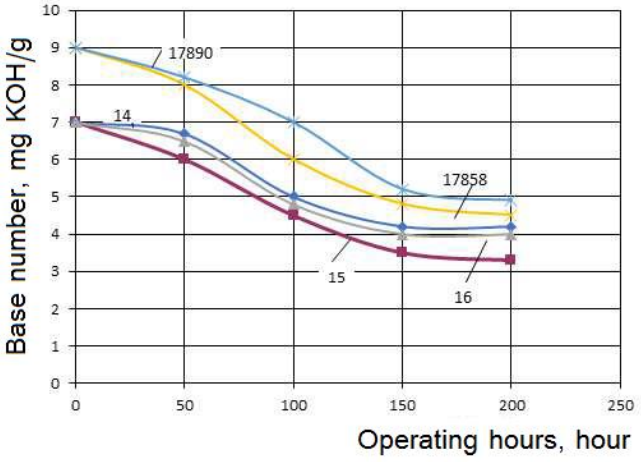

Fig .2. Dependence of changes in the base number content on the operating time of combine engines using M-10G2 and M-10DM engine oils.

The base number of M-10DM oil in the engine of combine No. 17890 changed from 9 mg KOH/g to 4.8 mg KOH/g by 200 hours of operation. While in the engine of the combine with less operating time No. 17858, the motor oil had an alkaline number value close to 4 mg KOH/g. This fact is explained by the more frequent and larger amounts of oil being added to waste.

The base number of the oil in the engine of combines with a service life of more than 10 years was in the range of 3.5 - 4 mg KOH/g at 150 hours of operation, which is explained by the lower value of this indicator for the original oil M-10G2.

Assessing the values of the alkaline number of the oil as a first approximation, it was established that after completion of the harvesting work before storage, almost all oils had a reserve of anti-wear, anti-oxidation, and anti-corrosion properties[6-9].

The content of mechanical impurities in motor oil most often indicates wear occurring in an internal combustion engine. Mechanical impurities also include quartz particles that enter the oil with air, taking into account the increased dust content that occurs during harvesting operations.

It is not possible to separate wear products and dust particles in engine oil under operating conditions. This analysis can only be carried out in laboratory conditions, determining the elemental composition of the oil. As a result of physical and chemical analysis, a fairly wide range of mechanical impurity content in motor oils was established (Figure 3).

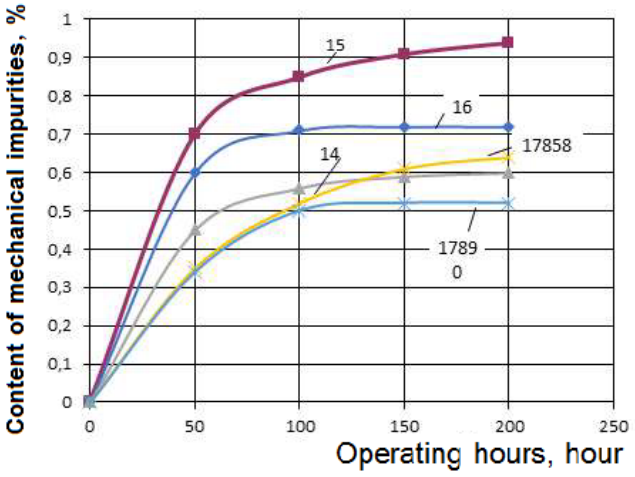

Fig .3. Change in the content of mechanical impurities

Motor oil from the engine of combine No. 15 had a rejection value for the content of mechanical impurities already at 150 hours of operation.

In the first year of operation, combine No. 17858, after 150 hours of operation, the content of mechanical impurities was 0.6 5, while in the oil operating in combine No. 17890, this figure was lower.

The bulk of mechanical impurities accumulated in the oils of combines No. 14, No. 15, No. 16 in the first 50-100 hours of operation.

Before filling with fresh oil, the engines of combines No. 14, No. 15, No. 16 were not washed. The engines of the new combines were filled with oil by the service organization after the engines had worked for a break-in period of 50 hours. Analysis of the content of mechanical impurities in the oil after running-in showed a high content of mechanical impurities. Over 50 hours of operation, the content of mechanical impurities was 0.25 and 0.43%.

As a result of studies of changes in the properties of motor oils, changes in the color of oil M-10G2 and M-10DM were considered (Figure 4). The color of M-10G2 oil was analyzed based on a sample from the engine of a combine with a significant (more than 10 years) service life No. 14. The color of M-10DM oil was analyzed based on samples taken from the engine of a 2021 combine No. 17585.

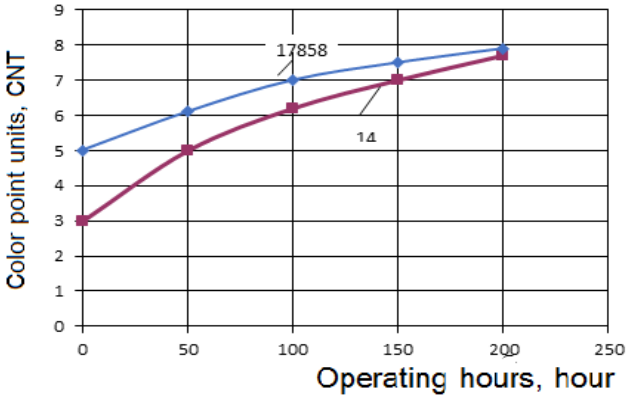

Fig .4. Dependence of the color change of motor oils M-10G2 and M-10DM on operating time.

It was found that an active change in the color of the oil was observed after the first hours of operation (50 hours). Visually, the oils were black in both cases, despite the fact that combine No. 14 was filled with M-10G2 oil, the initial value was 3 points per unit. CNT, oil M-10DM (combine No. 17858, manufactured in 2021) had a color of 5 points. By 150 hours of operation, the color of the M-10G2 and M-10DM oils was almost equal.

The content of insoluble sediment in the oil indicates the content of resins and asphaltenes in the motor oil. This indicator is relatively consistent with the acid number of the oil and color, characterizes combustion processes, temperature, fuel properties and the efficiency of the internal combustion engine, the content of detergent-dispersant and antioxidant additives in motor oil.

Figure 5 shows the dynamics of changes in the content of insoluble sediment in the oil M-10G2 and M-10DM operating in the engines of Polesie combine harvesters.

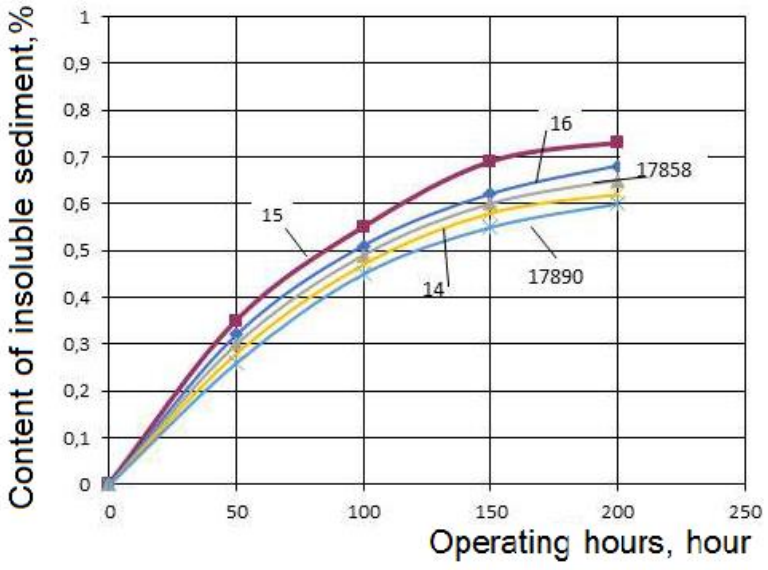

Fig .5.Dynamics of changes in the content of insoluble sediment in motor oils M-10G2, M-10DM depending on operating time

The maximum accumulation of resins and asphaltenes is observed during the period of 100 hours of operation from 0 to 0.45%, then the growth continues less intensively.

In M-10DM oil, the content of insoluble sediment is 5...10% less than in M-10G2 oil. This fact can also be explained by the greater degree of wear of combines No. 14, No. 15, No. 16.

The flash point in motor oils used in engines in some combines (in particular No. 15, No. 16) decreased by 10 - 15 °C, from 220 °C to 205 °C and 210 °C, which indicates the ingress of fuel or other known causes (malfunction of fuel equipment, etc.). In the engines of combines produced in 2021 No. 17890 and combine No. 14, the flash point remained at the level of commercial oil 220 °C and 230 °C.

Analyzing the overall change in the properties of motor oils in the engines of combine harvesters, it was established that by the time the work was completed, before the equipment was put into storage, the motor oils had a residual reserve of operational properties.

The viscosity of the oil was acceptable for considering the operating oil as a protective medium for the formation of a protective film.

Comparing the viscosity of working oils 15 - 16 mm2/s and working and conservation oil K-17, the viscosity of which is also 16 mm2/s, we can talk about their similarity in this indicator.

The base number, as has been repeatedly noted, is an indirect indicator of the content (presence) of antioxidant, anti-corrosion and anti-wear additives in the oil.

According to the results of the studies, the alkaline number of the oil by the time the combine was finished operating was in the range of 3.5 – 4.5 KOH/g. The M-10DM engine oil used for 200 hours had the predominant values. A relatively high content of detergent-dispersant additives may indicate the ability of an oil containing resins and tiny mechanical impurities

to hold particles of contaminants in suspension during equipment storage, thereby preventing them precipitation to the bottom of the oil sump, carrying with it some of the additives.

The content of mechanical impurities in operating oils was in the range from 0.55% to 0.9%, which limits the further use of the oil both as motor oil and as a conservation fluid.

Mechanical impurities when cranking the crankshaft during storage of combines or starting the engine when changing the oil (after completion of the storage process before starting operation next season) can negatively affect the appearance of wear marks on the walls of the cylinder liners.

In addition, during the storage period (9-10 months), mechanical impurities and partially resins precipitate, forming a fairly dense substance that is difficult to lift from the bottom of the crankcase with engine oil. When replacing used oil with fresh oil, part of the “dense” sediment will pass into the fresh oil as the engine operates, reducing its performance properties and service life before replacement. To avoid additional contamination of fresh oil, a deep oil cleaning operation is necessary before storing the combine.

3. CONCLUSION

The satisfactory properties of motor oils that have spent the harvest season in engines do not yet confirm their high protective anti-corrosion properties. An important and necessary condition for maintaining the protective properties of the oil during storage is compliance with basic preservation rules - sealing the engine, minimizing the process of interaction of the oil (both in a thin film on the mirror of the cylinder liners and in the crankcase) with atmospheric oxygen [5].

Conflicts Of Interest

The paper explicitly states that there are no conflicts of interest to disclose.

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