Petroleum and Coal

Article **Open Access**

SELECTING FEATURES OF MOTOR OILS FOR THE FACILITIES OPERATION IN ABNORMAL CONDITIONS

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Received February 16, 2018; Accepted April 27, 2018

Abstract

The article deals with the features of selecting motor oils for the facilities operation in abnormal conditions, where the level of quality of lubricants must ensure the reliable operation of agricultural machinery. In this regard, the accumulation of the water in the oil SAE 10W-40, fuel and particles of incomplete combustion of fuel were simulated in the laboratory; the pollution significantly reduced the level of oil quality. It has been established that the accumulation of water in the oil under study leads to the elution of additives, as evidenced by a 45% decrease in the values of the alkaline number and sulfate ash by 50 %, from the initial value. With an increase in the concentration of soot particles to 10 %, the value of the dispersive stabilization capacity decreases to 0.67, the accumulation in diesel oil to 7.0 %, the flash point decreases by 73°C, and the kinematic viscosity by 34.16 %. The compatibility of motor oils was also studied using the example of oils SAE 10W-40 API CJ-4 and SAE 10W-40 API CI-4 which showed that as there was no oil turbidity, precipitation and discoloration then the oil data can be considered compatible. Based on the undertaken studies, it is possible to predict a change in the oil quality level during the facilities operation and to determine its residual life before replacement.

Keywords: *motor oil; operating conditions; quality level; dispersive stabilization capacity; additives; compatibility of oils..*

1. Introduction

It is known that one of the most abnormal conditions for the facilities operation is considered to be the field conditions during sowing and harvesting. Under the circumstances, there is considerable air pollution, difficult meteorological conditions, impassability of roads, as well as very high loads on the machinery, and therefore its reliable operation will be largely determined by the ability of lubricants, in particular motor oils, to maintain their operational properties throughout the lifetime until replacement.

2. The purpose and objectives of the research

The main purpose of the research is to create an investigation program, which will be characterized by the creation of severe, extreme conditions of the oils operation. Under the circumstances oils are able to show their properties to the maximum. In framework of the goal implementation, it is necessary to select the quality oil factors, which will reflect the qualitative state most adequately, and as a result it reflects on the reliable facilities operation. These indicators include alkali neutralization number, sulfate ash, indicator of dispersing and stabilizing properties, flash point and kinematic viscosity. Also, this series of indicators should be supplemented by studies in the field of oils compatibility. On the basis of information on the numerical values of these indicators, it is possible to predict the behavior of motor oil in emergency situations that may arise from the facilities operation in the field conditions, and to justify the support system for those brands of motor oils, which are not available in the operation manual of the equipment.

3. Results and discussion

During the engine operation, motor oil loses its properties due to accumulation of such contaminants as water, dust, products of incomplete combustion and high boiling fuel fractions [1-3]. The most negative contamination of motor oil when it is transported, stored, pumped and refilled is water. The presence of water causes the hydrolysis of oil additives [4], increases the oxidetion of oil and worsens its lubricity [5], contributes to the formation of deposits and engine corrosion [6]. In the presence of water, oil is foamed intensively and the mode of supplying the oil to the engine parts [7] is violated, which causes increased wear of the parts in the friction zone [8].

Therefore, to determine the effect of water on the oil it is necessary to conduct its flooding with the subsequent definition and comparison of the alkaline number and the sulfated ash of pure and watered oil, as these indicators characterize the presence of oil additives [9]. The oil was flooded in the laboratory in the following way: 50 cm^3 of diesel semisynthetic oil SAE 10W-40 and 50 cm^3 of distilled water were poured into a conical flask at a temperature of (60 ± 5°C) and then carefully mixed for 2 hours. The resulting emulsion was treated with a centrifuge at a separation factor of 3000 to separate the emulsion completely. From the upper part, a sample of oil was selected, and the alkaline number and sulfate ash were determined (Tab. 1).

Table 1 Alkaline number and the sulphate ash of the oil results

Indicator name	Pure oil sample	Watered oil sample
Alkaline number, mg KOH/g of oil	8,2	4,5
Sulfate Ash, % (mas.)	0,86	0,43

The obtained results showed that the number of impurities in the watered oil decreased in comparison with the pure oil, as evidenced by a decrease in the alkaline number by 45 % and a decrease in the value of sulfate ash by 50 %. However, these values of the indicators are not critical [10], but during the actual operation such amount of water never gets into the oil, then on the basis of this, it can be assumed that the oil was passed the flood test.

Then we will consider the effect on the dispersion and stabilization oil properties (DSP) of incomplete combustion products of diesel fuel - the soot particles that accumulate in the oil during the operation of a diesel engine [11-12]. The dispersion and stabilization oil properties are determined by the method of the drop test [13-14]. To do this, into the pure SAE 10W-40 diesel oil, soot particles were artificially injected and dispersed by ultrasound at a frequency of 50 Hz for 2 hours, and they were obtained by the thermal process [15]. Further, the sample of oil was applied to a filter paper to obtain the paper chromatograms, and the dispersion and stabilization oil properties were determined. Taking into account that the washing-dispersing oil additives begin to show their properties at a certain temperature [16], the following studies have been carried out to establish this temperature (Fig. 1).

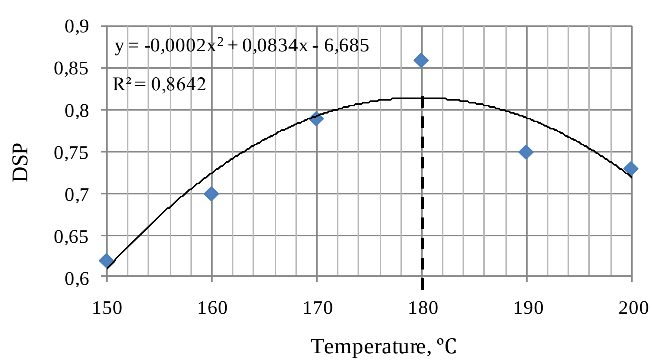

Fig.1. Dependence of the activity of the dispersion and stabilization oil properties on the temperature

According to Fig. 1, the maximum activity of the additive is observed at 180ºC. Hence, further studies on the influence of the concentration of the soot particles on the dispersion and stabilization oil properties (Fig. 2) will be carried out at that temperature.

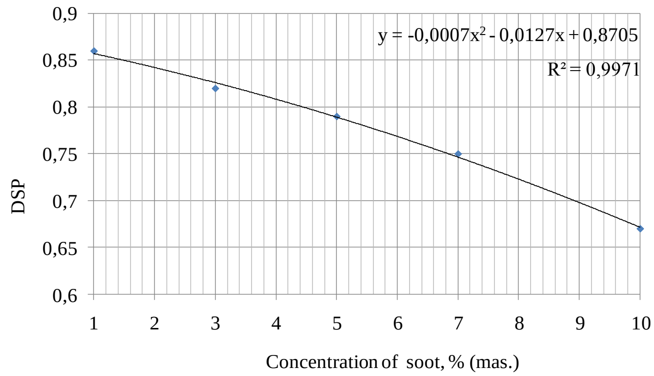

Fig. 2. Dependence of the activity of the dispersion and stabilization oil properties on the concentration of soot particles

It is clear that with an increase in the concentration of the pollutant (soot) from 1 to 10 %, the dispersion and stabilization oil properties deteriorate, and the numerical value decreases from 0.86 to 0.67. However, oil properties are considered unsatisfactory, and it should be replaced by new oil if the numerical value is equal to 0.3 standard units [17]. Therefore, in our case, we believe that the dispersion and stabilization oil properties are preserved when the oil concentration is up to 10 % of incomplete combustion products.

It is known that the presence of fuel in motor oil negatively affects its performance [18], and therefore, in accordance with [19], the influence of diesel fuel on the flash point in an open crucible (Fig. 3) and the kinematic viscosity of the oil at 100ºC have been discovered (Fig. 4).

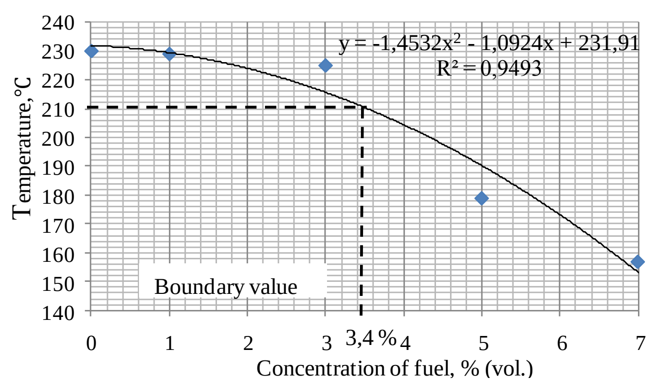

Fig. 3. Dependence of the flash point of the tested oil on the concentration of diesel fuel in it

It is obvious that when the concentration of diesel fuel in oil increases from 0 to 7 % (vol.), the flash point of the oil decreases from 230°C to 157°C, that is 73°C. A defective value for oil is the reduction of the flash point by more than 20ºC [13]. And therefore, keep in mind that according to Fig. 3, the maximum allowable concentration of diesel fuel in the oil is equal to 3.4 % (vol.).

With increased concentration of the diesel fuel in the oil, its kinematic viscosity decreases from 14.05 mm²/s to 9.25 mm²/s, i.e., 34.16 %. Such a decrease in the kinematic viscosity is considered critical, and the oil should be immediately replaced by the fresh one. The initial stock of kinematic viscosity of the investigated oil allows observing the normal working capacity of the equipment at a decrease in viscosity by 25 % [20-21], that is, to the concentration of fuel in it up to 4 %.

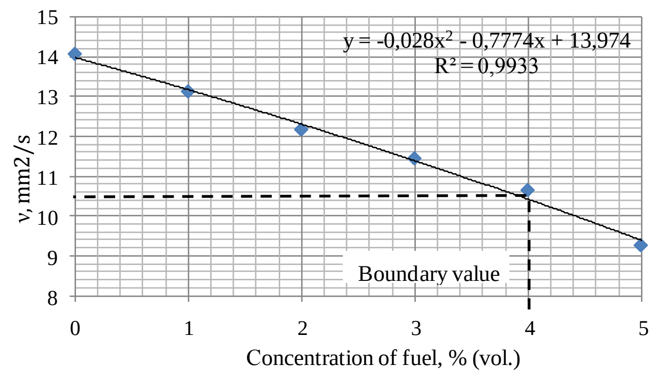

Fig. 4. Dependence of the viscosity of the tested oil on the concentration of the diesel fuel in it

In addition to the above-mentioned oil quality indicators, it is also possible to determine the compatibility of the studied oil with other ones. This is necessary to determine the principal possibility of the emergency extraction oil in the lubrication system of the engine instead of the system that has burnt or escaped. Basic oils must be mixed in one another, and the greatest danger when mixing oils of different grades is the additives added to the base. Each brand uses its own additive package, so when mixing motor oils, they can conflict with each other, which can lead to an increase in carbon content, foaming the mixture of oils, blush and color changes in oils, increasing the aging rate of oil in the engine [22].

To determine the compatibility of the oil, it was taken 50 cm^3 of the semi-synthetic diesel oil grade viscosity SAE 10W-40 API CJ-4, which was added diesel oil SAE 10W-40 API CI-4, but another manufacturer. The resulting mixture was thoroughly mixed, warmed to a temperature of 100ºC, and heated air was blown through the mixture for 2 hours. Next, the compatibility of the oils was determined visually by comparison with the pure oil. It was considered that the oils are not compatible if the mixture produces a precipitate, cloudiness and a change in color (Tab. 2).

Table 2. Results of the compatibility of oils determination

Oil №1, cm^3	Oil №2, cm^3	Impurity level, %	External features		
			Residue	Blush	Change in color
45	5	10	no	no	no
35	15	30	no	no	no
25	25	50	no	no	no

As a result of the study, it can be concluded that the tested oils are conventionally compatible, and gaining a complete understanding of compatibility it is necessary to conduct more detailed laboratory studies according to a clearly defined program [23].

4. Conclusion

Based on the results obtained, we can propose the following program, which will allow from the whole spectrum of motor oils presented in the Ukrainian oil market to select oils that can store their properties under abnormal operating conditions.

The proposed program at stage I involve the creation of extreme weather conditions, i.e. the addition of various contaminants that may fall into the oil, both in the normal operating conditions of the equipment and in an emergency. That is addition of water, creating a hydrolysis of oil additives; contamination of soot particles, which can form similar ointments, which complicate the supply of oil to the friction zone; contamination of high boiling fractions of the fuel, which promotes the oil dilution, thereby violating the hydrodynamic mode of friction of the engine parts.

At stage II, among the quality indicators, it is necessary to choose the most adequately describing the qualitative status of the oils and to determine the indicators in the laboratory.

These indicators include: alkaline number, sulfate ash, index of dispersing and stabilizing properties and kinematic viscosity.

Also, at this stage, it is necessary to determine the compatibility of the studied oils, which will provide information on the possibility of replenishing their volume in the lubricating system of the engine, in the field conditions without reducing the engine reliability.

Stage III involves the interpretation of the obtained numerical values of indicators and the construction of the mathematical models. That will allow to predict the change in the quality oil level during the facilities operation and determine its residual life to the replacement.

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