RESEARCH OF CHANGES IN THE MOTOR OILS QUALITY WHEN OPERATING AN ENGINE AND IMPROVING THEIR

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ABSTRACT

This article contains the research results about changes in oil quality during engine operation. The main reason leading to formation of high-temperature deposits in engines are oxidation processes occurring in the oil volume and on a metal surface. These deposits adversely affect the reliability, efficiency and durability of an engine. Lacquer deposits pose the greatest danger to piston rings. Filling the gaps formed by the piston rings and grooves grooved in the pistons leads to reduction of the rings mobility. Therefore, we suggest introducing detergents into engine oil. The mechanism of action of detergents is that they keep the carbon particles formed in the oil in a fine-dispersed state. As the detergents, we used calcium alkylarylsulfonate - calcium salts of aromatic sulfonic acids. The action of such additives gives flowability, promotes removal of the deposits from the surface of the parts and transfer insoluble substances into suspension. Based on this, an analysis was made of M-10B_2 engine oils and a CS-3 sulphate additive. Having determined the dissolution of the CS-3 additive in the engine oil, we determined the physicochemical parameters of engine oil for various concentrations of the additive. Based on the results of the analysis, we offer the optimal content of additives CS-3, which allows increasing the service life of the oil.

Keywords: oil quality, contamination, viscosity, alkaline number, varnish deposit, piston ring, experimental data, cleaning additive.

INTRODUCTION

Currently, the main areas of engine building are: increasing power, increasing efficiency and reliability, improving starting properties and reducing weight and dimensions.The effectiveness and reliability of the operation of equipment for various purposes depends not only on its design and technological features, but also largely on how correctly selected lubricants and their quality. To ensure the operation of constantly upgraded engines, high-quality motor oils are required.

Studies of the contamination of lubricating oils under operating conditions of equipment show that in hot climates and high dusty air motor oils are intensively contaminated by mechanical impurities, water, fuel and organic products, which leads to premature aging of the oil.

As you know, in a car engine a large number of moving and rubbing together parts. During the operation of internal combustion engines, their components and parts are contaminated with various deposits.The process of deposit formation is associated with thermo-oxidative transformations of products of incomplete combustion of fuel and oil components. These transformations occur both in the volume of oil and in its thin layer on a heated metal surface. The main reason leading to the formation of high-temperature deposits in engines are oxidative processes occurring in the volume of oil and on a metal surface. These deposits adversely affect the reliability, efficiency and durability of the engine.

MATERIALS AND METHODS

The aim of this work is to study changes in the quality of oil during engine operation, and methods for improving the properties of motor oils are proposed.

It is known that oils for internal combustion engines are operated under conditions conducive to their deep oxidation and thermal decomposition, which ultimately leads to deposits of various kinds of sediments, deposits and the formation of varnish pellicles on engine parts [1].

The oxidation of oil in a thin layer on heated engine parts occurs in two fundamentally different conditions - dynamic and static (in flow and rest). The oxidation of oil in the stream occurs during engine operation, when there is a continuous circulation of lubricating oil and engine parts. Oil oxidation occurs only when the engine is stopped, when the oil circulation stops. Oil under static conditions has a significant effect on varnish formation in engines [2].

To achieve this goal, we took samples of engine oils M-10B_2 of ISUZU buses every 1000 km and were analyzed by the main quality indicators.

RESULTS AND DISCUSSION

The duration of the oil in the engine depends on its chemical stability, which is understood as the ability of the oil to maintain its original properties and withstand external influences at normal temperatures. When establishing the service life of oil in engines, the so-called reject indicators are used, upon reaching the maximum permissible values of which it is necessary to replace the oil. The rejection indicators are usually: changes in viscosity, flash point, alkalinity, the content of contaminants, water and fuel, and a number of others.

Table 1 - Limit values for reject performance of engine oils

No	The name of indicators	Rejection Limitsindicators for engines	
		Gasoline	Diesel
1	Change in viscosity,%: growth decline	 25 20	 35 20
2	Alkaline number, mg,KOH/g, not less	0,5-2,0	1,0-3,0
3	Decrease in flash point, °C, no more	20	20
4	Water content,%, no more	0.5	0.3

Based on this, we determined several indicators of qualifying motor oil. Table 2 shows the test results.

Table 2 - Experimental data on the quality indicators of fresh and working engine oil brand M-10B_2

No	Indicators	Oil M-10B_2	1500 (km)	2500 (km)	3500 (km)	4500 (km)	5500 (km)	6500 (km)	7500 (km)
1	Density at: t=20^{0}C, g/sm^3	0.900	0.900	0.902	0.903	0.905	0.908	0.909	0.910
2	Viscosity at:t=40^{0}C	104	103.2	102.9	102.2	101.9	100.9	99.9	98.4
3	Viscosity at:t=100^{0}C	11.00	10.94	10.91	10.81	10.21	9.57	9.02	8.97

Table 2 continuation

4	Viscosityindex	129	126	125	124	123	122	121	120
5	Flash pointin an open crucible^{0}C	205	200	198	195	193	190	180	175
6	Alkalinenumber	5.0	4.5	3.82	3.80	3.72	3.42	2.94	2.38

As follows from the table, viscosity deviations became noticeable with a bus run of 5,000 km or more. The coefficient of friction depends on viscosity, and therefore the reliability and efficiency of the machine, aggregates and friction units. With a low viscosity of the oil and an increase in the load in the friction unit, the oil film may break, which will lead to increased wear of the parts. The use of low viscosity oil leads to increased friction (the oil film is squeezed out of the friction zone), heating and increased wear of parts (there is direct contact between the rubbing surfaces).

Fig. 1 shows the dependence of piston ring wear on oil viscosity.

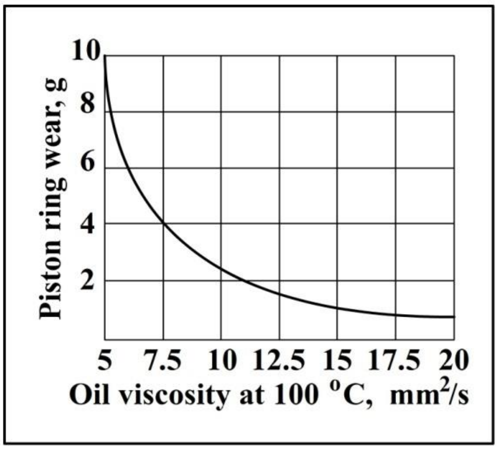

Fig. 1. Dependence of piston ring wear on oil viscosity

According to the experimental data, the alkaline number decreased from 5.0 to 2.38. Such a reduction has acceptable limits, upon reaching which the oil is considered to have lost working capacity.

The elevated temperature and oxygen of the air with which the oil is in contact cause oxidation and oxidative polymerization of its molecules. Hydrocarbon oxidation products present in the oil in a dissolved state contribute to a decrease in the alkaline number. At the same time, acidic products accumulate in the oil, which increases the corrosion wear of parts. All this can lead to contamination of parts of internal combustion engines with various varnish deposits.

The addition of oxygen is accompanied by a rupture of the ring. The higher the molecular weight, the greater the number of cycles, the shorter and branched side chains, the easier the oxidation, the main products of which are acids and hydroxy acids.

The accumulation of various oxidation products in oil causes very harmful consequences. They come down to the following:

1. Low molecular acids intensively corrode metals and especially non-ferrous ones (lead, cadmium, etc.).

2. High molecular acids in the presence of oxygen and water react with the formation of iron oxide hydrate formed under these conditions:

$$Fe(OH)_2 + 2RCOOH (RCOOH)_2Fe + 2H_2O$$

Salts of higher acids are poorly soluble in oils, precipitated and accumulate in the form of sludge on lubricated surfaces and in the circulating oil system. In addition, these salts catalyze the primary oxidation reactions. The accumulation of acids, as well as water in the transformer oil, is extremely negatively reflected in its main operational characteristic - breakdown voltage, as this increases its electrical conductivity.

Lacquer deposits pose the greatest danger to piston rings. Filling the gaps formed by the piston rings and grooves grooved in the pistons, it reduces the mobility of the rings. It is here that high-carbon compounds form, which are deposited in the grooves in the form of pellicles[3].

Simultaneously with the formation of high-carbon deposits, soot, dust and other solid particles entering the high-temperature zone are introduced into it. After some time, these deposits with solid particles embedded in it cause burning of the piston rings, which externally manifests itself in their complete loss of mobility.

Fine stable mechanical mixture of oxidation products leads to the formation of soot and sludge. Deep oxidative polymerization products that differ in high temperature zones and flow back to the crankcase, like other deposits that have formed, continue to have a negative effect on the oil. Thus, in the crankcase of a running engine, a complex mixture of the starting oil with a wide variety of aging products is formed, from which it is not possible to completely clean the oil by filtration.

Considering the experimental data obtained by us on changes in viscosity and alkaline number, we recommend introducing detergents into engine oil. The mechanism of action of detergents is that they keep the carbon particles formed in the oil in a finely divided state.

As detergents, we used the detergent additive calcium alkylarylsulfonate (CS-3) - calcium salts of aromatic sulfonic acids (Fig. 2).

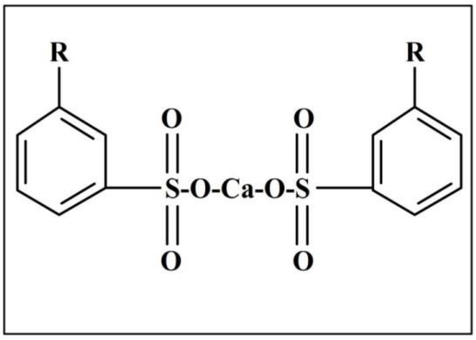

Fig. 2. Calcium alkylarylsulfonate (CS-3)

These additives have the ability to improve the quality of oils. The action of such additives is based on their ability to loosen, wash away deposits from the surface of parts and transfer insoluble substances into suspension and keep these particles in this state without enlargement [4].

This additive protects the oil from oxidation by the action aimed at breaking the chain by reducing the number of generated radicals. The advantage of this additive over other additives is quite effective at relatively low temperatures (up to 150-175 °C) and stable up to 300 °C. To achieve the desired effect, it is required to apply it in amounts of 5-10%.

Based on this, we analyzed the motor oils M-10B_2 and the calcium sulfonate additive CS-3. Having determined the dissolution of the CS-3 additive in engine oil, we determined the physicochemical parameters of the engine oil for various concentrations of additives.

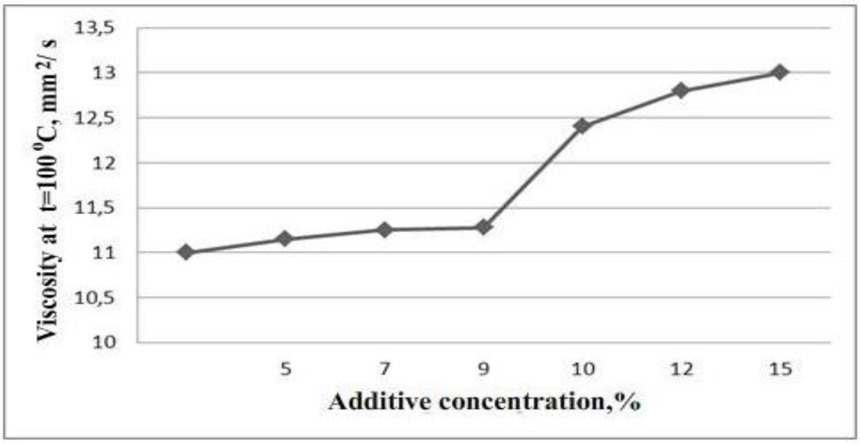

Fig. 3.Viscosity change chart

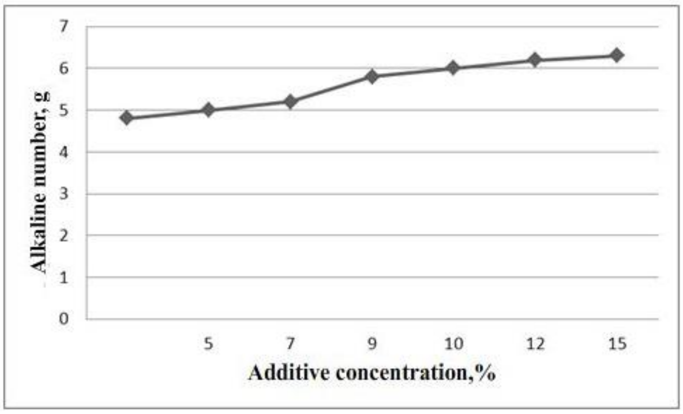

Fig. 4. Alkaline number change chart

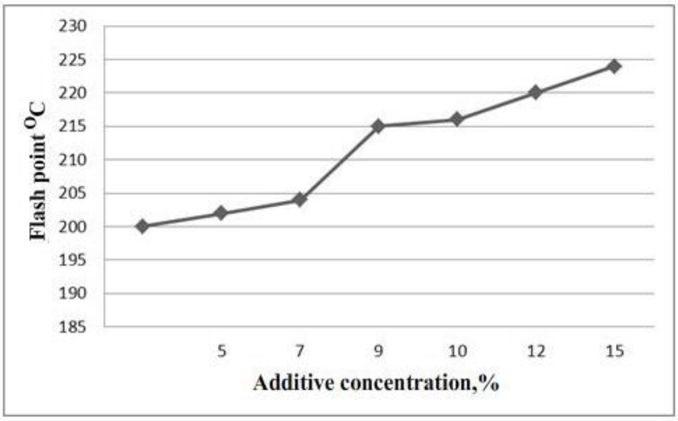

Fig. 5. Flash point temperature change chart

CONCLUSION

According to the results of laboratory studies of tests with the introduction of additives in the M-10B_2 engine oil, physico-chemical parameters gave a positive result compared to M10B_2 oils. The alkaline number increased from 5.0 to 6, and the flash point rose to 224^{0}C, which indicates the effectiveness of the added additive. This means that using this additive will increase the life of the engine oil.

From the results of the analysis, we selected the content of additives CS-3 9%, which shows the optimal value of viscosity and alkaline number. With a further increase in concentration, the viscosity increases significantly, which can lead to increased friction losses. With increasing viscosity, the thickness and resistance to mechanical stresses of the oil layer between the rubbing surfaces increase.

Studies show that the addition of additives reduces the wear process of piston rings by 3-4%, as well as an increase in efficiency by 1%, which leads to an increase in engine power by about 4%.

From the comparison results it is seen that the operational properties of the obtained sample of hydraulic oil far exceed the domestic M-10B_2 and meets the standards according to GOST. This is the effectiveness of the possible use of the new sample we have received. In the future, these oils can be admitted to the next stage - to operational tests on special equipment.

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