IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

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To cite this article: M V Boiko *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **560** 012054

IOP Conf. Series: Materials Science and Engineering **560** (2019) 012054 doi:10.1088/1757-899X/560/1/012054

Tests of energy-saving additives to engine oils on gasoline engine stand

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Abstract. The influence of energy-saving engine oil additives on the parameters of the internal combustion engine has been studied. The tests were carried out on a stand with a 4-stroke gasoline engine. The additives contained a pentaerythritol ester and a complex compound of copper or molybdenum. It is shown that the introduction of additives in motor oils SAE 10W40, SAE 30 reduces fuel consumption, reduces the content of CO and CH in the exhaust gases. The resulting effect is explained by the formation on the conjugate surfaces of a tribopolymer antifriction film, which reduces the gap between the piston and the cylinder. This leads to an increase in compression and a more complete combustion of fuel.

1. Introduction
Fuel economy in the operation of transport is one of the most important tasks of modern science and technology. Increasing the efficiency of internal combustion engines (ICE) is currently achieved through the modernization of engine designs, the improvement of engine management systems and selection of fuel mixtures [1-3]. According to the literature data, frictional losses in ICE are not less than 17 % [4]. We believe that reducing these losses will improve the efficiency and other technical characteristics of the engines.

The frictional losses can be reduced due to the formation of antifriction surface films [5-8], which can reduce the coefficient of friction (under the conditions of boundary lubrication) up to 10 times. Such films are formed by tribochemical reactions involving components of the lubricant.

The effect of increasing the antifriction characteristics of oils is observed in lubricating compositions containing carboxylic acid esters and coordination compounds of transition metals (Cu, Ni, Co, Zn, Mo) [5]. On metal surfaces, as a result of tribochemical reactions involving esters and complexes of transition metals, an antifriction film is formed [5]. High cohesive strength and adhesion to the metal surface of this film increase the load characteristics of the oil.

We found that in the process of friction of steel samples in a lubricating medium containing esters of pentaerythritol and a complex copper compound, a film is formed on the friction surfaces (Figures 1). This film smoothes surface asperities, increases the contact area of friction bodies and possesses antifriction properties.

The purpose of this work was to investigate the effect of energy-saving additives forming antifriction films on the performance of a gasoline engine. We have developed the following additives for motor oils: AMMo-based on the ester of the pentaerythritol and molybdenum complex; AMCu-based on the ester of pentaerythritol and copper complex. In engine oils SAE 10W40 and SAE 30 2% additives were added.

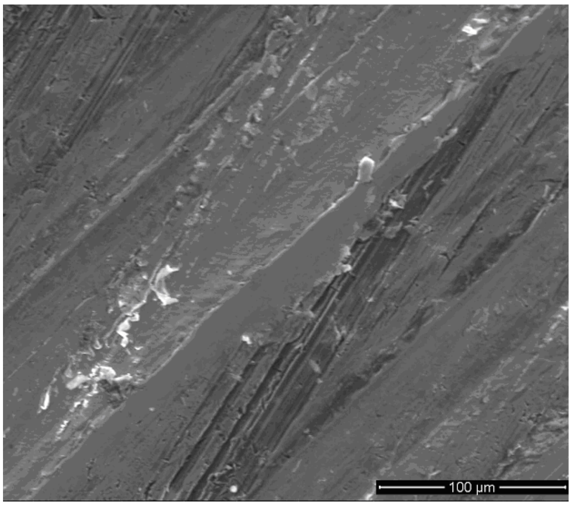

Figure 1. SEM image of the friction surface.

2. Materials and methods

The efficiency of energy-saving additives was studied at the stand consisting of a 4-stroke petrol engine of internal combustion with a capacity of 5.5 hp, an alternator, a load block and a measuring unit (Figure 2). The volume fraction of CO and CH in the exhaust gases was determined using the Infrakar 08.01 gas analyzer. Before use, Infrakar 08.01 was warmed and air-blown. After that, the probe of the device was placed in the exhaust pipe and measurements were made of the content of CO and CH in the exhaust gases.

Figure 2. Test bench for motor oils.

The test procedure is as follows. Before each test, 500 ml of A-92 gasoline was filled into the fuel tank of the stand using a measuring cylinder. The engine crankcase was filled with test oil to the required level. Then, the engine was started with a starter and a load block was connected. The engine was loaded in accordance with the required mode: 0 W; 250 W; 500 W; 750 W or 1000 W. For each mode, during the engine operation, the volume fractions of CO and CH in the exhaust gases were determined. The fuel consumption for a given mode of operation was defined as the ratio of the fuel volume (500 ml) to the engine running time until the engine is completely stopped (in minutes). At the end of the test, the engine crankcase was rinsed with the washing oil.

The tested oils are SAE 10W40, SAE 10W40 + 2% AMMo, SAE 10W40 + 2% AMCu, SAE 30, SAE 30 + 2% AMMo, SAE 30 + 2% AMCu.

3. Results and discussion

The results of tests of the modified oils were compared with the results of the tests of the original oils. The dependence of fuel consumption on the load on the internal combustion engine when using the SAE 10W40 oil is non-linear (Figure 3). When using modified oils, fuel consumption was reduced by 6.4-8.1 % compared to the original oil.

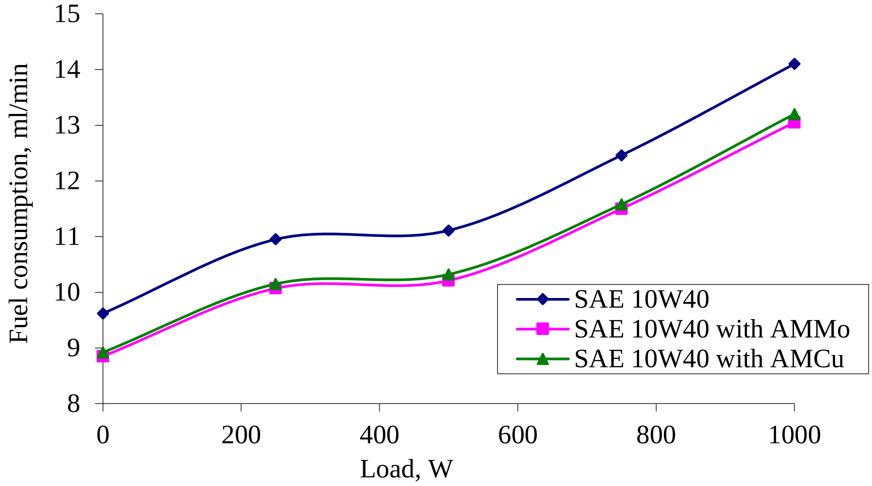

Figure 3. Change in fuel consumption for different engine loads using initial and energy-saving oils SAE 10W40.

The change in the volume fractions of CO and CH in the exhaust gases at different engine loads using the initial and energy-saving SAE 10W40 oils is shown in Figures 4 and 5. The effectiveness of AMMo and AMCu additives is close to each other, but the AMMo additive is somewhat more effective.

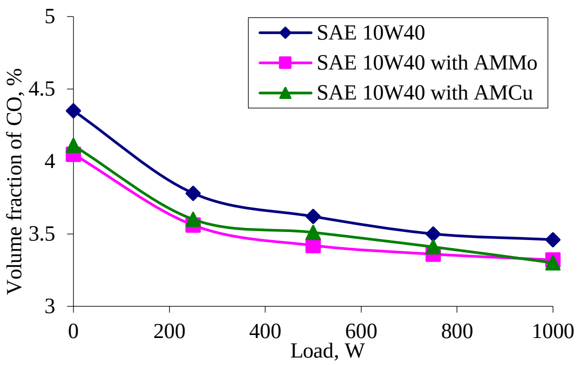

Figure 4. Change in the volume fraction of CO in exhaust gases under different engine loads using initial and energy-saving oils SAE 10W40.

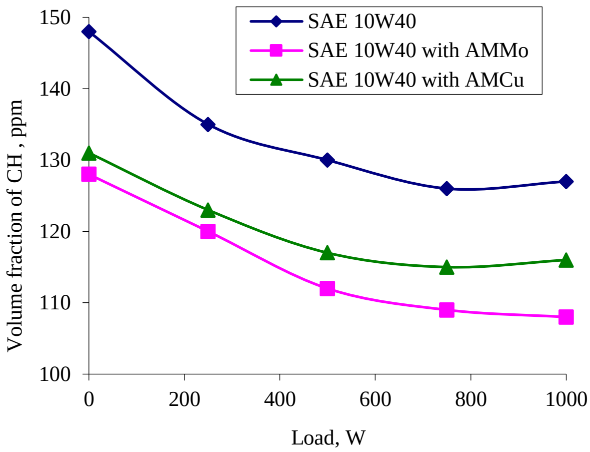

Figure 5. Changing the volume fraction of CH in exhaust gases under different engine loads using initial and energy-saving oils SAE 10W40.

The use of SAE 10W40 modified with AMCu additive results in a 2.5 % to 5.5 % decrease in the volume fraction of CO in the exhaust gases. This lubricant composition is most effective under low - up to 25 W and high - 1000 W loads. The efficiency of SAE 10W40 oil with AMMo additive is higher. The use of such oil leads to a decrease in the volume fraction of CO in the exhaust gases by 4.0 – 6.9 %. This lubricant composition is effective over the entire load range.

The use of SAE 10W40 oil, modified with additives AMMo and AMCu, also leads to a decrease in the volume fraction of CH in the exhaust gases. The oil modified by the AMCu additive reduces the volume fraction of CH in the exhaust gases by 8.4 – 11 %. The oil modified by the AMMo additive reduces the volume fraction of CH in the exhaust gases by 11.6 – 17.7 %.

We believe that the obtained results are related to the fact that on the surfaces of the engine cylinder, a tribopolymer film is formed during friction, which reduces the gap between the piston and the cylinder. This leads to an increase in compression and a more complete combustion of fuel.
Similar results were obtained when testing the SAE 30 oil, which was also modified with AMMo and AMCu additives. The results are shown in Figures 6-8.

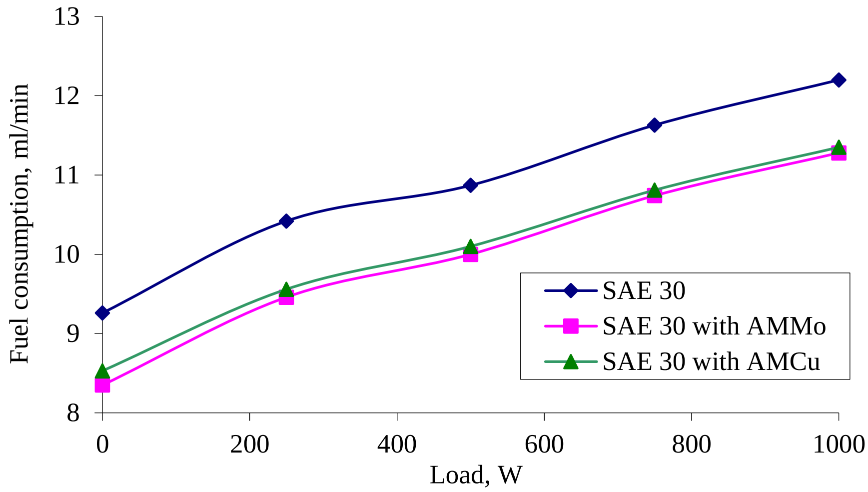

Figure 6. Dependence of fuel consumption on load using initial and energy-saving oils SAE 30.

The dependence of fuel consumption on the load on the internal combustion engine is linear (Figure 6). When using modified oils, fuel consumption is reduced by 6.9-9.8 % compared to the use of the original oil. The efficiencies of AMMo and AMCu additives are close to each other, but the AMMo addition was also somewhat more effective.

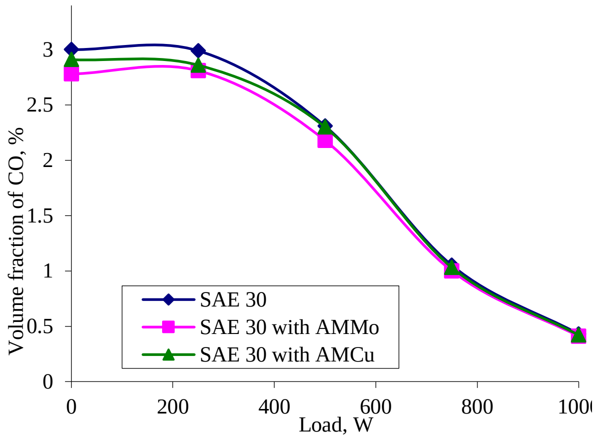

Figure 7. Change in volume fraction of CO in exhaust gases under different engine loads using initial and energy-saving oils SAE 30.

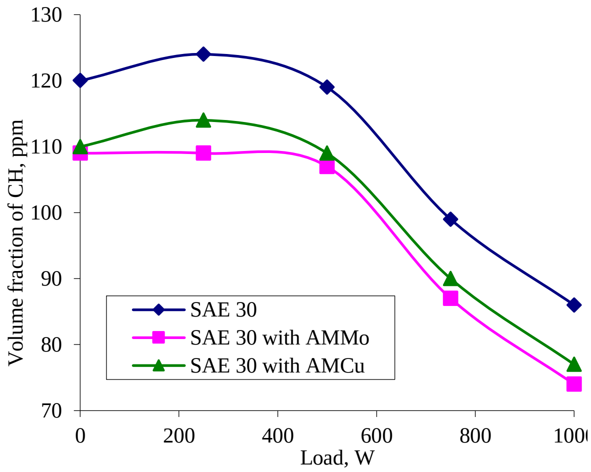

Figure 8. Changing the volume fraction of CH in exhaust gases under different engine loads using initial and energy-saving oils SAE 30.

Using SAE 30 oil modified with AMCu additive leads to a decrease in the volume fraction of CO in the exhaust gases by 0.5-4.3 %. The efficiency of SAE 30 oil with AMMo additive is higher. Use of such modified oil leads to a decrease in the volume fraction of CO in the exhaust gases by 3.5-7.3 %.

The use of SAE 30 oil, modified with additives AMMo and AMCu, also leads to a decrease in the volume fraction of CH in the exhaust gases.

The oil modified by the AMCu additive reduces the volume fraction of CH in the exhaust gases by 7.8-10.6 %. The oil modified by the AMMo additive reduces the volume fraction of CH in the exhaust gases by 9.3-13.8 %.

Long-term tests of energy-saving additives are carried out on the engines of cars. Data are received that the effectiveness of additives AMCu and AMMo is maintained for 10000 km of run, after which it begins to decrease.

4. Conclusion

Improved performance of a gasoline internal combustion engine using SAE 10W40 and SAE 30 oils modified with such additives has been established.

The most effective additive is AMMo. By using SAE 10W40 oil modified with this additive, the fuel consumption in the engine is reduced by 6.4-8.1 %, the volume fraction of CO in the exhaust gases is reduced by 4.0-6.9 %, the volume fraction of CH in the exhaust gases is reduced by 11.6-17.7 % compared to the use of the original oil. When using SAE 30 oil modified with AMMo additive, the fuel consumption in the combustion engine is reduced by 6.9-9.8 %, the volume fraction of CO in the exhaust gases is reduced by 3.5-7.3 %, and the volume fraction of CH in the exhaust gases is reduced by 9.3-13.8 % compared to the use of the original oil.

Acknowledgments

The study was carried out with the support of the Russian Science Foundation grant (project No. 18-19-00292). Boiko M.V. and Nikogosov M.V. have performed bench tests of energy-saving oils.

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