INFLUENCE OF OIL ADDITIVE ON ENGINE PERFORMANCE

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Abstract. The article analyses the influence of the oil additive on engine performance. In order to maximize the life of the engine, the oil is obliged to preserve its active substances and properties. The oil should perfectly adhere to the surfaces of the parts, create a solid film, wash off contaminants from the surfaces of the parts, with a wide temperature range, provide lubrication. To maintain the properties of the oil, each manufacturer indicates the recommended oil change interval. As the chemical industry is increasingly penetrating into everyday life, another alternative to engine maintenance is offered as oil additives. Many manufacturers of these additives claim that this mixture diffuses into a crystal lattice on the metal surface under the limit conditions of lubrication, as well as under high pressure and high temperatures. From the components of the oil additive, a ceramic layer is formed. This layer partially compensates for the wear of the surfaces of the cylinders and reduces the gap between the piston and the cylinder. The purpose of the study was to assess the influence of the regenerating oil additive on the performance indicators of the engine. For conducting experimental research, research methodology and equipment were prepared. Measurements of engine performance indicators were carried out. As a result of the experimental measurements, an increase in the engine compression was measured using a regenerating oil additive, with a 3.2% reduction in average fuel consumption. No significant changes were observed in the results of the engine power and torque. At a speed of 2000 min^{-1}, after the use of a regenerating oil additive, the emission of nitrogen oxides increased by 15.3%, and carbon monoxide emissions decreased by 10.2%.

Keywords: diesel engine, oil additive, engine performance indicators, exhaust emissions, smokiness.

Introduction

Modern cars are rich in friction nodes operating in different conditions. Boundary or mixed lubrication modes, in which direct contact of surfaces is formed, lead to intense abrasion of the parts. To ensure high-quality and long-term operation of the engine, motor oils are used, which not only separate the friction surfaces, but also clean the engine elements and additionally cool it. The main task of the oil is to reduce friction and abrasion between the moving parts of the engine, to remove soot and combustion products. The quality of the oil is especially important due to the different temperatures and loads that affect the parts of the engine.

As the chemical industry is increasingly penetrating into everyday life, another alternative to engine maintenance is offered – oil additives. As many manufacturers of these additives claim, this oil additive mixture diffuses on the surface of the metal under the limit conditions of lubrication, as well as under high pressure and high temperatures. From the components of the oil additive, a ceramic layer is formed with high temperatures in micro-volumes [1]. This layer partially compensates for the wear of the surfaces of the cylinders and reduces the gap between the piston and the cylinder. [2]. In order to optimize the use of these additives and increase the efficiency of application, knowledge of the properties of these substances, as well as various processes occurring in lubrication mechanisms, is necessary.

The engine transmits the generated torque through the transmission to the driving wheels, thereby forcing the car to move. For a longer engine life, it should be properly maintained. Under the influence of great forces and moving quickly relative to each other, the engine parts rub against each other. This friction can be reduced by the oil penetrating their gap. This is done by the lubrication system. The durability and reliability of the engine depend on the lubrication system. The purpose of motor oil is to lubricate the internal parts of the engine, remove combustion products, reduce friction inside the engine, protect parts from corrosion, maintaining their working capacity as long as possible [3].

The working capacity of the engine can be extended with proper care. For engines of light, freight, tractors, buses, tractors, self-propelled machines and mechanisms, different oils are selected. According to the type of raw material, oils are divided into mineral, made from oil, semi-synthetic – produced from oil both by chemical synthesis, and synthetic, produced only by chemical synthesis. The oil must perfectly adhere to the surfaces of the parts, create a strong film, wash off contaminants from the surfaces of the parts with a wide temperature range and ensure lubrication [4]. Motor oils are produced by mixing

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them with each other from one or more base oils. Additives made from molybdenum oxides, alcohols, esters, fatty acids and other compounds can be used to reduce friction.

During the operation of the car, the quality of the oil, its physical and chemical properties change. During the operation of the engine, oxidation occurs due to the high temperature, so antioxidants are used. The viscosity of the oil is influenced by the change in temperatures, at low temperatures the viscosity increases, and at high temperatures it decreases, the decrease or increase in viscosity adversely affects the nodes of the motor, viscosity index modifiers are used to solve this problem [5]. Lubrication must be ensured and at such time when the oil has to withstand heavy loads, wear reduction additives are used for it. Since the function of the oil is not only to lubricate the nodes of the internal combustion engine, but also to wash off undesirable substances and particles, dirt, accumulated soot, etc., special additives can also be used to improve this function of the oil.

Additives are an important part of the oil and can compensate and improve the performance of the base engine oil. Oil additives are important to ensure proper engine operation and protection. The stability and durability of accessories are important for long-term protection of the engine. The properties of additives can change during use due to high temperatures, oxidation and other factors [6]. They can also give the oil new properties. Research in this area is important to evaluate the effectiveness of additives and the effect on engine performance. Scientists studied the parameters of the internal combustion engine using an oil additive. The results of the studies showed that the use of a motor oil with boron additive led to a corresponding decrease in fuel consumption by 2.4-8%. The use of the oil additive did not significantly change emissions of carbon monoxide and unburned hydrocarbons, but emissions of nitrogen oxides decreased by 11.4 to 12.9%. The authors noticed in their work that the addition of a boron-modified oil to a gasoline engine leads to a relative improvement in the engine performance and exhaust emission indicators [4].

The authors studied the influence of diesel engine oil additives on the formation of particulate matter. In their work, scientists emphasized that the physicochemical properties of motor oil, as well as the variation of additives, have a significant impact on the composition of the exhaust gas flow [7]. Other authors in their works compared oils containing nanomaterials. In the results, it is noted that these oil additives are distinguished by excellent thermal and tribological properties [8]. The utilization of nanoparticles (NPs) as additives to enhance tribological performance of base fluids can minimize wear loss, frictional force, increase performances, and prolong moving objects life [9].

Effective indicators of the engine depend on the design of the engine, the technology of manufacturing the materials and parts used. During operation, many extraneous factors appear that reduce the economy of the engine. These parameters are affected by the use of fuel, oil, coolant, various sealing elements [10]. During the work, the engine parts and their elements that are rubbing or exposed to thermal and chemical processes wear out. Impeccable operation of modern machines and vehicles can be ensured by complex measures consisting of modern design solutions in design, the use of operational and structural materials, and timely maintenance. The links of this system are closely interrelated.

The application of geo modifiers, particularly KGMF-1, has been extensively studied for enhancing the wear resistance of tribomating surfaces in fluid-lubricated systems. Experimental research has demonstrated that incorporating KGMF-1 into base oils like M-10G2K (SAE 30) significantly improves tribological performance. These findings underscore the efficacy of KGMF-1 as a functional additive in lubricants, offering substantial improvements in wear resistance and load-bearing capacities without necessitating structural modifications to machinery components [11].

Parts of the assemblies of various mechanisms wear out and are in constant need of maintenance. Replacing worn-out components with new ones requires large investments, so such a solution to the problem is economically unprofitable. In order to avoid this, additives to the oil can be used, which would reduce friction as much as possible and extend the time of operation of the mechanism, but research carried out by scientists on this topic lacks research that would relate to the influence of the regenerating oil additive on the engine performance. The purpose of the work is to assess the influence of the regenerating oil additive on the performance of the engine.

Materials and methods

Experiments were carried out on a diesel car of the “Fiat Doblo 2006” edition. The experiment was carried out with a new synthetic engine oil and an oil filter. Before the regenerating additive was added to the oil, measurements were made of engine compression, noise emitted, engine performance indicators and combustion emissions. After pouring, the measurements of the regenerating additive were repeated when the car was driven ~15000 km. New synthetic motor oil WOLVER Super tec, SAE 5W30, ACEA S/C and oil additive (revitalizant) were used for the research. This is a repair restorative mixture (metal conditioner). This additive is specially designed for diesel engines of passenger and cargo cars. Suitable for use with all types of engine oil. The granules of the additive dissolve in oil at the normal operating temperature of the engine. The process of revitalization is completed after 1-1.5 thousand kilometres of mileage.

In the course of experimental studies, with the help of a compressor, changes in the compression of the “Fiat Doblo” diesel engine were measured. Compression measurements of the cylinders of the car engine were carried out 3 times each. The resulting data is systematized and processed in “Microsoft Excel 2016”.

To carry out measurements of the engine power, a drum stand for measuring the power of cars was used. The V-Tech VT-2 modular power test bench was used to measure the car power and torque using the inertia method. Power measurement accuracy ± 0.1%. Power measurement tests were carried out on the car “Fiat Doblo” in 4th gear, from 50 $km \cdot h^{-1}$ to 160 $km \cdot h^{-1}$ in the speed range, creating a load with the help of the stand. Measurements of torque and power were carried out before the use of the oil additive, and after full regeneration of the engine after the use of the oil additive.

To record the parameters of average fuel consumption, an iOBD2 diagnostic device was used before and after the use of the additive in the engine.

The exhaust emissions of nitric oxide (NO), nitrogen dioxide (NO_2), carbon monoxide (CO), and total unburned hydrocarbons (THC) expressed in parts per million (ppm) were measured with electrochemical cells built-in the Testo 350 XL flue gas analyser (Testo AG, Lenzkirch, Germany). The total NOx emissions were evaluated as a sum of both NO and NO_2 components.

Exhaust smoke (soot) was measured by using a “Bosch” RTT 110/RTT110 opacity-meter (Robert Bosch, Stuttgart, Germany), the readings of which are provided as Hartridge units (% opacity) in a scale range of 0 to 100%.

The engine was warmed up to operating temperature (the oil temperature was 85 to 95 °C and the coolant temperature was 80 to 90 °C). Measurements were made when the engine was idle and at a speed of 2000 min^{-1}. When the engine was operating in the established modes, exhaust gas emissions and smokiness were recorded. After statistical processing of the data obtained, emission graphs of exhaust gases were compiled. Measurement accuracy: Engine speed ± 0.1%; Engine torque ± 1%; Nitrogen oxides (NOx) ± 5 ppm; Carbon monoxide (CO) ± 3 ppm; Carbon dioxide (CO_2) ± 3 vol%; Total unburned hydrocarbons (THC) ± 2 ppm; Exhaust smoke (opacity) ± 0.1%.

At least three iterations were performed on each of the various measurement variants described above, and the results provided arithmetic averages of these measurements with 95% confidence intervals.

Results and discussion

The durability and reliability of the internal combustion engine largely depends on the presence of a sufficiently strong oil film between the slip surfaces in all modes of operation. The pressure in the cylinder at the end of the compression stroke is also called engine compression. Engine compression characterizes the maximum pressure that can be caused by the piston when moving in the engine cylinder. It is possible to determine the overall stability of the engine by measuring the compression, this is an excellent integral characteristic of the motor. In experimental studies, compression was fixed in the cylinders before and after the use of the oil additive.

Figure 1 shows the results of measuring compression of a warm engine, cylinders. In the presented graph we see changes in the compression of the “Fiat Doblo” diesel engine in the presence of a warm engine. From the presented graphs we can see that after the use of the regenerating additive, compression was increased in all cylinders. In percentage terms, the compression increased by 7.4% in cylinder 1, 9.2% in cylinder 2, 14.3% in cylinder 3 and 10.2% in cylinder 4.

The general technical condition of the engine is assessed by power, mechanical losses, the composition and temperature of the exhaust, fuel consumption and smoke. Engine power and comparative fuel consumption are the main parameters that indicate the performance characteristics of the engine.

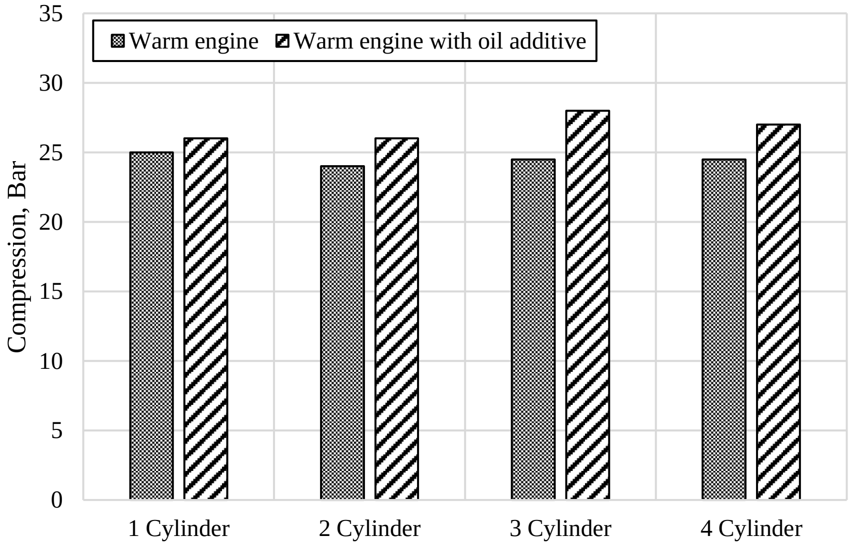

Fig. 1. **"Fiat Doblo" compression measurement results with a compressor in the presence of a warm engine**

In Figure 2 the results of the variation in the power and torque measurements of the "Fiat Doblo" car are given. After measurements, the change in the power is observed at peak times. The maximum difference in power measurement was 2% (Figure 2(b)). Slight changes in the power and torque are also confirmed by the research results obtained by other authors [12].

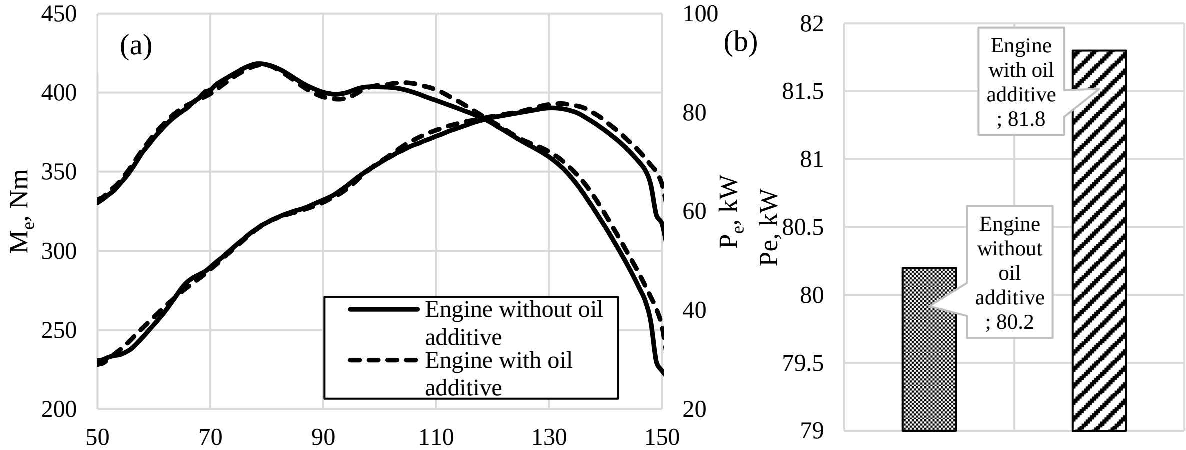

Fig. 2. **"Fiat Doblo" car power and torque measurements results**

As it can be seen in Figure 2, in the results of the variation in the torque after the use of the oil additive regenerating the engine, the curve became more even than before the use of the oil additive, which indicates a more even operation of the engine.

Before and after the use of the additive, the average fuel consumption of the "Fiat Doblo" car in the city was monitored, driving on weekdays along the same route and in the same style. When analysing the data obtained, it was noted that the fuel consumption after the use of the oil additive was 3.2% lower. This is explained by increased compression and improved combustion, requiring less fuel to extract the same amount of energy.

The variation in nitrogen oxides (NO_x) emissions of the "Fiat Doblo" diesel engine before and after the use of the regenerating oil additive is given in Fig.3. The use of an oil additive to a diesel engine increased nitrogen oxide emissions of 15.3% at a speed of 2000 min^{-1}. This is explained by the use of the oil additive. From the presented Figure 1, it can be seen that after using the oil additive, the compression of the engine cylinders has increased, at the same time the temperature in the cylinder increases, combustion improves, but as this progresses, the amount of nitrogen oxides emitted increases.

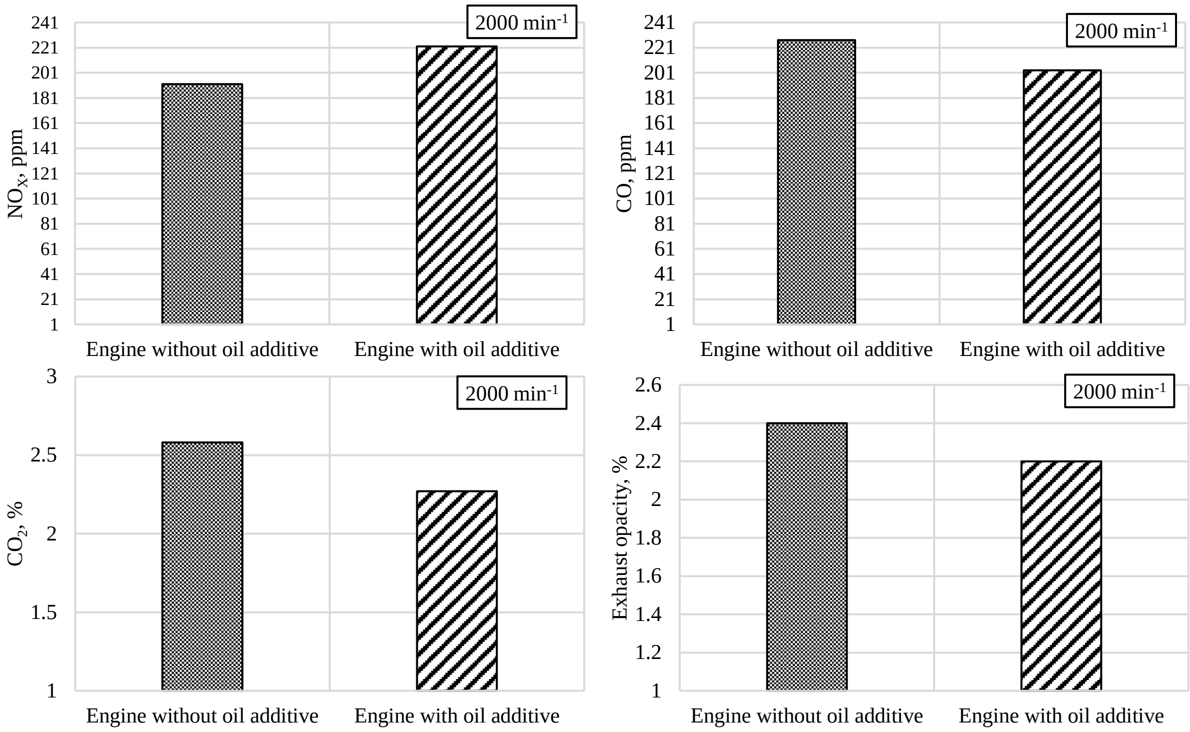

Fig.3. **"Fiat Doblo" car exhaust and smoke opacity change results**

Figure 3 shows the variation in the carbon monoxide (CO) emission of a "Fiat Doblo" diesel engine at a speed of 2000 min^{-1} when the engine is running at a speed of 2000 min^{-1}. It can be seen that when using a motor oil additive, CO emissions of 10.2% were obtained lower.

The variation in the carbon dioxide (CO_2) emission of a diesel engine at a speed of 2000 min^{-1} before and after the use of the regenerating oil additive is shown in Fig.3. The use of an oil additive to the engine reduced CO_2 emissions by 13.7%.

The results of the variation in the smoke of the "Fiat Doblo" diesel engine before and after the use of the regenerating oil additive are shown in Fig.3. From the presented graphs it can be seen that before the use of the oil additive, the smoke content was obtained higher. After pouring the oil additive into the engine and passing the mileage of the revitalization process with it, the smoke decreased by 9.1%, when the engine was running at a speed of 2000 min^{-1}.

Conclusions

1. Having considered the factors influencing the durability of the lubrication system, it can be said that the oil additives used reduce friction and extend the life of the mechanisms, but the lack of results of scientific studies confirming their real influence on the performance of the engine indicates the need for further, detailed and reliable tests in order to objectively assess their effectiveness and long-term impact on the engine performance.
2. The use of a regenerating oil additive increased the compression of the diesel engine, respectively, in cylinder 1 by 8%, in cylinder 2 by 12,5%, in cylinder 3 by 12% and in cylinder 4 by 16%.
3. In the case of use of the regenerating oil additive, no significant values were observed in the results of the engine power and torque. When the engine is worked out with the regenerating oil additive, a 2% increase in power is visible, but this may also have been influenced by variations in the errors of the power bench.

4. When the diesel engine was working with a regenerating oil additive, the average fuel consumption was measured 3.2% lower.
5. At a speed of 2000 min^{-1}, the use of the regenerating oil additive increased nitrogen oxide emissions by 15,3%, while carbon monoxide emissions decreased by 10,2%.
6. When the engine was running at a speed of 2000 min^{-1} and using an oil additive, the diesel engine smoked 9.1% less compared to the use of new oil without an additive.

Author contributions

Povilas Šaulys (P.S.), Tomas Mickevičius (T.M.). Conceptualization, P.S., and T.M.; methodology, P.S. and T.M.; software, PS. and T.M.; validation, P.S. and T.M.; formal analysis, P.S. and T.M.; investigation, P.S. and T.M.; data curation, P.S. and T.M.; writing – original draft preparation, P.S. and T.M.; writing – review and editing, P.S. and T.M.; visualization, P.S. and T.M.; project administration, T.M.; funding acquisition, T.M. All authors have read and agreed to the published version of the manuscript.

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