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Research Article

Analysis of Some Tribological Properties of Hazelnut Oil in Gasoline Engines

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Abstract

In this article, oil obtained from vegetable was used to lubricate a single-cylinder 2-stroke gasoline engine as lubricating oil, and the tribological function of the obtained oil was investigated. To investigate the tribological functions of the lubricating oils, a 2-stroke single-cylinder gasoline engine was used. For mineral oil and hazelnut oil, the test engine was run for 100 hours for each one and was used to lubricate in the test engine as lubricating oils. Samples were prepared with the aim of determining the wear on the cylinder surface, and also EDS (Energy Dispersive Spectrograph) analysis was obtained. The results of the analyses showed that the wear on the cylinder surface was increased in the studies using hazelnut oil, and the C content of the cylinder sample increased compared to the study with mineral oil. Al element was detected in the cylinder sample in the hazelnut study, and the reason for this is the transport of the Al element during the friction event in the piston material to the cylinder surface.

Keywords: Cylinder, Wear, Lubrication, Nut Oil

Benzinli Motorlarda Fındık Yağının Bazı Tribolojik Özelliklerinin Analizi

Öz

Bu makalede, tek silindirli 2 zamanlı benzinli bir motorun yağlama yağı olarak bitkisel yağlardan elde edilen yağ kullanılmış ve elde edilen yağın tribolojik fonksiyonu araştırılmıştır. Yağlama yağlarının tribolojik fonksiyonlarını araştırmak için 2 zamanlı tek silindirli benzinli motor kullanılmıştır. Madeni yağ ve fındık yağı için test motoru her biri için 100 saat çalıştırılmış ve yağlama yağı olarak test motorunda yağlama yapmak için kullanılmıştır. Silindir yüzeyindeki aşınmanın belirlenmesi amacıyla numuneler hazırlanmış ve ayrıca EDS (Energy Dispersive Spectrograph) analizleri yapılmıştır. Analiz sonuçları, fındık yağı ile yapılan çalışmalarda silindir yüzeyindeki aşınmanın arttığını ve madeni yağ ile yapılan çalışmaya göre silindir numunesinin C içeriğinin arttığını göstermiştir. Fındık çalışmasında silindir numunesinde Al elementi tespit edilmiş, bunun nedeni Al elementinin piston malzemesindeki sürtünme olayı sırasında silindir yüzeyine taşınmasıdır.

Anahtar Kelimeler: silindir, aşınma, yağlama, fındık yağı

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1 Introduction

The production and development of biodiesel is still one of the most studied subjects in the world. Studies on this subject have been advanced and there are detailed studies in the literature. Studies are concentrated on low emission and renewable fuels and motor oils [1, 2, 3]. Hand tools make our daily life better, easier and faster and continue to enter in every area. Day by day this kind of hand tools (paint machine, lawn mower, brooms, etc.) have become an essential part of our life. Those kinds of machines work generally with being driven by an internal combustion engine or an electric motor. The properties of compactness and lightweight of the hand tools especially for carrying make them preferable. Internal combustion engines convert chemical energy into motion energy by using petroleum and its derivatives in the cylinder. The kinetic energy obtained in this way gives movement to the hand tools. Being compact and lightweight gives superiority to them. For those reasons, low-power 2-stroke engines are very good and preferable in between hand tools [4]. Research on two-stroke engines, is less than on four-stroke ones. However, research on low-polluting, low-emission, renewable and economical motor oils has gained great importance in recent years. Two-stroke engines consume less fuel than 4-stroke engines. The environmental and emissions performance 2-stroke engines are becoming a real problem because of the difficulty of complying to the emissions regulations. 2-Stroke engines provide very good fuel economy than 4-stroke ones [5]. Lubricating in two-stroke engines can be in the form of mixing the fuel with the lubricant, or it can be in the form of pumping the lubricant into the cylinder in a separate tank. In both cases, the lubricant burns with the fuel. For this reason, it is desired that the lubricant has many important properties such as fulfilling its lubricating task at high temperatures and not leaving any residue after combustion (soot, etc.), not causing toxic emissions. Since two-stroke engines are more polluting than four-stroke engines due to the combustion of the lubricant with the fuel, the development of environmentally friendly lubricants is of great importance. Automobile engines consist of thousands of parts and hundreds of them have surface friction contact, so lubrication is vital. The frictions between bearings, pistons, transmissions, clutch and differential boxes and other moving elements increase the importance of lubrication.

Y.C.Tan and Z.M.Ripin, have obtained the frictional behavior of piston rings in 2-stroke engines. In their study the cylinder surface is cut from the outlet and from the inlet sections for discharge and suction. That was causes discontinuous and secondary vibrations in the piston movement and more vibrations in the engine when they compared with the 4-stroke. Since the piston rings constitute around 30-50% of the friction in the engine, their lubrication becomes vital. As it is known, the lubrication of the ring cylinder surface can be in three ways depending on the amount of lubricant. This shape, where the lubricant is high (hydrodynamic lubrication), is especially in the middle of the piston and the lubricant covers the entire cylinder surface. In mixed lubrication (the lubricant is more in some parts and less in some parts), it is the situation that occurs near the dead points where the lubricator has lubricated some parts of the ring adequately and insufficiently lubricated in some parts, and the speed of the piston slows down. Poor lubrication (limit lubrication) is the situation where the amount of lubricant is reduced to a minimum on the surface of the ring and is insufficient and pushed down from the surface due to high pressure [5].

In their article, Jayadas et al. have researched one of the environmentally friendly lubricants properties of coconut oil. They said that, 2-stroke scooters were mixed the fuel with lubrication. The users said that lower emissions obtained and better acceleration and fuel economy were achieved, in some part of India. They reported that coconut oil, as the same with other vegetable oils, has good lubricating properties, high viscosity index, low evaporation loss and high flash point. However, at low temperatures they said that performance was poorly, however they have very high lubricating properties as the same with other vegetable oils. Vegetable oils contains fatty acids which make them better. In their experiments for coconut oil, they added additives (ZDDP to prevent wear and increase high pressure resistance) to further improve its lubricating properties. Then, according to ASTM standards, four ball testers and tribological tests were performed three times each. In the tests they made on 2-stroke engine, it was used an air-cooled engine of a scooter. At first, they used commercial oil and after that coconut oil were used in the air-cooled scooter engine. Before tests the cylinders were measured of an accuracy of 4 microns. After the tests the measurement was repeated to see the effects on the cylinders [6]. It was found that in the use of coconut oil after 1.000, 5.000 and 10.000 km tests, the cylinder loses its circularity a little and became oval, however it wasn't too different when compared with commercial oil properties. They found that, if ZDDP and anti-wear additives were added into the high-pressure resistance, the situation is better improved and the ovality is reduced [6]. By this way coconut oil would compete with commercial oils. They said using additives could not be recommended.

Kultarni et al., in their article on canola oil, investigated the mixing of canola oil with methanol and ethanol and the use of ester as a lubricant in the transesterification of canola oil. They carried out the transesterification of canola oil in methanol, ethanol and methanol-ethanol mixtures in different ratios by keeping the alcohol-oil ratios of 1 to 6. They explained that alcohol mixture increases the rate of transesterification and increases the formation of methyl ethyl esters. They explained that the reason for this increase was well mixed and that the ratio of ethyl ester to 3 to 3 molar ethanol was around 50% of methyl ester. They explained that the acid values, viscosity and densities of all esters examined, including the mixed ones, are in accordance with ASTM standards and the lubricating properties of these esters are in the form of ethyl ester > methyl ethyl ester > methyl ester [7, 8].

2 Material and Methods

In this study, by using different lubricating oils the tribological functions of a single-cylinder 2-stroke gasoline engines were investigated. for every selected oil under a certain load, the engine used was operated for 100 hours for the experiments in the study. Mineral and hazelnut oils were used to lubricate the test engine as lubricating oil. Mineral and hazelnut oils were used and were run separately in the test engine. After the experiments, the engine was disassembled, the rings, cylinder, and piston were taken. At the end of each study they were examined, and the resulting wears were compared. Because of the determining the wear, samples were prepared and also EDS analyses were done. These studies were continued on the simulation test device, after the studies of the test engine. The simulation tester was produced for this study. The wear of the cylinder was examined in the simulation test device, as done before in the test engine. Canola oil, hazelnut oil, hazelnut oil ester and mineral oil were used to lubricate the simulation test device as lubricating oil. The cylinder used to investigate wear on its surface in this device, the surface is coated with CrN. The surfaces of the cylinder were coated approximately 2 μm with a thickness of by the method called PVD (physical vapor deposition). The coated cylinder surfaces in the simulation test device were run differently with the specified oils. Their wear degrees of the specified oils were determined and compared. For each sample to determine the wear specified balances were applicate.

The test engine used in experimental studies is a two-stroke single-cylinder gasoline engine. There is a water engine coupled to the engine. The gasoline engine is loaded with water by a water pump. The gasoline engine has a volume of 98.2 cc and a power of 3.4 HP. The water inlet/outlet pipe diameter of the water pump is 2 inches, the water suction depth is 7.5 meters vertically, and the delivery head is 40 meters. The total weight of the motor pump is 14.2 kg. A water tank was produced in order to operate the water engine used in the experimental studies under load. This two-stroke engine takes the water in the tank and presses it into the same tank from the top. In this way, the water engine can be operated under load.

3 Results and Discussion

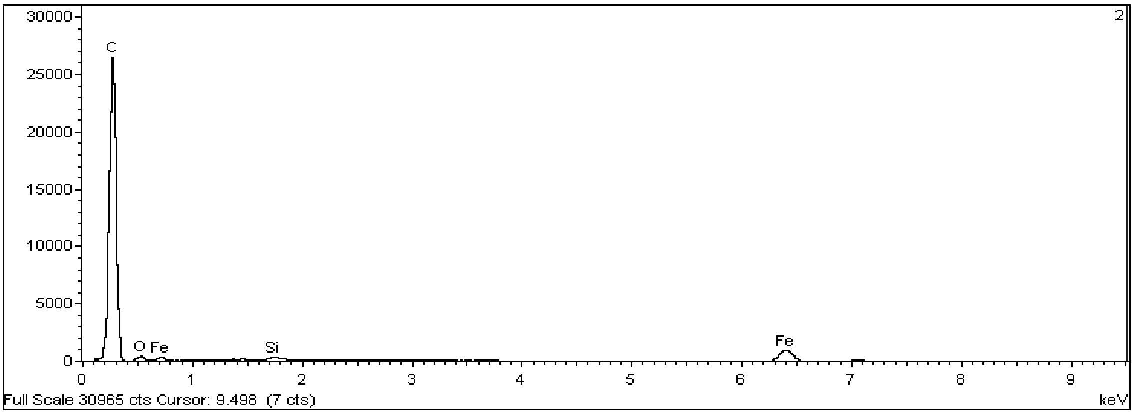
EDS (Energy Dispersive Spectrograpy) determines the point analysis of the microstructure on the cylinder surface. In this study, for the same regions of the cylinder samples taken after different studies of the test engine EDS analyzes were made. These analysis results were investigated and compared with each other. In the test engine were made, EDS analyzes of the cylinder samples taken as a result of the studies carried out with hazelnut and mineral oils. EDS was made to reveal point analyzes of cylinder samples. Figure 1 and Figure 2 give the EDS analyzes of the samples which were taken from the regions close to the TDC of the cylinder.

Figure 1 and Figure 2 give as a result of the studies carried out with hazelnut and mineral oils of the analysis of the samples taken, respectively. in Figure 1 the content according to EDS results were determined as 4.00% O, 83.52% C, 12.20% Fe, and 0.28% Si. It is can be seen that in Figure 2, 56.95% C, 15.82% O, 0.53% Si., 26.31% Fe, and 0.39% Mn, were determined inside of the sample. When both samples' contents are compared, we can see differences in the

content ratios of the elements of Fe and C. As a result of the study performed with hazelnut oil, in fact, the C content of the sample increases when we compared to the study performed with the mineral oil. When the mixture of gasoline and hazelnut oils were used in the test engine, extreme temperature and pressure obtained as a result of the combustion which increase the effect of the friction. The reason of this results are extreme temperatures and pressures. The piston expands because of the extreme temperature, as an effect of that expansion, the creep on the cylinder surface increases. Considering that the oil film on the cylinder surface is also deteriorated, material transport may occur in this region with the effect of friction. C and Fe content may vary in some areas of the cylinder surface due to material transport.

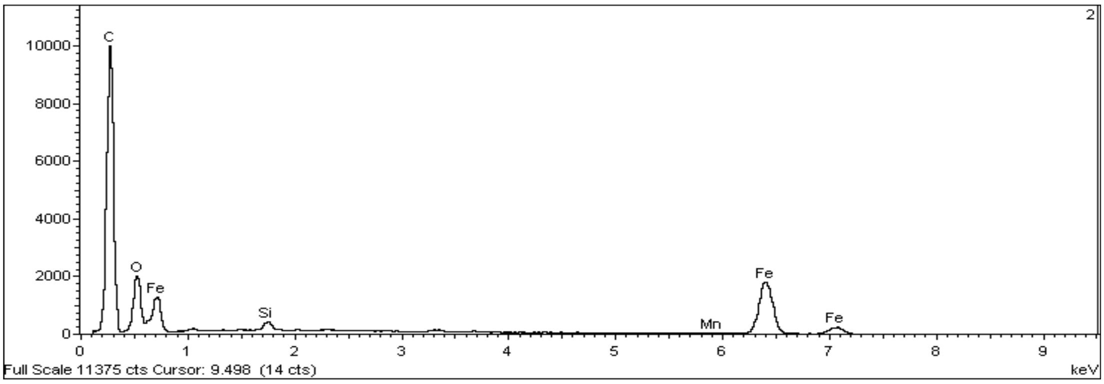
Figure 3 shows the EDS analysis of the sample taken as a result of the study with hazelnut oil. According to these analysis results, the elemental content of the sample was determined as 42.4% C, 19.1% O, 0.2% Al, 1% Si, 0.5% Mn and 36.8% Fe. Figure 4 shows the EDS analysis of the study with mineral oil. Elementary content of the sample in these analysis results was determined as 43.7% C, 16.5% O, 0.8% Si, 0.5% Mn and 38.5% Fe. The samples analyzed in Figure 3 and Figure 4 were taken from the regions close to the TDC of the cylinder. When these two samples were compared, 0.21% Al was found in the content of the cylinder sample working with hazelnut oil. The presence of the Al element can be explained as a material transfer caused by friction. This material transfer is in the form of the transport of the Al element in the piston material to the cylinder surface during the friction event. When the C and Fe contents of both samples are compared, it is seen that the contents of these elements do not change much. The most important difference between these two samples is the Al transfer.

As one of the results of the studies made with hazelnut and mineral oils, respectively, in Figure 5 and Figure 6 can be seen the EDS analyses of the samples which are taken from the middle zone of the cylinder. In Figure 5, the content of the sample is 5.2% O, 42.7% C, 0.8% Si and 51.3% Fe. As can be seen in Figure 6 the contents of the sample are determined as 0.8% Mn, 1.8% Si, 17.4% C, 6.0% O, and 74% Fe. If we compare the results in the study with hazelnut oil of both analyses, it can be seen that the amount of C increased and the amount of Fe decreased. In element C the increase can be seen as a result of the wear phenomenon. It can be thought that graphite is transported from the cylinder surface during the friction phenomenon on the piston ring and cylinder surface.



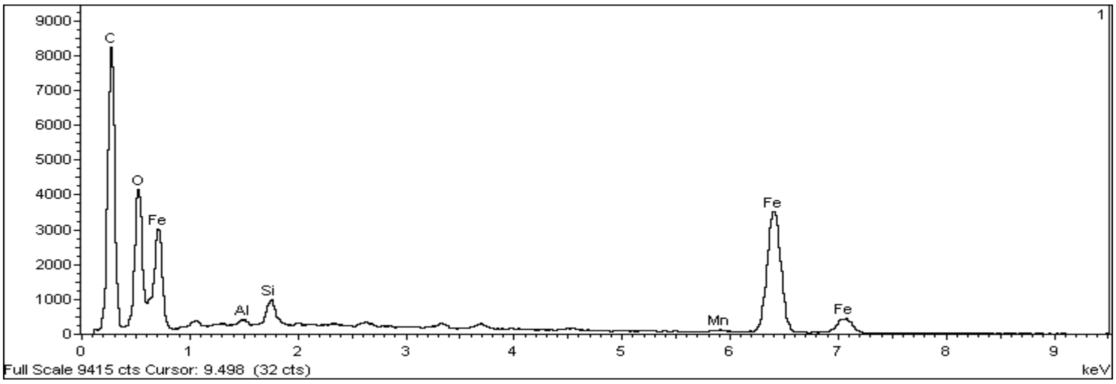
Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	1.5009	83.52	0.21	93.56
O K	0.5008	4.00	0.16	3.36
Fe K	0.763	12.2	0.16	2.94
Si K	0.983	0.28	0.02	0.13
TOTAL		100.00		

Figure 1. EDS analysis of sample no. 2 close to TDC of the cylinder in the study with hazelnut oil



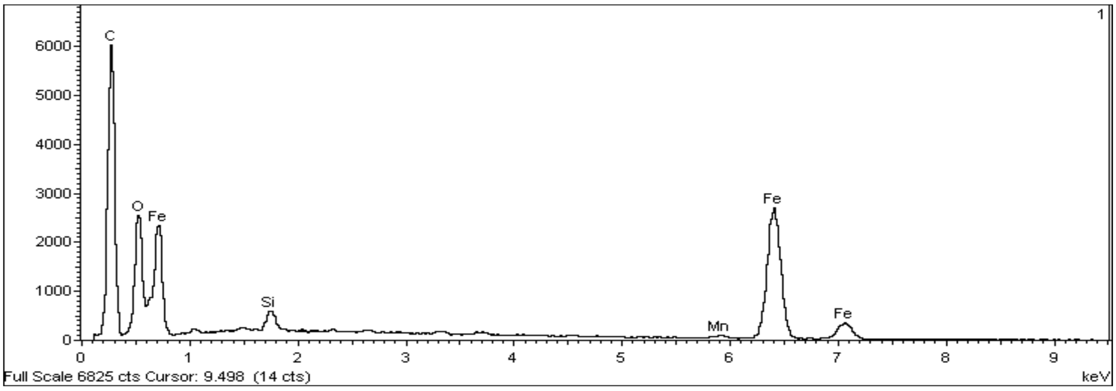
Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	1.0445	56.95	0.28	76.14
O K	0.7356	15.82	0.24	15.88
Si K	0.933	0.51	0.03	0.30
Fe K	0.8018	26.30	0.23	7.57
Mn K	0.792	0.39	0.07	0.11
TOTAL		100.00		

Figure 2. EDS analysis of sample no. 2 close to TDC of the cylinder in the study with mineral oil



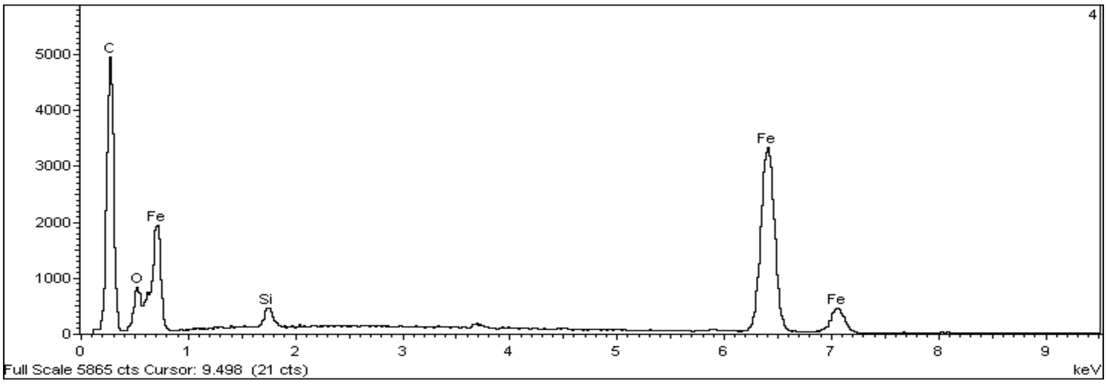
Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	0.8556	42.4	0.24	64.94
O K	0.92	19.1	0.21	21.98
Mn K	0.819	0.5	0.07	0.16
Si K	0.905	1	0.03	0.64
Fe K	0.830	36.8	0.22	12.13
Al K	0.83	0.2	0.03	0.14
TOTAL		100.00		

Figure 3. EDS analysis of sample no. 1 close to TDC of the cylinder in the study with hazelnut oil



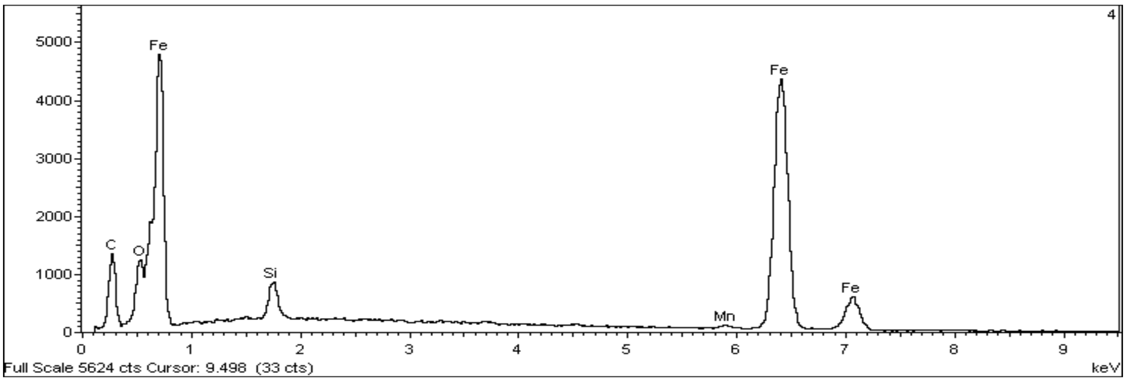
Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	0.8588	43.7	0.29	67.38
Mn K	0.8215	0.5	0.08	0.19
O K	0.9026	16.5	0.24	19.06
Fe K	0.8332	38.5	0.27	12.81
Si K	0.9046	0.8	0.04	0.56
TOTAL		100.00		

Figure 4. EDS analysis of sample no. 1 close to TDC of the cylinder in the study with mineral oil



Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	0.7809	42.7	0.29	73.57
Fe K	0.8596	51.3	0.29	19.04
O K	0.9083	5.2	0.17	6.83
Si K	0.8890	0.8	0.04	0.56
TOTAL		100.00		

Figure 5. EDS analysis of the sample taken from the middle of the cylinder in the study with hazelnut oil



Element	Density Ratio	% Weight Ratio	% Sigma	% Atom Ratio
C K	0.598	17.4	0.32	45.13
Si K	0.846	1.8	0.06	1.92
O K	1.335	6	0.19	11.61
Fe K	0.926	74	0.35	40.89
Mn K	0.910	0.8	0.10	0.45
TOTAL		100.00		

Figure 6. EDS analysis of the sample taken from the middle part of the cylinder in the study with mineral oil

4 Conclusion

In this study, the tribological function of 2-stroke single-cylinder gasoline engine was researched by using different lubricating oils. Mineral and hazelnut oils are used to lubricate as lubricating oil. It is seen that there is more wear and more soot accumulation on the cylinder surface, when the 2-stroke test engine is run with a specified mixture of hazelnut and gasoline oils as lubricating oil. It is found and seen that, the hazelnut and mineral oil mixtures worsen the combustion. The reason oh the worsening of the combustion is the high cetane number of hazelnut oil. The high cetane number of the hazelnut oil cause knocking because of the increasing self-ignition in gasoline engines. In the study the cylinder samples EDS analyses are investigated. It is understood that there was a difference in the content ratios of the elements of C and Fe. In the study with hazelnut oil, the C content of the cylinder sample increased when we compared with the study with mineral oil one. It is found that the reason of this result is the graphite transport because of the effect of frictions. In these analyses Al element was detected in the cylinder sample as the results of the hazelnut oil studies. It found and obtained that the reason of Al element is during the friction, the transport of the Al element from the piston material to the cylinder surface. It has been obtained that without any changes, inclusion of hazelnut or mixing hazelnut and mineral oils in gasoline in 2-stroke engines as lubricating oils doesn’t give good results in terms of wear and/or emissions.

Ethics in Publishing

There are no ethical issues regarding the publication of this study.

Author Contributions

KEVEN, A.: conceived and designed the study, scanned the literature, collected the material, implemented the method and wrote the study, determined and interpreted the results.

KARAALİ, R.: scanned the literature, organized the study, analyzed and interpreted the study, evaluated and interpreted the result.

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