THE EFFECTS OF ALCOHOL ADDITION TO FUEL ON PISTON WEAR IN A TWO-STROKE ENGINE

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ABSTRACT

In this study, the effects of 20% methanol (BM20) and ethanol (BE20) addition to the fuel of a motor scythe with a two-stroke gasoline engine, which is also used as a hand tool, were examined. The effects of adding alcohol to gasoline on fuel consumption value, the amount of deluge release on the piston, piston overflows and exhaust emissions were investigated. The motor scythe was operated for 50 hours and 100 hours to investigate the amount of wear. With the addition of methanol and ethanol, it was determined that the fuel consumption value and wear increased and the amount of hallucinations decreased compared to gasoline. In terms of emission values, reduction in CO and HC emissions with alcohol use, reduction in CO_2 emissions with BM20 fuel mixture, increase with BE20 fuel mixture was determined.

Keywords: Two-stroke engine, Alcohol, Wear, Exhaust Emission

1. INTRODUCTION

Energy is defined as the ability of machines to work. The machines use solid, liquid and gas fuels as a source of energy when doing business. In the world, such fuels are of petroleum origin. Therefore, the search for fuels that can be an alternative to oil is increasing. At the beginning of this field, publications on a wide range of biological origin fuels that have the potential to be used or used in internal combustion engines are increasing. In addition, the search for fuel that can be produced with its own resources continues in countries that cannot produce oil themselves and that receive oil from outside. At this stage, studies focus on both domestic and environmental fuels [1].

However, the studies are generally tested on four-stroke engines with large cylinder volume considering the size of their usage areas. However, many hand tools we use in daily life (generator, hoeing machine, watering machine, lawn machine, spraying machine, etc.) are also used in internal combustion engines [2]. Such hand tools are often used in many workplaces and factories. Since this type of hand tools need to be carried continuously, motors with small engine volumes are used. Gasoline or diesel options are available for sale in these household vehicles used in the fuels used in vehicles. An internal combustion engine works by providing thrust with its piston under the fuel burned area. After the combustion of the fuel burned in the cylinder is created by the thrust force movement energy is transferred to the hand tool. Internal combustion engines are called two-stroke or four-stroke according to the operating conditions. Two-stroke engines, which are usually compact and light engines, are preferred because hand-held instruments need to be carried continuously. The two-stroke engines used in hand-held instruments do not have an extra lubrication system and the lubrication oil involved in the fuel is used to lubricate the segments. In the lubrication process, 2T oils, which are generally included in the fuel at a rate of 1:50, are mixed. These oils can sometimes cause adhesion during the long running of the engine. Adhesion, which is the simplest type of wear, damages the parts that are formed and rubbed by the friction of iron with iron. In internal combustion engines, friction of the ring with the shirt or friction of the piston with the cylinder liners can damage the piston and the piston rings. In this case, the running engines can become inoperable by decreasing power over time [3]. Alcohols can be produced from vegetable sources. In general, they come to the fore as the most used alternative fuel in vehicles. Today, up to 15% of the gasoline in many countries participating in the samples is available [4].

It has been reported that the high octane number of alcohols causes improvements in the operation of the engine, and even increases in engine power by increasing the compression ratio [5, 6]. Many studies with the addition of alcohol into gasoline indicate that there are no negative effects in terms of engine performance until a certain amount of use [7]. Studies also show that some improvements have occurred in the addition of alcohol to gasoline in terms of emissions [8].

Zulfattah et al. [9], studied the effects of spark plug nails on emissions in a two-stroke single-cylinder engine and the additional biological oils they add to the fuel. They examined the emission parameters by operating the experiment engine in idling, medium throttle position and full throttle position to see the effects. They reported that emissions changed as the number of quotes increased.

Raviteja, et al. [10], studied the engine effects of nitromethane, an alcohol type, as a fuel additive in an unmanned aerial vehicle with a two-stroke engine, such as thrust, rpm, torque, power, brake specific fuel consumption and brake thermal efficiency, and compared it with the results of methanol addition. Their data showed that with the addition of nitromethane compared to methanol fuel, an increase of approximately 24% in engine propulsion was observed at mixture rates of 40% by mass.

This study was carried out on a two-stroke single-cylinder 3 hp gasoline engine with a lawn mower. These engines do not have a lubrication system, oil is mixed directly into gasoline or diesel fuel and lubrication is carried out. In this study, the effect of adding 20% ethanol and methanol to gasoline by volume on piston and piston ring overshoot and fuel consumption values and emissions was examined. The engine was operated under 50-hour and 100-hour conditions in a full throttle position with each fuel mixture for wear and tear experiments.

2. MATERIAL AND METHOD

A single-cylinder, two-stroke gasoline engine grass scythe was used in this study. Some technical specifications of the machine are given in Table 1. The motor scythe machine used is shown in Figure 1. Methanol and ethanol used in experiments are 99.6% pure. The properties of the experimental fuels are given in Tables 2 and 3.

Table 1. Technical Specifications of Motor Scythe [11].

STHIL FS460	
Cylinder Volume	45.60 cm^3
Engine Power	3 HP
Total Weight	8.5 kg
Fuel Capacity	0.75 lt

Table 2. Characteristic of engine oil [12].

FULLTRAC 2T	
Kinematic Viscosity	42.3 mm^2/s
Density	0.873 g/m^3
Flash Point	180 (°C)
Pour Point	-12 (°C)

Table 3. Properties of fuels use [4, 13,14].

	Gasoline	**Methanol**	**Ethanol**
Chemical Formula	C_5H_{10}-$C_{12}H_{26}$	CH_3OH	C_2H_5OH
Density (g/m^3)	0.732-0.755	0.796	0.788
Flash Point (°C)	-45 - -13	-40 - -21	12 - 20
Thermal Value (Mj/kg)	44.3	20.11	26.9
Octane Number	95	108.7	108.6
Kinematic Viscosity (mm^2/s)	0.37-0.44	0.59	1.19

The manufacturer recommends adding 1:50 lubricating oil to the gasoline for this product (STHIL 2019b). Primarily gasoline and alcohol mixtures have been created for fuel mixtures. Ethanol and methanol are added to gasoline by 20% by volume. By adding 1:50 oil to this mixture, the fuels to be used in the experiments were prepared. The fuels were prepared on a daily basis and the duration of operation was recorded with a stopwatch and the total working time was determined. In order to measure the fuel consumption value, the depletion time of a tank of fuel was measured with the help of a stopwatch.

Figure 1. The appearance of the motor scythe.

Before the use of each fuel mixture, the engine's piston and piston ring set was refurbished. All pistons and ring sets are used in domestic production of Episan branded products. Fitted and dismantled engine piston and piston ring sets are shown in Figure 2. After the specified usage times, the engine piston and piston ring set were removed and weighed on a scale with a sensitivity of 0.0000, which was sediment and cleaned from the deposits. Experiments have been repeated for all fuel mixtures. The resulting mixtures are expressed in the charts as B100 (100% gasoline) BE20 (80% gasoline+20% ethanol) and BM20 (80% gasoline+20% methanol).

(a) (b)

Figure 2. Dismantled (a) and Fitted (b) pistons and segments.

Figure 3. Adhesive exposed piston.

Emission measurements were carried out with BOSH BEA350 brand emission device. During the experiments, CO, CO_2 and HC emissions were measured separately with gasoline and other fuel mixtures in the full throttle position of the engine. The device used is sensitive to measurement for CO emission (0.001%), CO2 emission (0.01%), HC emission (1 ppm). All measurements were carried out in accordance with the standards numbered TSE13231.

3. RESULTS AND DISCUSSIONS

Figure 4 shows the effect of alcohol addition on fuel consumption. The fuel consumption value may vary depending on the idling condition or full throttle condition of the engine. Therefore, the fuel consumption value was measured by operating the engine in full throttle position. By bringing the throttle button to full throttle, the 0.75 liter tank was finished and the measurement was made with the stopwatch during this time. Fuel consumption value is directly proportional to the thermal value of fuels [15]. Studies report that low heat value fuels should be consumed more. The results of the experiment were similar to many previous studies in the literature [16].

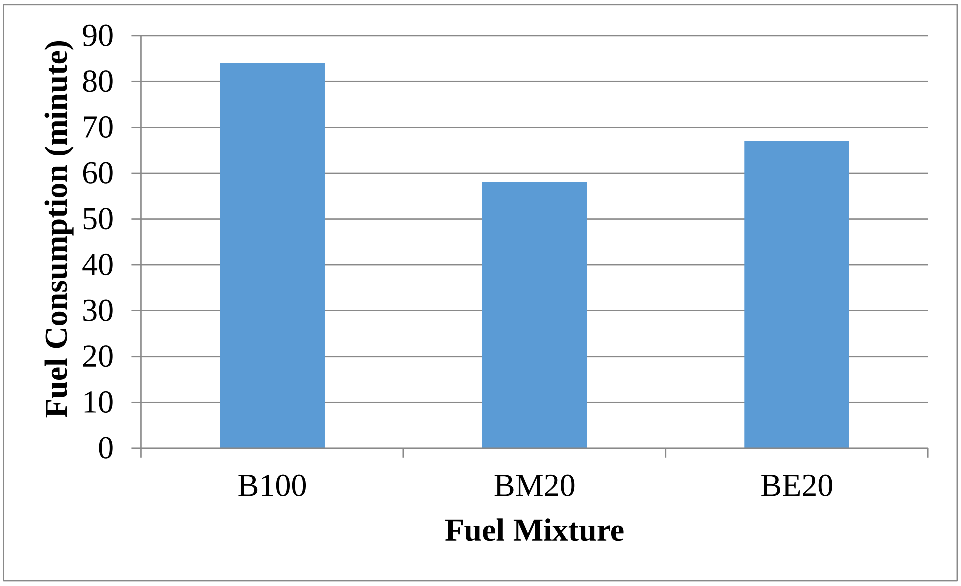

Figure 4. Consumption time of a tank (0.75 lt) fuel mixture.

Figure 5 shows the total amount of delusion in the piston and piston rings after 50 and 100 hours of use. The longer the engine's operating time, the higher the amount of delusion in the piston and piston rings. With the addition of alcohol into gasoline, the amount of delusion was reduced. This condition is thought to be caused by the decrease in total carbon (C) amount in the fuel mixture with alcohols added to the gasoline [17]. In addition, alcohols reduce the viscosity of fuels and cause the oil in gasoline to dissolve. In this case it may have reduced the amount of delusion.

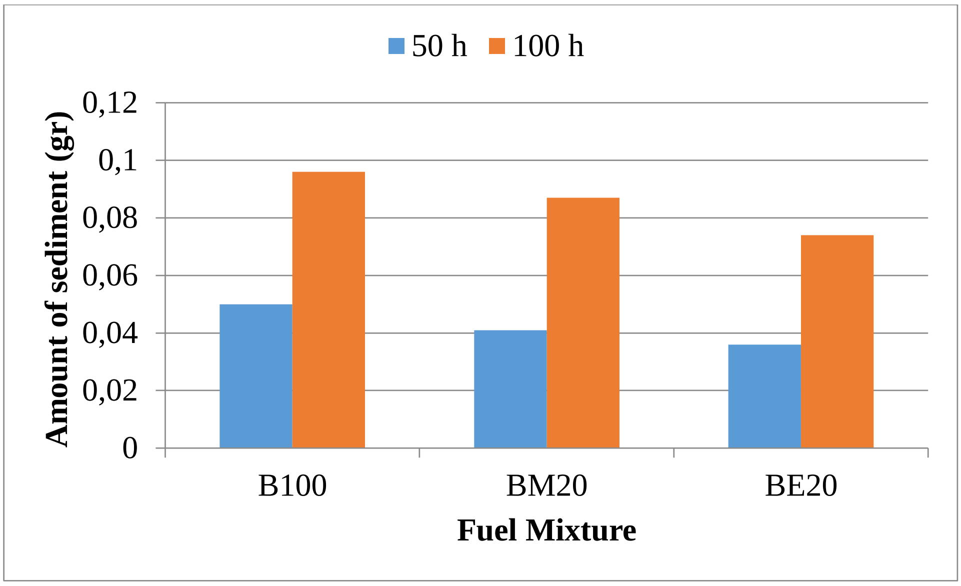

Figure 5. Change in the amount of the total exchange rate.

After 50 hours and 100 hours of use of the engine, the change of the piston and piston rings, which are cleaned from the institutions and weighed according to the first situation, is given in Figure 6. It is observed that the amount of overshoot increases with the increase in usage time. As it is known, the pistons work based on the cylinder liners during operation. Therefore, it is expected that there will be wear at the points where lubrication weakens. There has been an increase in the amount of excess with the addition of alcohol [18]. This can be explained by the reduction in viscosity of fuels. The reduced viscosity value prevents lubrication from taking place in full terms. Therefore, alcohol use increases friction compared to gasoline.

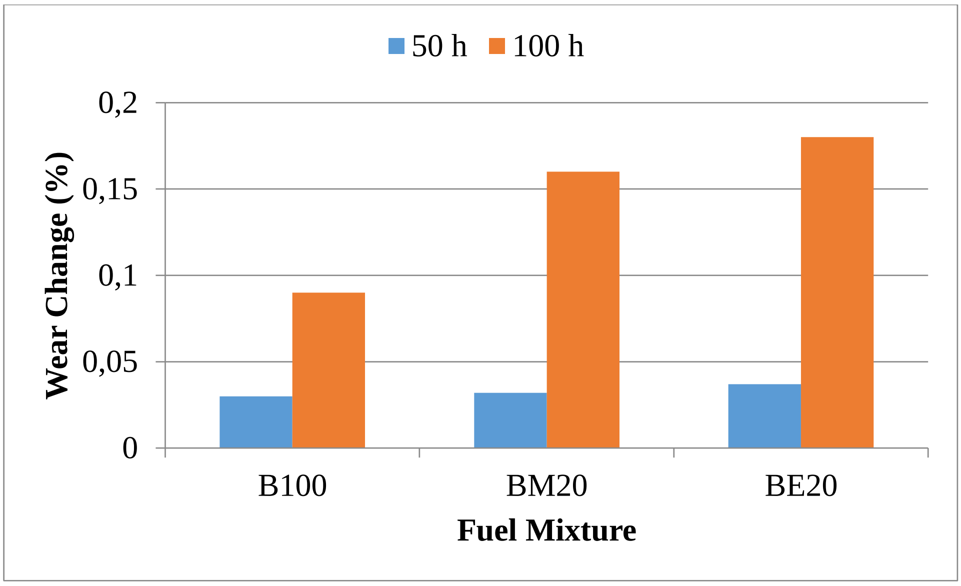

Figure 6. Total erosion diversity.

In Figure 7, the effects of methanol and ethanol addition to gasoline in full throttle position on carbon monoxide (CO) emissions are given. With the addition of methanol and ethanol into gasoline, CO emissions decrease. It is possible to explain this situation by decreasing the total number of carbon (C) atoms in the fuel. In addition, it is thought that the high thermal value of ethanol is an advantage and that CO emissions are reduced more than methanol by providing better combustion than methanol [19]. Measured at 4.5% with B100 fuel, CO emissions fall to 4.3% with BM20 fuel mix and 4% with BE20 fuel mix.

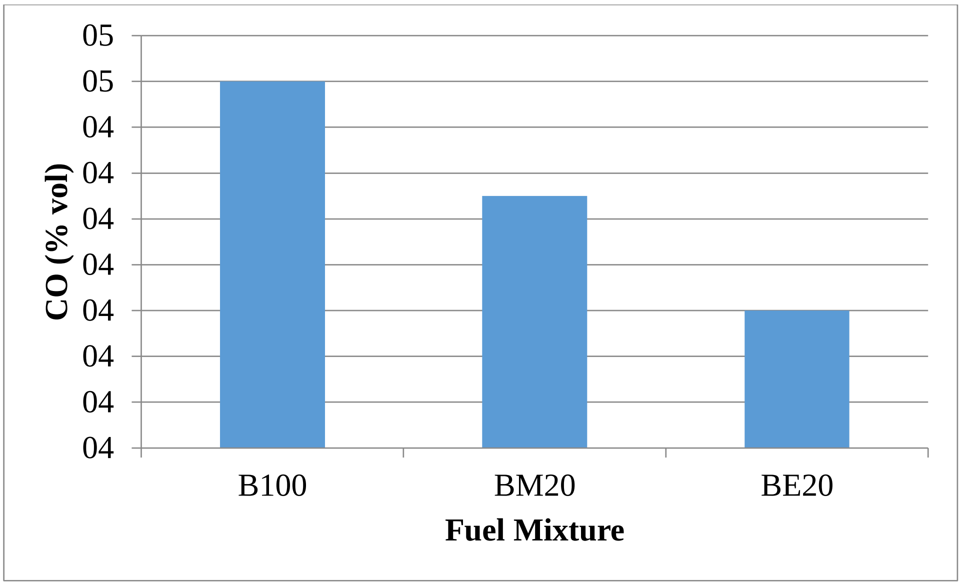

Figure 7. Effect of alcohol addition on CO emissions.

Figure 8 shows the effects of methanol and ethanol addition to gasoline on carbon dioxide (CO_2) emissions at full throttle position. CO_2 emissions are reduced with BM20 fuel while CO emissions are reduced with BE20 fuel. CO_2 emissions occur as a result of the full combustion of the fuels in the cylinder by mixing with the air. In addition, it is mentioned in many studies that the oxygen content in alcohols partially improves combustion and leads to increased CO_2 emissions [20]. Therefore, due to the oxygen-rich content of BM20 fuel, CO_2 emissions can be said to be reduced. On the other hand, the fact that the BE20 fuel mixture is extremely low in thermal value increases CO_2 emissions. CO2 emissions measured at 3% with the B100 fuel mixture were achieved at 2.6% with the BM20 fuel mixture and 4% with the BE20 fuel mixture.

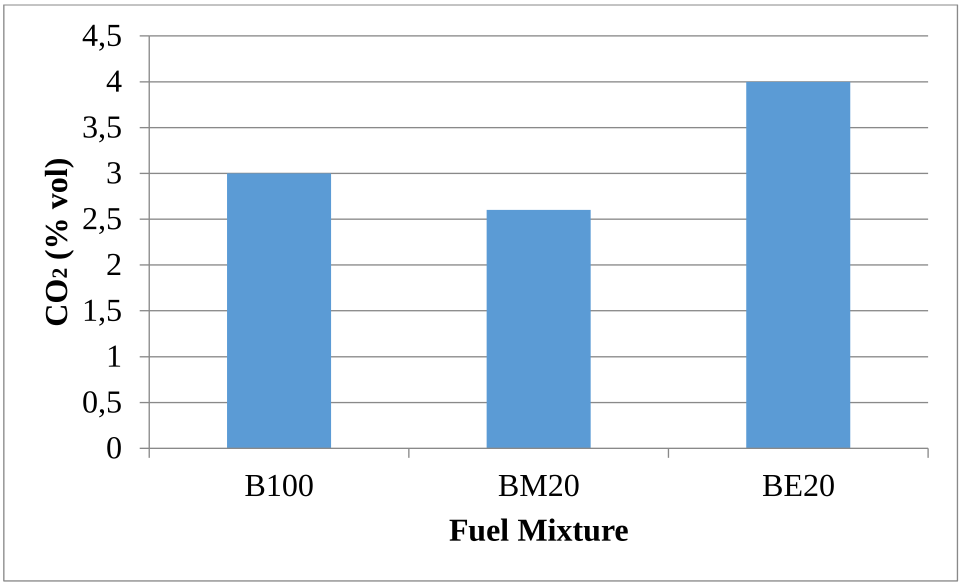

Figure 8. Effect of alcohol addition on CO_2 emissions.

Figure 9 shows the effects of methanol and ethanol addition to gasoline on hydrocarbon (HC) emissions at full throttle position. Hydrocarbon emissions are caused by the disposal of partially unburned fuels in the cylinder from the exhaust [21]. With the addition of alcohol into gasoline, it is observed that there is a decrease in HC emissions. This condition is thought to occur as a result of the oxygen-rich content of alcohols partially improving combustion. The HC emission value obtained from 6985 ppm with the B100 fuel mixture decreased to 6551 ppm with the BM20 fuel mixture and 6367 ppm with the BE20 fuel mixture.

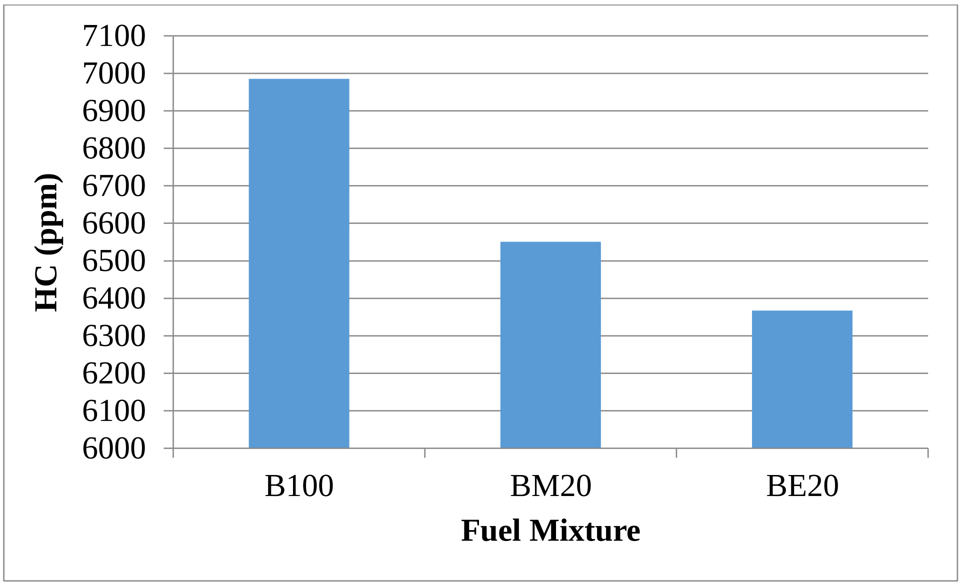

Figure 9. Effect of alcohol addition on HC emissions.

The study also shows that a better performance is achieved when compared to gasoline in the first-run situation. This is due to the fact that the evaporation temperatures of alcohols are lower than that of gasoline. This feature of the fuels is an important advantage in these vehicles, where the first ignition is achieved by hand shot.

4. CONCLUSIONS

In this study, the effects of adding alcohol in a two-stroke engine used in hand tools were examined. The results obtained shows that;

- It can be operated by adding 20% alcohol by volume on a hand tool with a two-stroke engine.
- With the addition of alcohol, there are setbacks in lubrication and the amount of wear increases.
- There is a decrease in the amount of hallucinations produced by the engine.
- Improved emission values are observed.
- By taking advantage of the emissions improvement properties of alcohols, trials may be increased with fuels that are high in heat value.

REFERENCES

[1] Bayraç NH, Çelikay F, Çildir M. Küreselleşme Sürecinde Sürdürülebilir Enerji Politikaları. Ekin Publishing, Bursa 2018.

[2] MAPAS. Operation and maintenance conditions of two-stroke engines. http://mapas.com.tr/blog/2-zamanli-benzinli-motor-calistirma-ve-bakimi/304, (Access History: 26.06. 2019).

[3] Kaleli H. Wear, lubrication and cooling in internal combustion engines. https://www.yeniatmaca.com/blogs/icten-yanmali-motorlarda-asinma-yaglama-ve-sogutma.pdf, (Access History: 26.06. 2019).

[4] Onurbaşavcıoğlu A, Atasoy ZD, Türker U, Koçtürk D. Tarımsal Kökenli Yenilebilir Enerjiler: Biyoyakıtlar. Nobel Publishing, Ankara, 2013.

[5] Balki MK, Sayın C, Çanakcı M. Experimental Investigation of the effect of different Alcohol fuels on the performance, emission and combustion characteristics of a spark plug-fired engine. 12. International Combustion Symposium, (ICS 2012), June pp. 228-234.

[6] Thakur AK, Kaviti AK, Mehra R, Mer KKS. Progress in performance analysis of ethanol-gasoline blend on SI engine, Renewable and Sustainable Energy Reviews 2017; 69:324-340.

[7] Wua X, Daniel R, Tianb G, Xub H, Huanga Z, Richardson D. Dual-injection: The Flexible, Bi-Fuel Concept for Spark-Ignition Engines Fuelled with Various Gasoline and Biofuel Blends. Applied Energy 2011; 88: 2305-2314.

[8] Yüksel T, Temizer İ, Can İ, Koca F. Effects of using heated bioethanol as a secondary fuel in a gasoline engine. Firat University Journal of Engineering Sciences 2019; 31: 67-77.

[9] Zulfattah ZM, Zulkifli NWM, Masjuki HH, Harith MH, Syahir AZ, Norain I, Jumaidin R, Yusoff MNAM, Azham A, Jamshaid M, Arslan A. Effect of bio-based lubricant towards emissions and engine breakdown due to spark plug fouling in a two-stroke engine. Journal Of Cleaner Production 2019; 221: 215-223.

[10] Raviteja S, Ramakrishna PA, Ramesh A, Performance Enhancement of a Small Two-Stroke Engine Using Nitromethane Blends. Journal of Propulsion and Power 2019; 35:1-10.

[11] STHİL. Features of Motor Scythe. https://www.sadal.com.tr/Product?productId=211, (Access History: 26.06.2019).

[12] OPET. Technical Properties of Lubricating Oil. http://www.opetfuchs.com.tr/urun/fulltrac-2t, (Access History: 26.06.2019).

[13] OPET. Engine fuel characteristics https://www.opet.com.tr/files/PDF/Urun/Ultra-Force-95-Oktan-urun-teknik-ozellikleri.pdf, (Access History: 26.06.2019).

[14] Özer S. Use of alcohols as alternative fuels in internal combustion engines. Journal Of Engineering And Architecture 2014; 19: 97-114.

[15] Çelik M, Solmaz H, Yücesu HS, Yılmaz E. Investigation of the effects of N-heptane contribution to canola methyl ester on engine performance and combustion characteristics. Journal of Thermal Science and Technology 2016;36:9-16.

[16] Geetesh G, Bhupendra S, Chauhan S, Kumar M, Amit D, Haeng MC. Effect of varying biogas mass flow rate on performance and emission characteristics of a diesel engine fuelled with blends of n-butanol and diesel. Journal of Thermal Analysis and Calorimetry 2019; 138:472, 1-14.

[17] Huang H, Teng W, Li Z, Liu Q, Wang Q, Pan M. Improvement of emission characteristics and maximum pressure rise rate of diesel engines fueled with n-butanol/PODE3–4/diesel blends at high injection pressure. Energy Convers Manag. 2017;152:45–56.

[18] Giakoumis EG, Rakopoulos CD, Dimaratos AM, Rakopoulas DC. Exhaust emission with ethanol or n-butanol diesel fuel blends during transient operation: a review. Renew Sustain Energy Rev. 2013;17:170–90.

[19] Akçay M, Özer S. Experimental investigation on performance and emission characteristics of a CI diesel engine fueled with fusel oil/diesel fuel blends, Energy Sources, Part A: Recovery, Utilization and Environmental Effects, https://doi.org/10.1080/15567036.2019.1689317, (2020).

[20] Yusoff MNAM, Zulkifli NWM, Masjuki HH, Harith MH, Syahir AZ, Kalam MA, Mansor MF, Azham A, Khuong LS. Performance and emission characteristics of a spark ignition engine fuelled with butanol isomer-gasoline blends. Transportation Research Part D: Transport and Environment, 2017; 57:23-38, https://doi.org/10.1016/j.trd.2017.09.004

[21] Lin CY, Li RJ. Engine performance and emission characteristics of marine fish-oil biodiesel produced from the discarded parts of marine fish. Fuel Processing Technology 2009; 90:883–888.