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Original Research Article

Investigation of tribological analysis of safflower oil and 15W40 engine lubrication oil and their blends

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ABSTRACT

In this study, 15W40 engine oil and Safflower oil were blended at 10% (A10), 20% (A20), 50% (A50) ratios. A total of 5 lubrication oil samples were obtained by adding the samples of pure safflower oil (A100) and lubrication oil with no safflower (A0). Viscosity and density tests of A100, A50, A20, A10 and A0 samples were carried out. Wear diameter test was performed on a four-ball testing machine to examine wear and friction properties, and welding load test was performed to examine extreme pressure properties.
We also had a study in the safflower oil industry where it can be used as an engine oil additive, especially in internal combustion engines. Since safflower oil is of vegetable origin, its use in engine oils will be environmentally friendly.
As a result of the examinations, it was determined that as the safflower ratio in the samples increased, the performance increased in terms of viscosity under cold working conditions. When the wear and friction performance was evaluated, it was concluded that there was an improving performance in 15W40 engine oil in A10, A20 and A50 samples in which safflower was used as an additive. When these samples were evaluated in terms of performance, there was little variation between them. For this reason, it is concluded that when Safflower is used as an additive in general, it exhibits positive performance in wear and friction performance. Considering that bio-lubricants are environmentally friendly, it can be said that the A50 sample is the most suitable lubrication oil among the samples, since it contains more vegetable oil than other samples.
As a result of this study, it is seen that the use of Safflower oil as an additive in engine oil is a positive result in terms of improving and clean environment.

Keywords: Bio-lubricant, Friction, Lubrication oil, Safflower, Wear.

1. Introduction

The ever-growing industrialization, modernization and development have increased the demand for energy, and such increases in energy consumption are often associated with fossil fuels. More petroleum-based products, including fuels and lubricants, are needed to meet the high energy demand. Some of the lubricants that are petroleum-based and harmful to the environment return to the environment. This is a matter of concern as most petroleum-based lubricants are toxic and non-renewable. Various studies are being performed to slow these imminent threats, including the development of green energy systems and the use of renewable resources as a potential alternative to mineral-based products [1]. Many bio-oil studies have been and continue to be carried out to prevent these concerns in terms of easy degradability and renewability in lubrication oils.

Since the beginning of the twentieth century, researches on the properties of bio-oils have attracted great attention because 50% of all lubricants worldwide end up in the environment through use, spillage, volatilization or improper disposal [2]. 95% of these lubricants entering the environment are derived from petroleum-based oils and are harmful to many biological ecosystems [3].

The term “bio-based lubricant” or “bio-lubricant” refers to all lubricants derived from bio-based raw materials, i.e. vegetable oils, animal fats or other hydrocarbons that do not harm the environment. In addition to being easily biodegradable and renewable, bio-based lubricants are known to have good lubricity [4]. Conventional environmentally friendly lubricants are typically derived from naturally occurring organic substances whose properties and benefits vary depending on biological factors such as nutrient availability, climate, light, temperature and water [5].

In this study, samples were obtained by blending 15W40 engine oil and Safflower oil. These samples were evaluated in terms of their physical properties such as viscosity and density using 15W40 engine oil as a reference. Welding loads and wear diameters values were obtained and analyses were made with the tests performed on four ball test machine.

1.1. Lubrication Oil in Internal Combustion Engines

Until the XIX. century, lubricants were manufactured using mainly, or even exclusively, vegetable and animal oils. When internal combustion engines appeared, these "classic" lubricants were gradually replaced by mineral oils. The main reason for this change is the stocking time of the new mineral oils and the stability in performance for both stocking and operation [6].

Internal combustion engines are widely used in many industrial sectors such as the marine industry, automotive industry and aerospace. In order for these power units to be used with full efficiency and to be long-lasting and strong, the lubrication system must also be strong. Engine oils used in internal combustion engines are an important factor affecting the engine's operating performance, engine efficiency and engine life. Therefore, the choice of engine oil is very important [7].

Friction is involved in a significant part of the physical events that occur in daily life. It is impossible to imagine a mechanical motion without friction, but friction has many advantages and disadvantages. Most of the energy losses during movement occur due to friction. In addition, the wear that occurs as a result of friction negatively affects the life of the machine and machine parts [8].

When it comes to fuel saving in internal combustion engines, friction losses are an obstacle. At the same time, minimizing friction losses in internal combustion engines is an objective. Approximately 4% to 18% of the energy generated by combustion of a standard vehicle is wasted as friction loss. Friction loss accounts for 6% to 25% of all engine losses [9]. It is possible that the share of friction losses in the total energy will increase to higher values in decisive stages such as the first movement. The energy usage areas resulting from combustion in internal combustion engines are shown in Figure 1. When the distribution of usage areas is examined, it is clear that mechanical friction provides a significant majority [9].

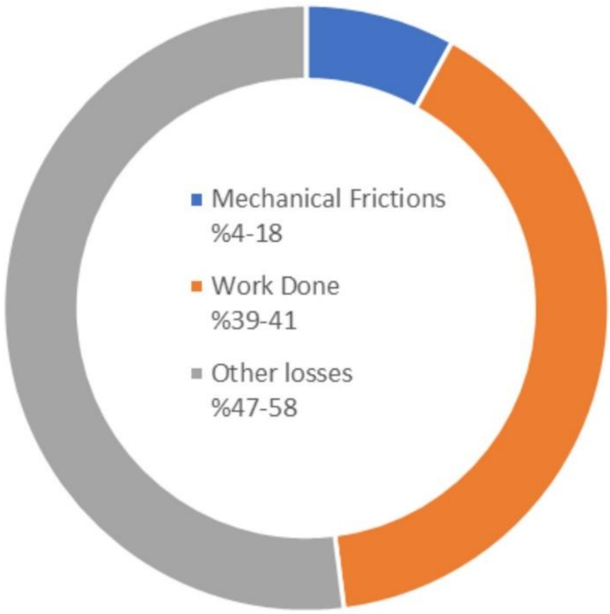

Fig. 1. Use of energy released as a result of combustion [9]

The distribution of mechanical friction according to the region where it occurs in the engine is shown in Figure 2. Considering this distribution, 40% to 50% of the friction losses in the engine occur in the pistons. Then, a significant portion of 20% to 30% occurs in crank bearings. 7% to 15% occurs during the operation of the valve mechanism and 20% to 25% occurs during the operation of auxiliary systems [9]. The goal of lubrication is to separate the surfaces that move relative to each other without damaging the surfaces. This process occurs with a thin film layer that can be easily separated from the surface. The process of engine oils is to form this film layer between moving surfaces. Engine oils prevent mechanical wear between metal surfaces with this film layer and reduce power loss [10].

Apart from lubricating the moving parts of the engine, engine oils have duties such as reducing mechanical friction losses and cooling the metal surfaces by melting the heat caused by friction in the moving parts. Its duties can also be considered to neutralize acids formed as a result of combustion and prevent sediment accumulation. The interface between the working part of the engine mechanism and the system is the area where friction and heat are transferred. For the efficient use of the energy resulting from combustion, it is important to create an oil film that can reduce friction to the maximum extent in a wide temperature range and provide the appropriate viscosity for the machine system in which the lubricant is used [10].

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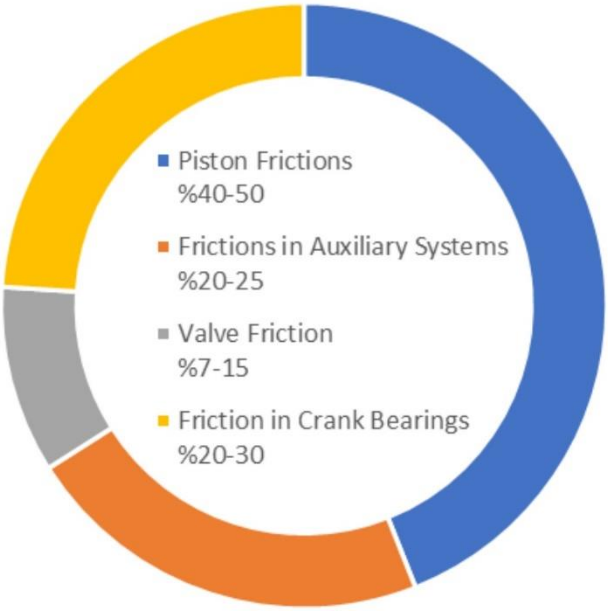

Fig. 2. Distributions of friction losses in engines [9]

The type of friction that occurs when the engine starts and stops is boundary lubrication. In the case of boundary lubrication, the two surfaces are in contact with each other, although there is a lubricant between the surfaces. Boundary lubrication is the type of lubrication with the greatest frictional effect. Mixed lubrication is the situation where two surfaces moving relative to each other continue to partially contact while being partially separated by an oil layer [11]. It can be said that valve mechanisms in internal combustion engines operate more predominantly in the boundary and mixed lubrication range [8].

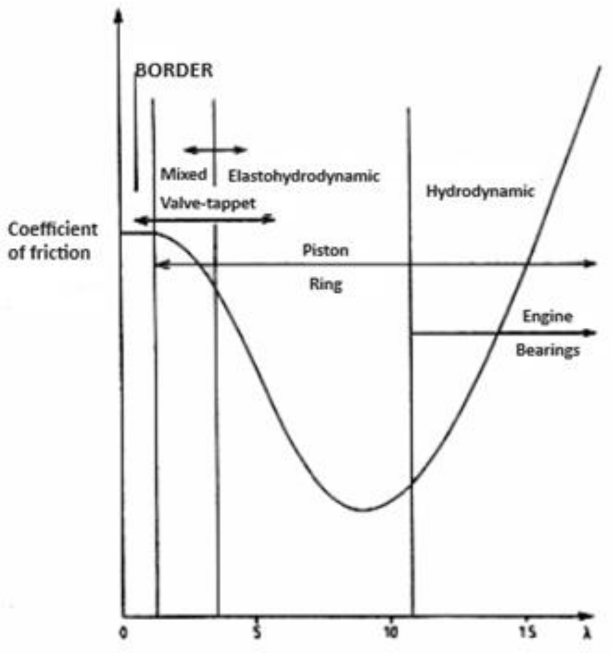

Fig. 3. Stribeck diagram showing lubrication regimes associated with lubricated engine parts [11]

A friction system, in which sufficient fluid film and pressure is formed between slippery surfaces or moving relative to each other, occurs in the hydrodynamic lubrication type. Resistance to movement occurs with the viscosity of the lubricant. Under hydrodynamic lubrication conditions, the coefficient of friction is extremely low (f= 0.001 - 0.005), so wear is theoretically zero [11]. Hydrodynamic lubrication type is seen in engine bearings in internal combustion engines. It can be said that piston rings work in all three lubrication types mentioned [8].

The main purpose of engine lubrication systems is to provide the lubrication flow rate and pressure required to keep friction within the limits of hydrodynamic lubrication and mixed lubrication [8].

1.2. Safflower

Vegetable oils are very good candidates for use as lubricants, these oils offer good lubricity, "weak viscosity-temperature dependence", high biodegradability, non-toxicity. The negative aspects of vegetable oils can also be improved by using some additives [12, 13].

Most of the natural vegetable oils can contain 12 different fatty acids in at least 4 ways [14]. They are commonly saturated (no double bonds), oleic (one double bond), linoleic (two double bonds), and linoleic (three double bonds) long carbon chain fatty acid components [15]. Polar fatty acid chains, also known as long carbon chains interacting with metallic surfaces, have a positive effect on the friction and anti-wear properties of the lubricant [14].

The tap root system of the safflower plant makes it an ideal crop for arid agricultural lands or areas with seasonal rainfall [16]. In many parts of the world, safflower oil is used as a cooking oil due to its higher linoleic acid content and characteristic nutty taste with a distinct pale yellow to golden color [17].

There is an increasing oil deficit in our country, the reason for this deficit is the increase in oil demand. In our country, the Agricultural Research Institute started Safflower studies [18]. The current major application of safflower oil is in the food industry due to its high levels of monounsaturated and polyunsaturated fatty acids. However, it can also be used as biodiesel alone or with other oils. There is some evidence for its use in combination with castor oil to produce a biodiesel, resulting in lower viscosity biodiesel [16].

Safflower contains medium to high oil content (23-36%), depending on the variety used. The functionality of oilseeds in industrial, pharmaceutical and food products depends on their fatty acid composition. The fatty acid composition of oils varies depending on plant species and growing conditions [16].

Khemchandani et al. (2014) evaluated the synergistic approach of phenolic and amine antioxidants in safflower oil

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in their study. Furthermore, to improve the oxidation properties of plant oil, they incorporated and examined synthetic esters (SEs) for thermo-oxidative stability using rotating pressure vessel oxidation test and differential scanning calorimetry. In addition to thermo-oxidative properties, tribological properties of pure base stocks were also studied. As a result, it was concluded that safflower oil has excellent lubricity properties, very high viscosity index and superior biodegradability properties, but is very poor in thermal oxidation properties [19].

In the study by Menesez et al. (2015), eight oils were selected to investigate the tribological performance of natural oils: avocado, canola (rapeseed), corn, olive, peanut, safflower, sesame and vegetable (soybean) oil. As a result of the experiments, it was shown that avocado oil has the best tribological properties with the lowest friction and wear compared to other natural oils. Natural oils with a high content of oleic acid have been proven to maintain low COF values and low wear rates. When the unsaturation number is high, the viscosity at room temperature is low, suggesting that oils containing higher amounts of monounsaturated acids have superior friction and wear properties [20].

2. Material and Method

2.1. Material

Considering the positive results such as reducing dependence on oil, clean environment and improving engine oil performances in line with the research conducted, the use of vegetable-based oils in engine oils is important. The triglyceride structure contained in vegetable oils provides the formation of an oil film that can withstand high pressure with its long and polar fatty acid chain. This film cuts the contact of metal surfaces and reduces friction and wear. This situation largely meets the performance expected from the lubricant under boundary lubrication conditions [21]. The polarity of fatty acids in vegetable oils enables the production of a molecular film that reduces the wear of surfaces and increases the lubrication performance of the oil [4].

Rudnick (2020) stated that canola and castor oil, among the vegetable oils used as lubricants, are one of the most widely used oils as base oils and additives to many oils [22]. It is stated that natural vegetable oils can be used as additives to improve the lubrication properties of mineral-based lubricants, and cottonseed oil can be used as an additive to reduce the coefficient of friction in low speed operating conditions [23].

While aiming to reduce the negative properties of mineral oils, it has been concluded that mineral engine oil and vegetable-based engine oils should be blended to obtain the best engine oil performance.

In this study, Petrol Ofisi 15W40 Engine Oil and Safflower oil were supplied. The supplied engine oil and Safflower oil were blended at 10% (A10) - 20% (A20) - 50% (A50) by volume in Selçuk University Faculty of Technology Fuel Laboratory. Viscosity and density analyses were also carried out in this laboratory. Welding Point Determination of Lubricants and Wear Diameter analyses of Lubricants in the four-ball Test machine were carried out in Opet Fuchs Mineral Oil Laboratory.

2.1.1. Safflower oil

Safflower oil from the Aromatic Oils company, obtained by cold pressing method, was preferred to be used in the prepared samples. Extra virgin safflower oil, which contains a high amount of unsaturated fatty acids, is given in Figure 3.

Fig. 3. Safflower oil

2.1.2. Engine oil

Maxsimus Turbo Diesel 15W40 heavy duty diesel mineral engine oil was preferred as the lubrication oil to be used in the prepared samples and as base oil. This engine oil is a recommended engine oil for all trucks, buses, lorries, heavy construction equipment and generator applications with diesel engines, especially turbocharged and low emission diesel engines.

The selected engine oil, with its high TBN (Total Base Number) values, protects the engine in fuels with high sulphur content, prevents wear at high speeds and temperatures, and ensures safe use in all turbocharged and non-turbocharged engines. It increases combustion efficiency and engine power by keeping the engine clean, and neutralizes combustion acids even when operating with high sulphur fuels. It provides long gasket and felt life and has a long service life [24]. Typical properties of the engine oil used are shown in Table 1.

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Fig. 4. 15W40 Engine oil

Table 1. Typical properties of 15W40 engine oil [24]

SAE Viscosity Grade	Standards	15W40
Density, 15°C, kg/L	ASTM D4052	0.886
Flash Point, °C	ASTM D92	240
Viscosity, 40°C, mm²/s	ASTM D445	114
Viscosity, 100°C, mm²/s	ASTM D445	15
Viscosity Index	ASTM D2270	139
Pour Point, °C	ASTM D97	-30

2.1.3. The four ball test machine

Four-ball wear test machine was used to determine the anti-wear and extreme pressure properties of oils. The four-ball wear test is performed by rotating a steel ball against three fixed steel balls under a given load.

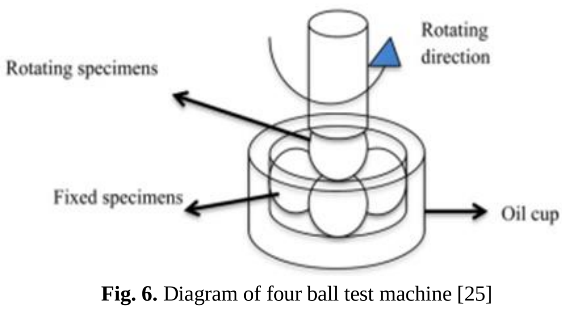

Fig. 6. Diagram of four ball test machine [25]

For the wear diameter analysis, the wear diameter on the surface of the ball was measured under a 40 kgf load at 75 °C, 1200 rpm rotation speed within the scope of ASTM D-4172 standard.

In a 4-ball test machine under the ASTM D2783 standard, the upper bearing is rotated against three deep-groove ball bearings at 1770 ± 60 rpm under variable load conditions. The temperature of the lubrication fluid is approximately 27 °C ± 8 °C for 10 seconds. The experiment is carried out with increasing loads until welding occurs. Four Ball Test machine used in the experiment is given in Figure 7.

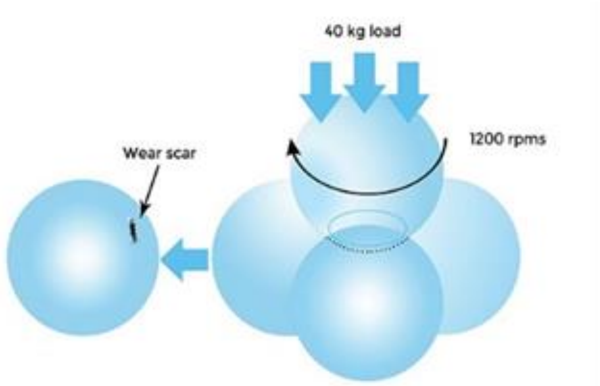

Fig. 7. ASTM D-4172 Four Ball Wear Test

2.2. Method

2.2.1. Preparation of samples and determination of their physical properties

This study was conducted with sample oils prepared by blending safflower oil and 15W40 commercial engine oil. The mixtures were prepared by measuring in beakers and made homogeneous by mixing in a magnetic stirrer. The mixing process is shown in Figure 8.

Fig. 8. Blending of the samples

- The sample called A0 was obtained by using commercial engine oil without adding Safflower oil.
- The sample called A10 was obtained by adding 10% Safflower to 15W40 engine oil.
- The sample called A20 was obtained by adding 20% Safflower to 15W40 engine oil.
- The sample called A50 was obtained by adding 50% Safflower to 15W40 engine oil.

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- The sample called A100 was obtained by using pure safflower oil.

The A0 sample was determined as the sample to be used as a reference value in evaluating the measurement results. Sample A100 was determined as the sample to evaluate the performance of pure safflower oil when it is used as engine oil. The A10, A20 and A50 samples obtained as mixtures were determined to observe how the performance of Safflower oil was affected when it is used as an additive in commercial engine oil. Samples are shown in Figure 9.

Fig. 9. The samples

Density analyses were performed for the samples by maintaining a constant temperature of 15°C and performing 3 identical repetitions. After density analysis, viscosity analyses were performed by performing 3 identical tests at 40°C and 100°C. The process of viscosity analysis is shown in Figure 10.

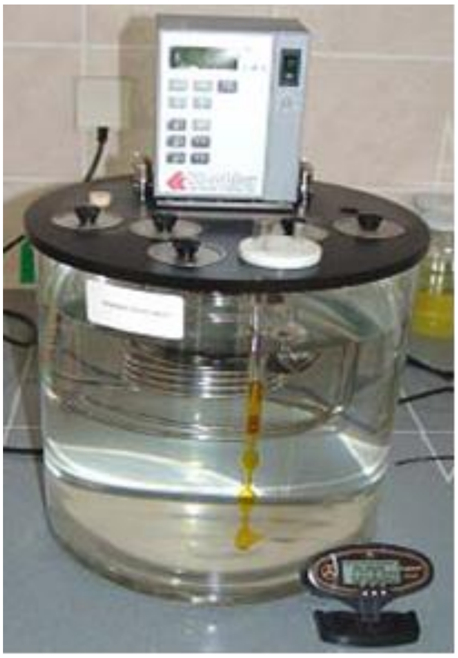

Fig. 10. Viscosity measurement

2.2.2. The tests performed with four ball test machine

In this study, a four-ball tribo tester was used to evaluate the tribological properties of the biolubricant as shown in Figure 11. This device uses three balls in a fixed position in a ball pot, which is pressed against the fourth ball fixed in the collar at the required pressure.

Fig. 11. Four ball test machine

Top ball rotates at desired speed according to test standards. The load is evenly distributed over the three points where the three balls touch the fourth ball. The pot (oil container) is filled with lubricant and heated to 75Co. After this, the drive motor starts, which is set to drive the upper ball at a speed of 1200 rpm.

The rotation of the drive shaft causes friction torque, which creates a track in the lower balls. The heater was turned off for 1 hour and the oil container assembly was removed from the oil chamber. Then the test oil in the oil pan was drained and the area with the wear scar was wiped with a cloth.

The test balls used had a diameter of 12.7 mm and a roughness of Ra D 0.016 mm and were made of AISI E 52100 steel.

Wear was evaluated based on the wear scar diameter (WSD) on the steel ball surfaces. The diameters of the circular wear scar on three stationary balls were measured with an optical microscope. Wear scar measurements for each run were reported as the average of the WSD of three balls. Three identical tests were performed for each sample to minimize data scatter.

To evaluate the extreme pressure (EP) properties of engine oils, EP four-ball tribo tester, similar to the standard four-ball test, was used. The primary difference is that the EP four balls operate at increased loads compared to the standard four ball test. The EP four-ball operates at a rotation speed of 1770 rpm for the upper ball. The temperature of the oil is 27C. A 10-second time sequence tests was performed until the four balls welded together at increasing loads. When welding occurred, the test was completed and the loads at which welding occurred were evaluated.

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3. Research Results and Discussion

3.1. Density and Viscosity Analyses

All blends of Safflower Oil and 15W40 engine oil showed no homogeneous phase, i.e. phase separation and precipitation, after three months of storage at room temperature.

The results obtained from density measurements repeated three times for A0, A10, A20, A50 AND A100 samples from the mixtures of 15W40 engine oil and Safflower Oil in different proportions are given in Figure 12.

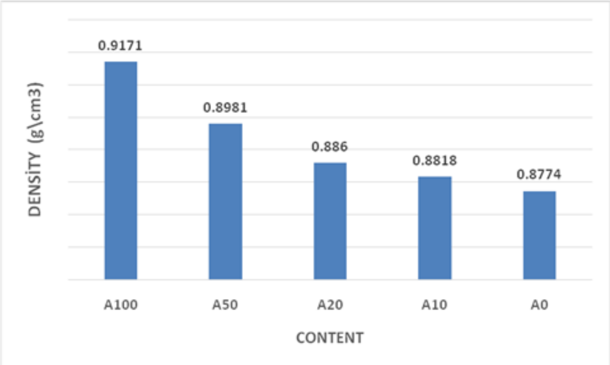

Fig. 12. Density analysis of samples

When the measurement results were evaluated, an increase in density was observed with the increase in the amount of safflower in the samples. As seen in the figure, the lowest density value was observed in engine oil (A0). A very small increase of 10% compared to engine oil and 0.5% compared to the sample mixed with safflower oil was observed. An increase of 2.35% was observed in the A50 sample. The highest density value was observed in the A100 (safflower oil) sample as 0.9171 g/cm3, and it increased by 4.5% compared to the A0 sample, which had the lowest density.

Viscosity is defined as the oil's resistance to flow. There is no ideal viscosity value that can be specified for the engine. Determining the viscosity value depends on the function of the lubrication oil and the characteristics of the part to be lubricated. For example, it can be said that high viscosity value is desired in crankcase oils. A sufficient oil film must be provided on machine parts at different operating temperatures, and to achieve this, there must be low viscosity at low temperatures and high viscosity at high temperatures. If the viscosity value is high, oil consumption decreases, but friction in the oil film increases [26].

The viscosity values of the samples obtained as a result of three repetitions at 40°C and 100° are shown in Figure 13. As seen in the figure, when the safflower ratio increases in the samples, there is a decrease in the resistance of engine oils to flow. The lowest viscosity values were observed in the A100 sample. It can be concluded that safflower oil is advantageous for cold operating conditions when used as engine oil or as an engine oil additive. The high viscosity of the engine in cold operating conditions, as in first start of the engine, causes damage to engine parts, so it is advantageous to use safflower oil to show a low viscosity value at low temperatures. However, excessive thinning of the lubricating film between the engine parts depending on the temperature in the engine oil at high speed and temperature causes the engine oil not to perform its duty fully and cannot prevent friction and wear. As a result, low viscosity at high temperatures is an undesirable feature in engine oils.

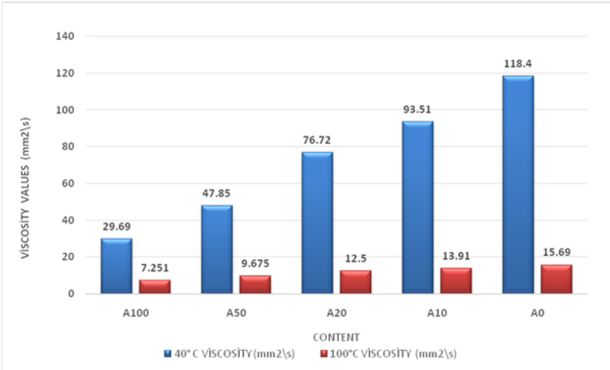

Fig. 13. Kinematic viscosities of samples

3.2. Friction and Wear

The molecular structure of oils and their ability to form thin lubricating films on the surfaces of contacting mechanical components determine the friction reduction effectiveness of the oils. A monolayer is formed by the adhesion of polar caps and the resulting vegetable oil molecules. It is often argued by biobased lubricant researchers that the basis for the superiority of vegetable oils over mineral oils with similar viscosities is vertical orientation of hydrocarbon chains near contacting metal surfaces.

The wear diameters of the ball samples obtained from the mixtures of 15W40 engine oil and safflower oil in different proportions, as a result of the test performed on 4 ball test machine, are given in Figure 14. Anti-wear properties are studied according to the diameters of the worn scar. The wear track diameter of the three balls was recalculated to obtain the average WSD for each lubricant test.

It can be seen in Figure 14 that unless safflower oil is added as a mixture, the wear diameter does not show good anti-wear properties compared to mineral oil. Sample A100 showed a 20.6% increase in wear diameter compared to sample A0. However, it showed better anti-wear performance in A10, A20 and A50 samples. The samples showed a decrease in wear diameters of 9.7% for A10, 7.5% for A20 and 8.8% for A50, respectively. In this case, it can be said that the contribution of safflower oil to mineral oil affects the anti-wear performance well, but it was concluded that pure safflower oil exhibits a relatively negative performance compared to commercial engine oil.

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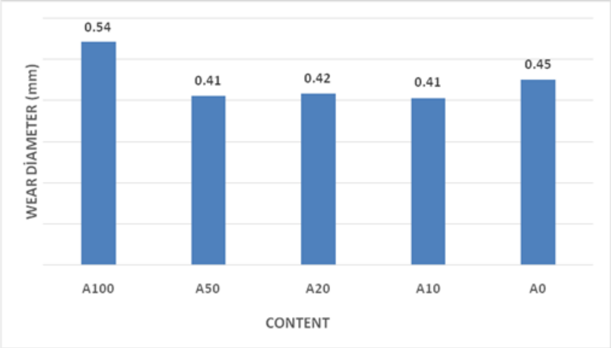
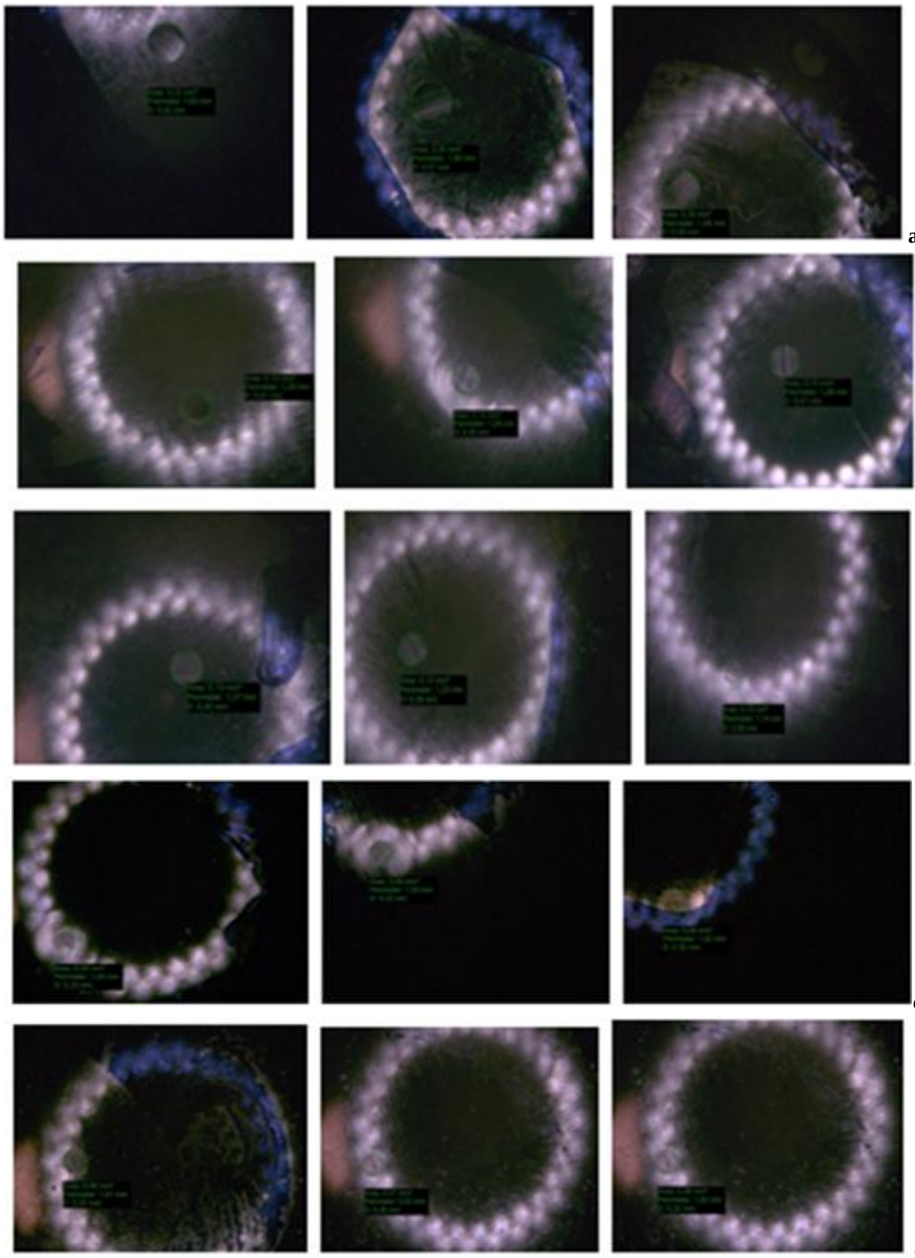


Fig. 14. Wear diameters of sample oils

Microscopic images of the mixtures obtained from safflower oil and 15W40 engine oil and of the ball samples resulting from the wear diameter determination in the 4-Ball Test machine are shown in Figure 15.

The morphology of the surfaces of the three subballs in each of the oils examined under the high magnification factor of the microscope is shown in Figure 15 (a), (b), (c), (d) and (e). Figure 15 (b) shows the worn surfaces in mineral engine oil. The surfaces have more homogeneous wear. This is due to the effectiveness of anti-wear additives. The surfaces revealed the power of the tribochemical reaction between the surfaces of the balls with additives that make the surfaces very resistant to mechanical slip and abrasive wear. The grooves on the surfaces of the balls in safflower oil (Fig. 15 (a)) are an indication of the absence of anti-wear additives.



a) A100 sample

b) A0 sample

c) A10 sample

d) A20 sample

e) A50 sample

Fig. 15. Ball wear microscopic images of samples

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3.3. Welding Load Determination

To evaluate the friction and wear properties of engine oil samples, their extreme pressure properties were examined over a 20 kg load range, defined as the final seizure load, until the ball samples welded together. The applied rotation speed was 1200 rpm, the temperature was 27±7°C, and a working time was 10 s. for each sample.

In Figure 16, it was concluded that the A0 sample is more stable in terms of the final seizure load, which is defined as the load where the lubricant film is completely disintegrated and the test ball materials are welded. It can be concluded that, unlike commercial engine oil, pure safflower oil exhibits a very low performance when evaluated in terms of welding load. This can be attributed to the fact that the lubrication film thickness at higher loads becomes thinner due to some of the asperities present in the boundary lubrication regime. As a result of examining the microscopic images, it was seen that the wear surface of the A100 sample was more corrugated compared to the A0 sample. At the same time, this confirms the assessment that the A100 sample has low resistance to abrasive wear.

When Figure 16 is examined, it is concluded that A0 (15W40 engine oil) has the highest performance in terms of welding load, while A100 (pure safflower oil) sample has a very low performance compared to it. To evaluate the use of safflower oil as an additive in commercial engine oil, it was concluded that the A10, A20 and A50 samples obtained by mixing them at 10, 20 and 50% ratios showed negative performance when added to engine oil in terms of welding load.

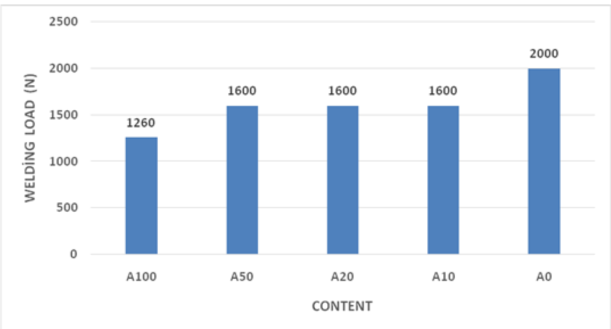

Fig. 16. Welding load values of the samples

As a result of the tests for the A100 sample, it is seen that the wear diameter is higher than the other samples and it exhibits a lower performance in welding load. These two results supported each other and it was concluded that the use of A100 sample as engine oil was not suitable for use over 15W40 engine oil in terms of wear and friction performance. When the A0 sample is evaluated, it can be seen in Figure 17 that although it has a more stable performance in terms of welding load compared to the A10, A20 and A50 samples, it has a worse result in terms of wear diameter. It was concluded that A10, A20 and A50 samples exhibited better wear performance before the seizure which occurred because the asperities, formed as a result of abrasive wear, prevented the oil film thinning due to excessive pressure. This can be explained as the asperity being covered by the long-chain fatty acids found in vegetable oils.

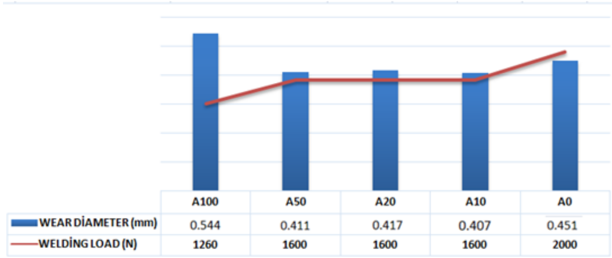

Fig. 17. Friction and wear test results of samples

4. Conclusion

We can conclude that it minimizes wear during first start-up in cold weather. As the safflower ratio increased, the viscosities of the samples decreased proportionally. When compared to 15W40 engine oil, which is used as a heavy commercial engine oil operating at high speeds and temperatures, it is concluded that it cannot be used as an alternative due to its low viscosity values. However, when the viscosity values of the samples are examined is taken into consideration, it can be said that Safflower oil can be used as an alternative for passenger car engine oils.

As a result of the wear diameters and wear images, it can be said that the A100 sample exhibits low performance in terms of anti-wear. The reason for this situation is that abrasive wear cannot be prevented in pure safflower oil, and microscopic images of the balls also support this situation. However, it was concluded that the anti-wear performance was better in the samples (A10, A20 and A50) in which Safflower was used as an additive and could be used as an alternative to 15W40 engine oil. When the final seizure points of engine oils were examined, Safflower oil showed a more unstable performance under excessive pressure and welded earlier. In the engine oil samples used as additives, the welding load value is between pure safflower and commercial engine oil.

Safflower oil can be used as an anti-wear additive. It has been concluded that by adding the necessary additives, it enables the use of environmentally friendly bio-lubricants as an alternative to 15W40 commercial engine oil.

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Authorship contribution statement for Contributor Roles Taxonomy

Buse Sergek: Conceptualization, Original Draft, Writing, Technical Reviews, Investigation, Analysis. **Abdullah Engin Özçelik:** Methodology, Design, Writing, Reviews. Testing, Evaluation, Writing.

Conflict of interest

The author(s) declares that he has no conflict of interest.

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