Available online at www.garmian.edu.krd

Passer Journal

Passer 5 (Issue 1) (2023) 59-64

http://passer.garmian.edu.krd/

Effects of Vehicle Mileage Rate on Engine Oil Properties

Dana Kareem Hameed[1*]

[1]*Department of Electrical Techniques, Darbandikhan Technical Institute, Sulaimani Polytechnic University, Darbandikhan, Kurdistan Region, Iraq.*

Received 09 December 2022; revised 16 January 2023;
accepted 16 January 2023; available online 23 January 2023

DOI: 10.24271/PSR.2023.376018.1191

ABSTRACT

The research focuses on the relationship between automotive mileage and its effect on engine oil deterioration. The effects of the new (2020) and old (2012) engines on the most important parameters, kinematic viscosity, flash point, and fire point were investigated. Measurements were performed on four-engine oil samples. Profi-car Endurance SAE 10W-30 semi-synthetic was used for all the engines. The maximum trip length for the oil samples was 8,000 Km. Kinematic viscosity was measured by using a KV1000 Bath (according to the ASTM D445). In addition, the flash point and fire point of the samples were determined by using the Open Cleveland method. This work investigates the difference between old and new engines in actual use on the roads in the rate of decrease in engine oil properties. The cumulative results obtained help drivers protect their car engines by changing engine oil when the engine's mileage is above 100,000 Km. The comparison of the average results shows that the rate of deterioration of used oil in old engines is higher than in the new engines. It has been shown that the rate of difference in oil viscosity deterioration between old and new engines at cold temperatures, 40°C, and 100°C were 9.3%, 10%, and 4.78% respectively. Also, the different rate for the oil flash points and fire points was 5.56% and 6.75%.

Keywords: Engine oil, Engine age, Flash point, Fire point, Viscosity.

1. Introduction

The most significant aspect is the engine oil for proper work of the engine and reducing the friction for better sliding between engine moving parts. The rate of wear inside the engine's construction, such as the wear produced by the piston rings and bearings during sliding on the cylinder block wall and the other technical state of the engine, influences the properties of the used oil[1]. The process of lubricating aging is the process of changes in physicochemical properties that occurs due to the engine condition and oil usage for a long time. All the changes in the engine oil properties have a negative influence on the engine function and engine lubricating system[2]. In addition, engine oil helps the cooling system by removing some of the heat inside the engine from hot spots to the sump[3]. To protect the engine from damage and choose an appropriate oil, it is essential to digest some factors for choosing suitable properties. These factors are the lubrication system of the engine, the condition and trip length of the engine, and lubricant cost[4]. Resistance to fluid flow at a specific temperature is called a measure of viscosity. The critical properties parameter for choosing the correct engine lubricant is the kinematic viscosity of the oil. Also, the kinematic viscosity of the lubricant affects the tribological properties of the engine parts, such as the amount of wear and the rate of friction between contact surfaces[5]. The required oil for the engine must retain its properties under different operation conditions, for example, when the load on the engine increases or during running at a cold start [6]. Automotive engine manufacturers advise customers and technicians to use the allowable viscosities for their engines and set a tight limit for changes in viscosity. Inside the engine, the maximum permissible rise or drop change rate in the lubricant viscosity is 25%[7]. After using 10W-30 Delta NL motor oil brand (unique synthetic with API SL) in different Nissan Sunny, the viscosity of the lubricant at cold start, 40°C, and 100°C dropped 22.92%, 23.61%, and 26.13% respectively. Also, the fire point of the oil decreased by 15.6%, and the flash point of the lubricant dropped by 14.22%[8].

* Corresponding author
E-mail address: dana.kareem@spu.edu.iq (Instructor).
Peer-reviewed under the responsibility of the University of Garmian.

In their research Kaleli and Yavasliol,[9] used SAE 20W-50 oil grade. In the test, they used 2 engines, and the result of the tests shows that in the second engine, the viscosity of the lubricant models after 15,000 Km reduced from 18.09 cSt to 13.24 cSt at 100°C and dropped from 160.16 cSt to 103.02 cSt at 40°C. The percentage rate of drop in viscosity at 100°C was 26.81 cSt and at 40°C was 35.67 cSt. In this study, another reason is the quality of the engine oil properties in which semi-synthetic oil was used, and the quality of the oil is lower than full synthetic oil.

The study of the contact between gasoline and lubricant and the information about gasoline dilution effect on the engine oil didn't establish clearly[10].

Flashpoint and fire point are other two factors that can be used to determine lubricant condition and their properties before and after use. The point at which the engine lubricant flashes is the flash point. It happens when the vapor on the oil produced by increasing the temperature will ignite or burn momentarily upon exposure to a naked flame or an igniting source in the laboratory under specific conditions[9].

Penetration of fuel in engine oil reduces the flash point. Pensky-Martens closed cup and open Cleveland are the two unique methods used to measure and determine the flash point of fuel and lubricants. For those fuels which have high flammability, the Pensky-Martens closed cup method is utilized, a closed container is used in this method, and the temperature is below 50 °C. The open Cleveland method is used with those oils which have low flammability, an open container is used in this method and the temperature is above 50 °C. However, the engine's oil fire point occurs when the engine's oil heating increases continuously, and the vapors on the oil surface are released rapidly to support burning for longer than 5s[3].

Oil dilution occurs when the fuel inside the combustion chamber leaks into the crankcase, especially at a cold start or when the piston rings are weakened. Inside the cylinder chamber, gasoline or fuel does not burn completely. The upper part of burned and unburned air-fuel mixture inside the chamber leaves with the burned gases and the remaining unburned fuel mixes with the oil films on the cylinder wall. The oil produces a thin film between the cylinder wall and piston rings, the contact between oil and fuel causes the engine oil to lose some of its kinematic viscosity, which makes the oil films weaker and less withstanding at high loads. According to the researchers[11], the oil films on the cylinder walls and around cylinder rings should be stable when the fuel dilution reaches 5 wt% because after this point the rate of the unburned gasoline decreases the oil flash and fire points to a value that are no more acceptable for use. Some researchers reported that mineral type of oil considerably loses its properties when the dilution rate reaches 1% and when the fuel dilution reaches 7%, the mineral oil completely loses its lubrication properties to protect the movable parts from wear[12]. Also, for synthetic oil at 7% dilution, the oil drops most of its properties but shows more stability[12].

Ljubas et al.,[11] prepared oil-fuel mixture samples to calculate the effect of contact between oil and fuel. They use AG240 digital balance Rotamix MM5 magnetic mixer from Tehtnica. They also used thermostatic bath M3 from Lauda, and test results show that for mineral engine oil (15W-40), when the rate of gasoline ES 95 increases to around 3 wt%, the kinematic viscosity of the mineral oil decreases to below 12.5 cSt. For synthetic oil (5W-30), test results show that the kinematic viscosity dropped to a minimum of 9.3 cSt.

This study was conducted to determine the effect of vehicle mileage on car oil properties. The research can be done in the laboratory, and the data will be closer to the truth, but the research focused on to achieve is to test the oil change and quality deterioration of engine oil in a moving car. Two vehicles of the same model and having the same features with nearly the same odometer were used to obtain the average data, and it has been done to be closer to the actual data and determine the changes.

2. Methods and Materials

The oil samples were collected from four different passenger engines, two old Nissan Sunny engines model 2012 (odometer of the passenger cars was upper than 100,000 Km) and two new Nissan Sunny engines model 2020 (odometer of the passenger cars was lower than 25000 Km) to calculate the effect of vehicle mileage on the oil properties (flash point, fire point, and the kinematic viscosity).

In this study, Profi-car Endurance SAE 10W-30 semi-synthetic engine oil for different trip lengths was used in all the passenger vehicles (one type of oil was used in the study to determine the effect of the different odometer on the same type of oil), the speed rate for all the vehicles was between 0 km/h to 120 km/h. The road type was paved, and the trip was between Sulaymaniyah and Hawler.

Air-conditioning (AC) was not used during the trips. The clean, unused oil properties are shown in Table 1 and Table 2.

Table 1: Profi-car endurance SAE 10w-30 the sufficiency of the lubricant engine is shown.

Title	Measurements
API	SL/CF
ACEA	A3/B4

Table 2: Shows Profi-car Endurance SAE 10W-30 engine oil physical and technical characteristics.

Technical Data	Units	ENDURANCE SAE 10W-30
Density at 15°C	Kg/m³	870
Flashpoint COC	°C	225
Pourpoint	°C	-36
Viscosity 40°C	cSt	75
Viscosity 100°C	cSt	11.5

The details about the rate of trip length, car odometer, and other details about the engine are shown in Table 3.

According to the details from Profi-car, Endurance SAE 10W-30 is a semi-synthetic high-performance, low-friction engine oil. Moreover, the oil composition and shear-resistant VI enhancers ensure that during the entire lubrication time, the oil saves its specified properties. Also, the oil contains additives to prevent cold sludge and deposits.

Clean bottles are used to collect engine oil directly from the car sumps, and all the bottles are closed to protect them from any contact with air, collect samples are kept in a dry place at room temperature. To remove oil sludges and tiny agglomerate particles produced by friction. All the oil samples were filtered before the tests. Fuel labs in the institute of Kurdistan in Sulaymaniyah, Iraq, were used for all the experimental tests and results.

For measuring the rate of the oil viscosity, adjustable frontier control KV1000 Bath (according to ASTM D445) was used. The Kinematic viscosity for all the collected oil samples was calculated by KV1000 Bath (according to the ASTM D445) and Koehler viscometer (conformed to ASTM D446) at the cold start (room temperature), 40 °C, and 100 °C.

Table 3: Shows trip lengths, used vehicles, and used oils.

Make	Model	Engine Capacity (L)	Year	Engine	Odometer (Km)	Trip Lengths (Km)
Nissan	Sunny	1.5	2020	1	3400-6425	3025
					6425-12443	6018
					12443-20480	8037
				2	2345-5374	3029
					5374-11421	6047
					11421-19453	8032
			2012	3	121245-124270	3025
					124270-130324	6054
					130324-138427	8103
				4	144153-147205	3052
					147205-153324	6119
					153324-161477	8153

Open Cleveland method with an open cup (NCL 120, Normes: according to the ASTM D92, ISO 2592, Ip 36) was utilized for measuring initial start and fire point at atmospheric pressure, and this method was used to determine the fluids that have flash and fire point above 100°C, and a thermometer with 300°C measuring rangeability was used to determine the temperature of both of them. Flash and fire points for oil are two essential properties used to determine the properties of oils and their ability to protect engines. In this study, approximately 50 mL of each oil sample was put in a special cup, and to increase the oil temperature, a heater was used. A heat regulator on the front of the heater was used to control the heating rate.

A fire source was used to ignite the oil vapor on the oil surface, and the fire moved every 3 seconds on the oil surface to determine at which temperature the flash appeared. Also, to determine the temperature of the oil samples, a thermometer was used.

3. Results and Discussion

In this section, the results of oil deterioration are illustrated and discussed. The most critical factors are viscosities, flashpoints, and fire points were used to evaluate the engine oil properties after different trip lengths.

The rate of drop in flash point and fire point in the engines (3 and 4) is higher than the engines (1 and 2). The change in oil viscosities, flashpoints, and fire points are shown in Table (4).

Table 4: Parameters of all engine oil samples (Viscosities, flash, and fire points) at different trip lengths are shown.

Engine No.	Length Trip	Oil Type	Viscosity (cSt) at cold start	Viscosity (cSt) at 40 °C	Viscosity (cSt) at 100 °C	Flash point °C	Fire Point °C
		Pure	86	75	11.5	225	237
1	3025	Used	71	67	10.1	206	216
	6018		66	63	9.5	192	201
	8037		62	56	8.7	173	185

2	3029		73	70	9.9	207	213
	6047		65	63	9.1	189	192
	8032		60	58	8.4	168	178
3	3025		76	64	9.3	202	206
	6054		63	58	8.6	180	189
	8103		55	51	7.9	159	165
4	3052		77	69	9.8	203	208
	6119		62	60	9.1	185	192
	8153		51	48	8.1	157	166

3.1 Engine oil kinematic viscosity

The oil viscosities significantly differ between the old (engine 3 and 4, model 2012) and the new (engine 1 and 2, model 2020) vehicles. Viscosity tests were conducted at three different temperatures to determine the rate of changes in the oil viscosity after use:

1. Viscosity at the cold start (room temperature)

In Figure (1), it can be seen that the decrease rate in oil viscosities engines (1 and 2) at 8000 km is lower than the oil viscosities engines (3 and 4). For the new engines (1 and 2), the rate of drop in viscosity for the first start was (27.91% and 30.23%), respectively, as shown in Table 5. Also, For the old engines (3 and 4), the rate of drop in viscosity for the first start was (36.05% and 40.7%), respectively.

The maximum permissible rate of oil viscosity drop should be less than 25%. In this case, we see that for all engines at 8000 km, the oil drop level is more than the permitted amount, although the first and second engine's oil lubricant drop is lesser than the other two engines. However, the drop is still above the permissible level, and the type of used oil should be used for less than this trip length.

Table 5: Parameters of all engine oil samples (Viscosities, flash, and fire points) at different trip lengths are shown.

Engine No.	Parameters	Test Condition	Rate of Drop %
1	Viscosity	Cold start	27.91
		40°C	25.33
		100°C	24.35
	Flash point		23.11
	Fire Point		21.94
2	Viscosity	Cold start	30.23
		40°C	22.67
		100°C	26.96
	Flash point		25.33
	Fire Point		24.89
3	Viscosity	Cold start	36.04
		40°C	32
		100°C	31.3
	Flash point		29.33
	Fire Point		30.37
4	Viscosity	Cold start	40.7
		40°C	36
		100°C	29.56
	Flash point		30.22
	Fire Point		29.96

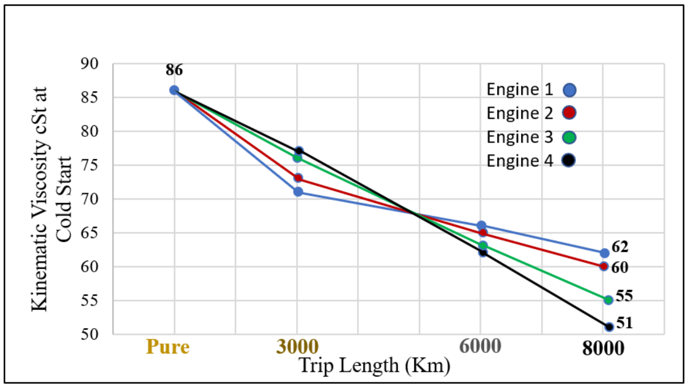

Figure 1: Drop in oil viscosity at cold start for four engines used in the study on different trips.

The average drop for the new engines is 29.07% and for the old engines is 38.37%. Here we see that the different rate of change in oil viscosity between the old and the new engines at the cold start was 9.3%, as shown in Figure (2).

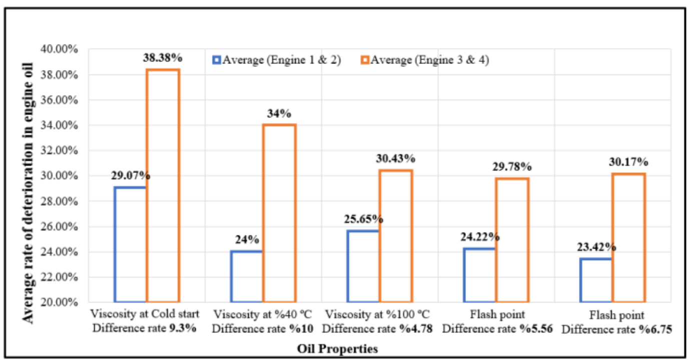

Figure 2: The difference in average rate between old and new engines.

2. Viscosity at the 40 ºC

Figure (3) shows the deterioration in oil viscosity at 40 ºC. This temperature is helpful for the early detection of physical and chemical changes in oil properties.

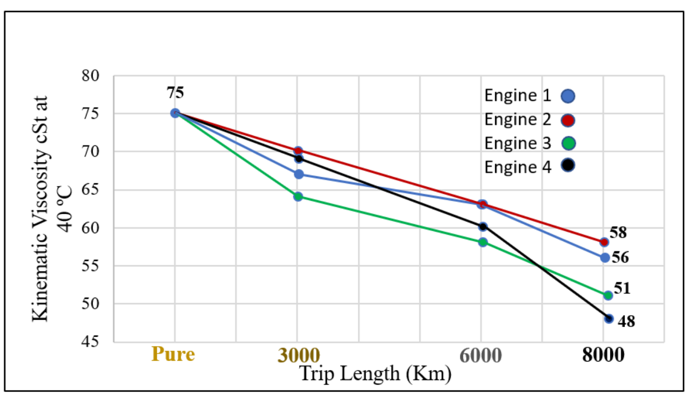

Figure 3: Drop in oil viscosity at 40°C for four engines used in the study on different trips.

The kinematic viscosity dropped at 8000 Km trip length from 75 cSt (pure oil viscosity at 40 ºC) to 56 cSt for the engine (1) (the rate of the drop was 25.33%) and 58 cSt in the engine (2) (the rate of the drop was 22.67%). At this temperature, the rate of the drop in oil properties is near or under the maximum permissible amount for the drop in oil properties. Nevertheless, in the old engines, the decrease in oil viscosity for engines 3 and 4 was 51 cSt and 48 cSt respectively (the rate of the drop was 32% and 36%, respectively). The comparison of differences in oil characteristics degradation rates between old and new engines at this temperature was %10.

3. Viscosity at the 100 ºC

Most engine oils are typically measured at 100°C because the SAE engine oil classification system (SAE J300) is referenced to the kinematic viscosity at 100°C, Figure (4) shows the decrease in oil viscosity at 100 ºC. The kinematic viscosity decreases at a different rate, for the new engines (1 and 2), the rate of drop in viscosity for 100°C was (24.35% and 26.96%). While for the old engines (3 and 4) the drop rate in viscosity is higher than new engines, the rate of drop in viscosity for 100°C was (31.3% and 29.57%), respectively. At 100 ºC the comparison of differences in oil degradation rates between old and new engines was %4.78.

3.2 Flash and fire points

Table 4 displays the flash point of pure oil is 225°C at 8,000 Km. The number of flashpoints decreased for all four engines to a different degree. As for the new engines (1 and 2), the rate of the drop in flash points was (23.11% and 25.33%). Although for the old engines (3 and 4) drop in flash point is higher than the new engines, the rate of drop in flash point was (29.33% and 30.22%). See Figure (5) and Table (5). The average difference in the flash point between old and new engines was 5.56%.

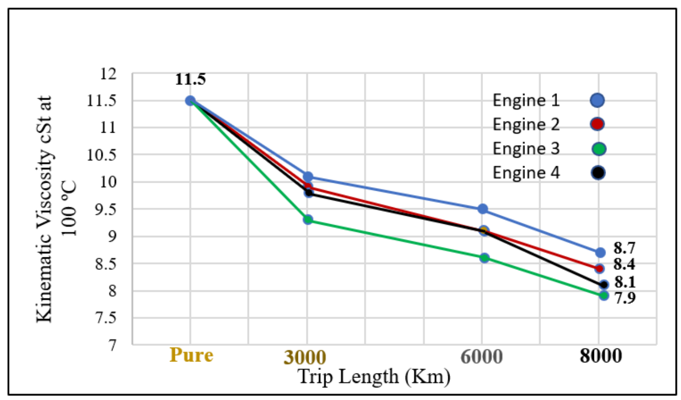

Figure 4: Drop in oil viscosity at 100°C for four engines used in the study on different trips.

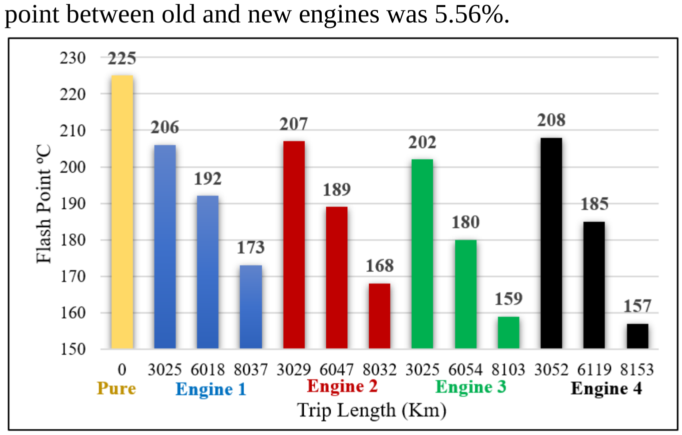

Figure 5: Decrease in oil flash point for four engines in different trips.

The amount of fire point of the engine oil decreases continuously with increasing trip length, as it is shown in Figure (6). The pure oil fire point was 237 °C, (see Table 4). For the new engines (1 and 2), the amount of decrease in fire points was (21.94% and 24.89%). See Figure (6) and Table (5). Although the old engines, (engines 3 and 4) decreased in fire points higher than the new engines, the rate of drop in fire points was (30.38% and 29.95%). The average difference in the flash point between old and new engines was 6.75%.

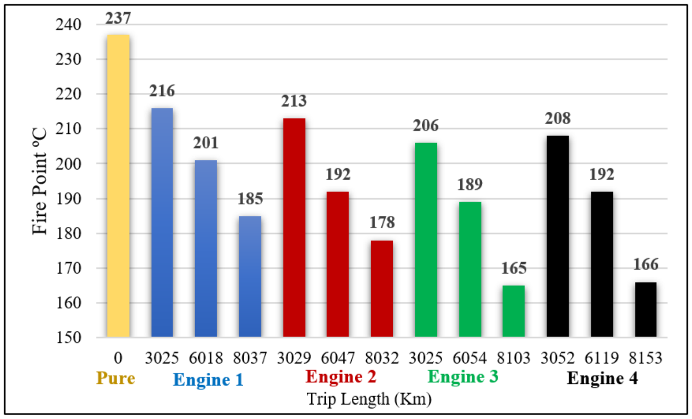

Figure 6: Decrease in oil fire point for four engines in different trips.

The difference in average rate between the old and the new engines shows in Figure (2). What we reach from this and other studies mentioned earlier, the most important characteristics, such as the oil viscosity, flash point, and fire point decrease, as a result of driving and engines in use. This decrease varies depending on the quality of the oil and the amount of driving. According to researchers, the causes of deteriorating oil quality are the wear of engine parts, fuel-oil contact in potential contact areas such as piston and ring movement areas, as well as the quality of oil used in the studies, and the amount of vehicle driving. In this study, the results are similar (oil properties decreased), but what is remarkable is that the decrease is more significant in older models than in newer models.

The result of this drop in oil properties in the older engines is due to the aging and decrease in the ability of the engines. In exploring the exact cause of this drop in the oil properties, more research is needed to determine the amount of fuel in the engine oil (make a comparison of the rate of fuel in the oil between the new and old engines) and determine the amount of wear in the oil-fuel contact area. The number of corrosive substances should also be checked, which is one of the causes of further deterioration of the oil properties.

Conclusion

This experimental research was conducted to evaluate the impact of the rate of engine mileage on the most critical parameters of the engine lubricant. Four different vehicles were used in this study to investigate flash points, kinematic viscosity, and fire points. The findings indicate that the physical and technical characteristics of the oil of the vehicles with higher mileage (above 100000 Km) drop more when compared with the vehicles that have lower mileage (lower than 25000 Km).

The conclusion can be summarized as follows:

- The rate of oil deterioration in the old engines is higher than in the new engines.
- The difference between the change in average viscosity for the old and new engines at cold, 40°C, and 100°C was 9.3%, 10%, and 4.78%, respectively.
- The rate of decrease in average flashpoints in the old and new engines is 5.56%. The rate of decreasing the flash point in the old engines is higher than in the new engines.
- The rate of decrease in average fire points in the old and new engines is 6.75%. The rate of decreasing the fire point in the old engines is higher than in the new engines.

Conflict of interests

None

References

1. Macia´n, V., Tormos, B., Olmeda, P. & Montoro, L. Analytical approach to wear rate determination for internal combustion engine condition monitoring based on oil analysis. *Tribology International* **36**, 771-776, (2003).
2. Sikora, G. & Miszczak, A. The Influence of Oil Ageing on the Change of Viscosity and Lubricity of Engine Oil. *Solid State Phenomena* **199**, 182–187, (2013).
3. Hameed, D. K. & Ali, K. R. Analysis of 0W-20 Totachi Brand Oil to Determine the Rate of Oil Deterioration. *UKH Journal of Science and Engineering* **4**, 139–146, (2020).
4. Vasishth, A., Kuchhal P. & Anand G. Study of Rheological Properties of Industrial Lubricants. *Conference Papers in Science* **2014**, 1–5, (2014).
5. Hlaváč P., Božiková, M. & Presová, R. Temperature Relations of Selected Engine Oils Dynamic Viscosity. *Acta Technologica Agriculturae* **17**, 105–108, (2014).
6. Taylor, R. I. Engine friction: The influence of lubricant rheology, Proceedings of the Institution of Mechanical Engineers. *Part J: Journal of Engineering Tribology* **211**, 235–246, (1997).
7. Coates, J. P. & Setti L. C. Infrared Spectroscopic Methods for the Study of Lubricant Oxidation Products. *ASLE Transactions* **29**, 394–401, (1985).
8. Hameed, D. K. Engine Oil Deterioration based on the Viscosity, flash point, and fire point for Different Trip Length. *Kurdistan Journal of Applied Research* **6**, 13–20, (2021).
9. Kaleli, H. & Yavasliol, I. Oil Ageing - Drain Period in a Petrol Engine. *Industrial Lubrication and Tribology* **49**, 120–126, (1997).
10. Khuong, L. S., Masjuki, H. H., Zulkifli, N. W. M., Mohamad, E. N., Kalam, M. A., Alabdulkarem, A., Arsalan, A., Mosarof, M. H., Syahir, A. Z. & Jamshaid, M. Effect of gasoline–bioethanol blends on the properties and lubrication characteristics of commercial engine oil. *RSC Advances* **7**, 15005–15019, (2017).
11. Ljubas, D., Krpan, H. & Matanovic, I. Influence of engine oils dilution by fuels on their viscosity, flash point, and fire point. *Nafta* **61**, 73–79, (2010).
12. Lapuerta, M., Armas, O. & Herreros, J. M. Emissions from a diesel–bioethanol blend in an automotive diesel engine. *Fuel* **87**, 25–31, (2008)