RESEARCH ARTICLE

Analysis of 0W-20 Totachi Brand Oil to Determine the Rate of Oil Deterioration

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ABSTRACT

Engine oil or lubricating oil has a major effect on the engine life and the proper operation of any engine. Changing the engine oil before it is due increases a customer's cost. The lubricating oil in every engine performs many functions such as reducing friction, preventing corrosion, protecting the engine against wear, removing all impurities, lubricating the moving parts, and cooling the engine parts. There are several causes for the deterioration of lubricating oil, including the properties of the oil, oil quality, and high engine temperatures. Consequently, the deteriorated oil must be replaced at a specified mileage or at specific time intervals to get the best engine performance. It is very important to know when to change the oil, because changing the oil too late can affect the engine parts and vehicle performance. However, replacing the oil too early influences the economy and environment and is an inefficient use of depleting resources. This study describes the kinematic viscosity, flash point, and fire point of multigrade Society of Automotive Engineers (SAE) 0W-20 Totachi (Totachi Industrial Co. Ltd., Japan) international brand oil, which has a 10,000 km guarantee and is approved by and used in 10 different vehicle brands, to determine the rate of deterioration of the parameters. These parameters are the most important physical behaviors of lubricating engine oils. Having information about these parameters is very important for maintaining an engine's lifespan. The results of this study showed that after 10,000 km, the Totachi oil parameters such as the kinematic viscosity at cold start, at 40°C and at 100°C, the flash point, and the fire point decreased by 22.03%, 25.98%, 26.75%, 16.94% and 17.34%, respectively, from the base values, and that the oil is suitable to use for 10,000 km.

Keywords: Computer network design, Data traffic sent, Network delay, Network performance, Server hypertext transfer protocol, Throughput, Transmission control protocol, Voice over internet protocol

1. INTRODUCTION

There are many purposes for using fresh engine oil in a lubrication system, but the main function is to keep the moving parts such as pistons, crankshaft, camshafts, valves and others separated, because separation is required to reduce the friction between the movable parts and to protect them from wear (Lajqi et al., 2016).

To protect the moving parts of a vehicle's engine, the oil produces a film on the engine's surface parts and cylinder walls, and the thickness of the engine oil films changes according to the engine oil type. Lubricating oil films in the engine prevent contact between the moving and nonmoving engine parts.

The lubrication system or the oil in the engines also helps the

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engine's cooling system to remove some of the heat produced during combustion inside the piston chamber and by friction. This means that the oil transfers heat from the high temperature areas to the sump when the oil is collected. Oil oxidation occurs when the oil temperature increases. Oxidation in a lubricant system aggravates the lubricants and creates a series of problems in the system. Corrosive acids, resins, and slugs are formed when the oil temperature increases (Owrang et al., 2004). Another function of oil in engines is to prevent corrosion (Sutar and Singare, 2018), for which purpose special anticorrosives are added to the oils. Sealing is used to prevent lubricants from leaking out of the engine, and therefore the oil that is used must also help to lubricate the seals without causing deterioration, shrinking, or hardening. There are many different quality levels and types of oils. For example, full synthetic oils are the best type and are derived from petroleum and nonpetroleum chemical compounds (Kumbár and Sabaliauskas, 2013). Many standard tests can be used to determine the condition of the oil in a lubrication system before using and after running an engine.

1.1. Kinematic Viscosity

Viscosity is a measure of the resistance to flow at a given temperature. It is very important to choose the correct oil viscosity for an engine. The owner's manual for a specific engine is the best source to identify the correct oil to use in the engine. During different operating conditions, such as when the engine is running at a low temperature or under load, the lubricating fluids must retain their properties, and the viscosity of the best oils changes only minimally in the working temperature range. According to the Society of Automotive Engineers (SAE), the oil grade can be used to identify the oil viscosity, and it is the same across the globe (Mang and Dresel, 2007).

The SAE has established a viscosity classification for engine oils to describe the kinematic viscosity. For example, in an SAE 0W-20 extra fuel economy engine oil, the first number indicates the flow of the oil at cold engine temperatures. The lower the first number, the better the flow at a cold engine temperature. The "W" indicates that the oil is suitable for use in winter. According to the SAE chart, 0W has acceptable viscosity properties to enable proper functioning at around –40℃. The second number indicates the lowest viscosity requirement at a high engine temperature to guarantee acceptable lubrication for the engine without damaging it (Pereira et al., 2007). Certain engine manufacturers set tight limits on the allowable changes in viscosity. According to Coates and Setti (1986), the maximum permissible changes (increasing or decreasing) in viscosity is 25%. An increase in viscosity is caused by contamination, nitration, or oxidation, whereas a decrease in viscosity occurs when the amount of fuel in the oil increases (Kaleli and Yavasliol, 1997). Temperature has a direct effect on the oil viscosity. Farhanah and Bahak (2015) studied the relationship between viscosity and temperature using 3 different engine oil manufacturers with the same SAE viscosity grade. They rotated the viscometer in accordance with the American Society for Testing and Materials (ASTM) D445 stipulations, and their results showed that the temperature is inversely correlated with viscosity; therefore, any decrease in the temperature will increase the engine oil viscosity. In addition, in the study by Kaleli and Yavasliol (1997), an SAE viscosity grade of 20W-50 was used in 2 different engines. The results showed that after 15,000 km, the viscosity of the oil used in the second engine decreased at 40℃ from 160.16 cSt to 103.02 cSt, and at 100℃ the viscosity of the oil decreased from 18.09 cSt to 13.24 cSt. Most engine wear occurs when the engine is cold.

When starting an engine, the oils must reach all the moving parts. If an oil with the wrong viscosity is used, and in this example an oil with a viscosity that is too high, the oil pump cannot push the required rate of oil to the upper parts of the engine when the engine is started. Wear occurs when the oil reaches the moving parts too late. In some newer engines when the wrong viscosity oil is used, the engine does not start, especially in diesel engines, because in those types of engines the oil is used to operate the pump to prime the fuel injectors. In addition, wax is produced when diesel fuel dilutes the oil, especially at low temperatures (Niculescu et al., 2016).

1.2. Flash Point and Fire Point

Another parameter used to determine the oil quality is the flash point. The flash point is the lowest temperature that causes the vapors in air to burn momentarily or ignite when exposed to a naked flame or spark under specific laboratory conditions (Kaleli and Yavasliol, 1997; Ljubas et al., 2010). A reduction in the flash point is caused by the penetration of fuel. In the laboratory, there are 2 ways to determine the flash point of the oil. The first method is called the open flash point (open Cleveland method), which is used for fuels with low flammability, and is conducted at temperatures above 50°C in an open container (Shri Kannan et al., 2014).

The second method is called the Pensky-Martens closed cup method, which is used for fuels with high flammability, and is conducted at temperatures below 50°C in a closed container (Azad et al., 2012). However, if heating of the oil continues after the flash point, a temperature will be reached at which the vapors from the oil are released fast enough to support combustion for a minimum of 5 seconds under specific laboratory conditions. This temperature is called the fire point. The fire point temperature is usually higher than the flash point temperature. Researchers have reported that the flash point decreases from 204°C to 128°C after approximately 10,000 km for the SAE 20W-50 oil type (Kaleli and Yavasliol, 1997).

In this study, the Japanese manufactured international Totachi (Totachi Industrial Co. Ltd., Japan) oil brand, SAE 0W-20 extra fuel economy, was used in different types of gasoline engines from different vehicles manufactured by the Nissan company. The properties of the unused oil in this study are shown in Table 1 and Table 2.

2. METHODS AND MATERIALS

Table 1: The performance grade properties of the SAE 0W-20 oil

API SN
Fully synthetic
ILSAC GF-5
High temperature high shear (HTHS) ≥2.6 cSt
Dexos 1™ 2011
Resource conserving
API SN
Fully synthetic
ILSAC GF-5

Table 2: The physical characteristics of the SAE 0W-20 oil

Kinematic viscosity at 40℃: 40.8 cSt
Kinematic viscosity at 100℃: 8.0 cSt
Flash point: 236 ℃
Density at 30℃: 0.851 Kg/L
Pour point: −42℃
Kinematic viscosity at 40℃: 40.8 cSt
Kinematic viscosity at 100℃: 8.0 cSt
Flash point: 236 ℃
Density at 30℃: 0.851 Kg/L

Table 3 shows the information about the oil samples taken from the vehicles. The Totachi oil samples were collected from a Totachi car service shop in Sulaymaniyah, Iraq. The oil samples from the vehicles were taken directly from the sump and kept in closed clean bottles until the day of the analysis. In the scope of this study, the Cleveland open cup flash point method according to the tester manual, NCL 120, Normes: ASTM D 92, IP 36, ISO 2592 was used to determine both the flash point and the fire point of the used oil. A thermometer with a 300°C measuring range was used to measure the flash point and fire point temperatures. To determine the kinematic viscosity of the oil, a KV1000 kinematic viscosity bath was used with a variable limit control according to the ASTM D445 stipulations. A Koehler viscometer that was manufactured in strict accordance with the ASTM D446 stipulations and calibrated against fully traceable ISO 17025 certified standards, was used. Before the kinematic viscosity test was conducted, the oil was filtered to remove any tiny particles produced as a result of the friction between the moving parts. These experiments were conducted in the petroleum laboratories of the Kurdistan Institute in the Sulaymaniyah province.

Table 3: Vehicle make, model, odometer, and trip length of the samples that were collected

Make	Model	Engine capacity	Engine	Year	Odometer	Trip length (km)
Nissan	Altima	2.5 L	1	2018	52,123–53,146	1023
			2	2017	73,221–75,226	2005
			3	2017	93,423–96,519	3096
			4	2016	88,507–92,534	4027
			5	2017	108,715–113,778	5063
			6	2016	64,802–71,028	6206
			7	2017	85,407–92,505	7098
			8	2017	73,254–81,320	8066
			9	2016	66,004–75,334	9330
			10	2017	72,060–82,154	10,094

3. RESULTS

The test results for the kinematic viscosity, flash point, and fire point of the Totachi engine oil that was extracted from the different gasoline engines (Nissan Altima) are shown in Table 1 and Table 2. The results were modeled using a linear function. The general linear function is calculated as follows:

$$Y(x) = Kx + q \qquad (1)$$

The kinematic viscosity of the Totachi brand gasoline engine oil at cold start as shown in Figure 1 is calculated as follows:

$$v\,(s) = -1.0536\,.\,s + 47.738\;[cSc; Km] \qquad (2)$$

The kinematic viscosity at 40℃ as shown in Figure 2 is calculated as follows:

$$v\,(s) = -1.0945\,.\,s + 41.072\;[cSc; Km] \qquad (3)$$

The kinematic viscosity at 100℃ as shown in Figure 3 is calculated as follows:

$$v\,(s) = -0.3582\,.\,s + 7.9829\;[cSc; Km] \qquad (4)$$

Here, v is the kinematic viscosity and s is the trip length. As shown in Figure 1 Figure 2, and Figure 3, the kinematic viscosity at a cold start, 40°C, and 100°C decreased as the trip length increased.

Figure 4 and Figure 5 show the flash point and fire point for the used lubricating oil, which is also shown in Table 3 and Table 4. According to the figures, the flash point and fire point decreased when compared with the unused oil. The reduction in the values of the flash point and fire point occurred because of the presence of volatile impurities in the oil with increasing trip length. To get the final results of the flash point and fire point, the test was repeated 3 times for every engine oil sample. The average value of the tests for every oil sample was used to determine the rate of deterioration at the flash point and fire point.

4. DISCUSSION

In the Kurdistan region, several types of lubricating engine oil are used in engine lubrication systems. In this study, 0W-20 Totachi international oil brand was used to determine oil viscosity, flash point, and fire point. At a low temperature, thin engine oils pour more easily and have a low viscosity compared to thick oil. The advance of thin oil reduces the friction between the engine’s moving parts, allowing the engine to easily starts evensin cold engines temperatures during cold weather. Engine oil viscosity can be differentiated according to the SAE standard scales.

Table 4: Kinematic viscosity, flash point, and fire point of the engine oil samples

Engine	Oil type	Viscosity at cold start (cSt)	Viscosity (cSt) at 40℃	Viscosity (cSt) at 100℃	Flash point (℃)	Fire point (℃)
	Unused oil	47.2	40.8	8.0	236	248
1	Used oil	45.4	39.9	7.95	229	240
2		45.1	37.2	7.8	220	233
3		43	37	7.55	216	228
4		43.3	35.4	7.49	209	220
5		41.2	32.05	7.44	204	215
6		41	33.5	6.57	205	214
7		39.3	31.6	6.08	203	212
8		38.5	31.1	5.96	199	209
9		37.1	30.8	5.94	198	207
10		36.8	30.2	5.86	196	205

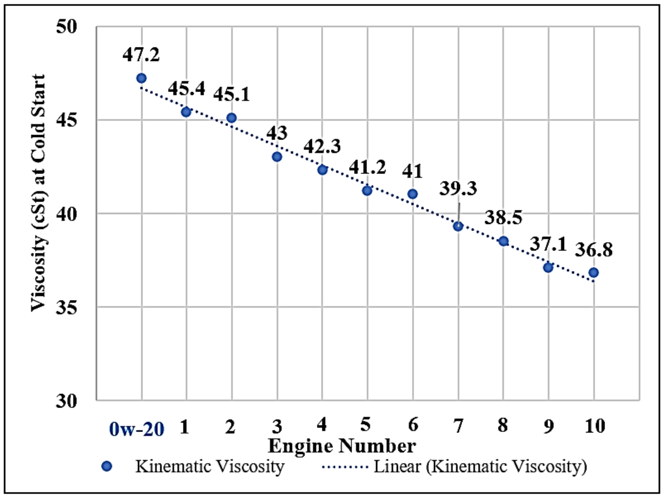

Figure 1. 0W-20 Totachi oil viscosity at cold start after different trip lengths

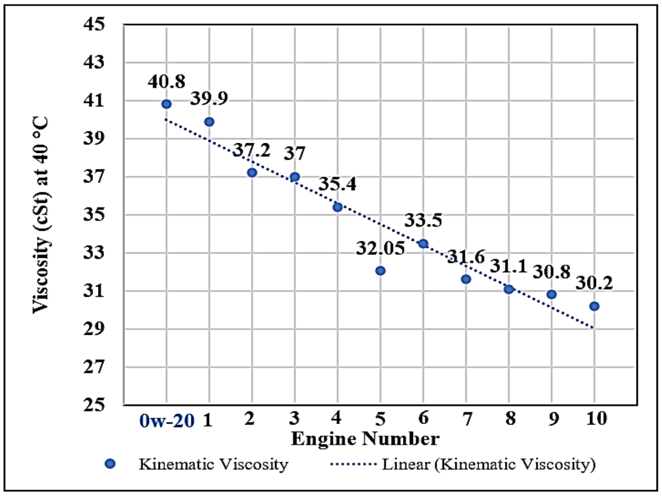

Figure 2. 0W-20 Totachi oil viscosity at 40°C after different trip lengths

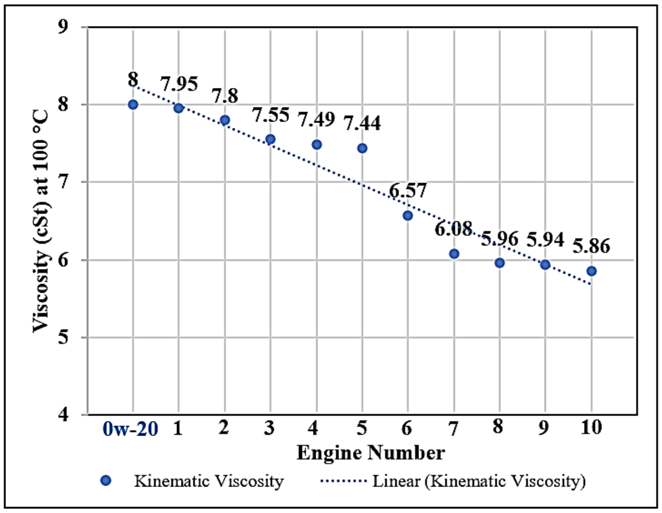

Figure 3. 0W-20 Totachi oil viscosity at 100°C after different trip lengths

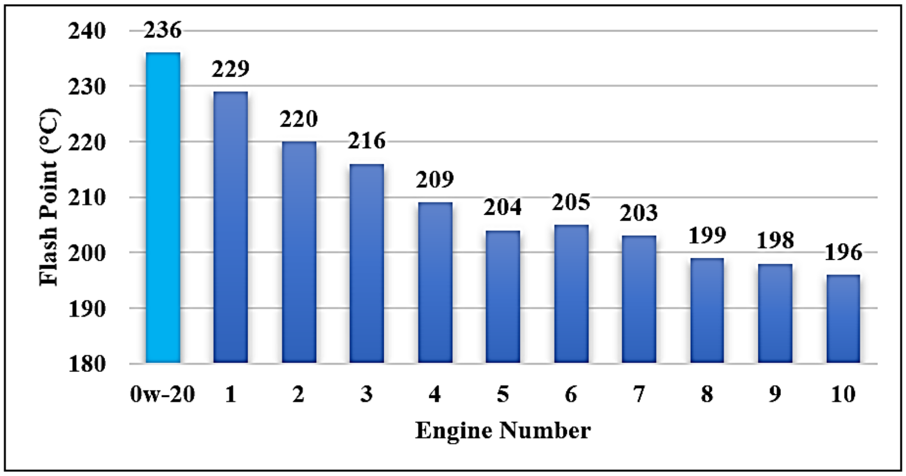

Figure 4. 0W-20 Totachi oil flash point after different trip lengths

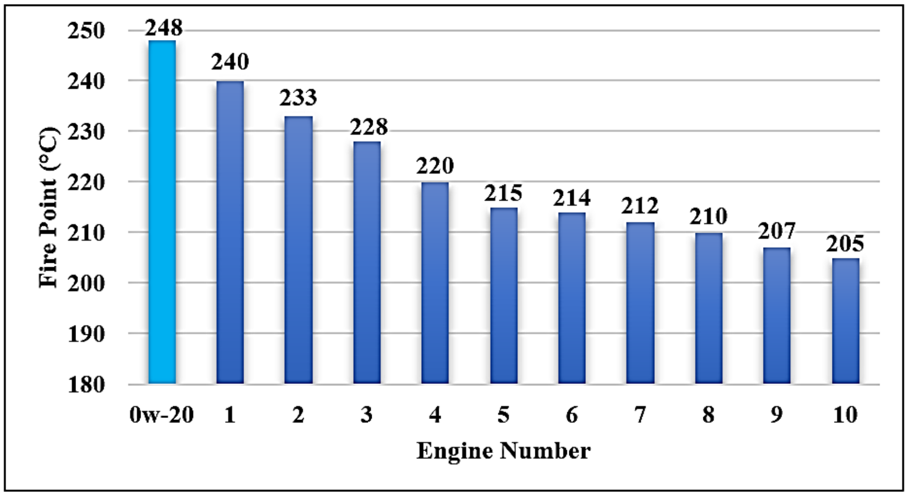

Figure 5. 0W-20 Totachi oil fire point after different trip length

The number after “W” indicates the oil’s viscosity at 100°C and represents the oil’s resistance to thinning at high temperatures. The oil viscosity decreases because of dilution with gasoline, whereas it may also increase because of contamination or oxidation (Abro et al., 2013). According to Figure 1 at a cold start after an increased trip length, the oil viscosity decreased from 47.2 cSt to 36.8 cSt, corresponding to a 22.03% decrease in the viscosity. In Figure 2, when the trip length increased, the viscosity at 40°C decreased from 40.8 cSt to 30.2 cSt, corresponding to a decrease of 25.98%. In addition, the viscosity at 100°C as shown in Figure 3 decreased from 8 cSt to 5.86 cSt, corresponding to a decrease of 26.75%.

To determine the flash point, approximately 50 mL of the used engine oil was placed in the special cup on an electrical heater, which was fitted with a thermometer. The heating rate was adjustable by using an energy regulator on the front panel of the NCL 120. To determine at which temperature a flash appeared on the surface of the cup, a flame source was used and moved every time a 3°C increase in the temperature was measured on the thermometer. As recorded in Table 2 the flash point of the unused oil was 236°C. For the used engine oil, the flash point decreased continuously from 1000 km to 10,000 km. As shown in Figure 4 the flash point decreased from 236°C to 196°C, corresponding to a loss of 16.94%. The reduction in the flash point occurred because of the presence of contaminants.

Another property of the oil that continuously decreased as the trip length increased was the fire point. The fire point of the unused oil was 248°C (Table 4). The fire point after 10,000 km was 205°C, as shown in Figure 5. This is a decrease of 17.34%. The reduction in the fire point indicates an increase in the amount of impurities in the used oil.

5. CONCLUSION

Engine oil lubricants are used in engines to decrease the friction between the moving parts, for cooling, and to prevent corrosion. In this study, SAE 0W-20 extra fuel economy Totachi brand international engine oil was used in 10 different engines to determine the change in the oil properties by focusing on how the viscosity, flash point, and fire point of the lubricating engine oils decreased after being used for different trip lengths. These parameters are the most important physical characteristics of lubricating engine oils. In the experimental work, the viscosity at a cold start, at 40°C, and at 100°C, the flash point, and the fire point were determined.

According to the test results, all of the engine oil parameters degraded after 10,000 km. The viscosity at cold start, at 40°C, and at 100°C decreased by 22.03%, 25. 98%, and 26.75%, respectively. In addition, the flash point decreased by 16.94%, and the fire point decreased by 17.34%. Therefore, based on the results of the above experiments, it is recommended that drivers should change their engine oil before the due distance to avoid any eventualities and unexpected damage to their engines. Another conclusion that drivers can draw from this study is that instead of changing their engine oil every 3000 km as required when using a low-quality oil, they can instead opt to change their oil every 10,000 km with greater peace of mind by using better engine oil types.

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