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The Effectof Engine Oil Viscosity On Fuel Consumptionand Exhaust Emissions

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ABSTRACT: *The global warming problem has been becoming more serious. The pollution caused by mobile pollution sources is the most serious. This research investigated the effect of the engine oil viscosity on exhaust emissions and fuel consumption. Three different oil brands with three different viscosities were used. Two vehicles with different mileage were used for testing. The results showed that static and dynamic pollution values for the oil with 5w20 viscosity for the car with lower mileage were better than those for the oil with the other two viscosities. While the static and dynamic pollution values for the oil with 5w30 and 5w50 for the car with higher mileage were better than those for the oil with 5w20. Therefore, it is recommended to use 5w30 or 5w50 oil, because the oil film can fill the gap and reduce exhaust emission pollution. In terms of dynamic exhaust emission, viscosity 0w20 was slightly better than viscosity 5w30 and viscosity 5w50. For average fuel consumption it is recommended to use 0w20 to achieve the best fuel economy.*

KEY WARDS: *Pollution, Engine oil, Viscosity, Fuel consumption.*

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I. INTRODUCTION

Engine oil lubrication has been used since ancient Egypt. When moving building stones, natural grease and moist soil were used to reduce ground resistance to achieve lubrication. Today lubricating oil is used in internal combustion engines. Its main function is lubrication but it also provides sealing, cooling, cleaning, and anti-rust functions. The oil used in the market today is petroleum oil plus additives. Therefore, basic oils can be divided into fully synthetic, semi-synthetic and mineral oils. All three are composed of carbon and hydrogen. However, global warming has become increasingly more serious. In 2009 Fontaras et al. used actual diesel vehicles and bench testing with low-viscosity lubricants [1]. The test results showed that the bench results and vehicle test results were consistent. However, at some operating points the lubrication effect was enhanced, and differences in pollutant emissions were observed. Low viscosity lubricants reduce emissions in most instances[1]. In 2014 the effect of motor oil on specified emissions, particulate matter and fuel economy was studied by Jang et al [2]. Gasoline and diesel vehicles were tested using three oils of the same SAE grade. The test results showed that neither type of oil would significantly affect the vehicle emissions or fuel economy [2].

In 2016 low-viscosity grade oils of SAE 0W-20, SAE 5W-30, and SAE 20W-40 were selected as base oils by Sehgal et al [3] to evaluate the effect of the engine oil on diesel vehicle power, fuel economy and emissions. The test results showed that higher fuel economy and lower emissions were obtained with lower viscosity oils [3]. In 2018 Premnath et al. used low volatility, low ash oil, and high volatility, high ash content oil to investigate the effect of these two oil on the particulate matter and ash. The test results showed that particulate matter and ash increased with high volatility and high ash [4]. In 2020 Wang et al. used eight 0W20 engine oils with different doses of added viscosity modifiers (VMs) and friction modifiers (FM) for mixed oil testing. The test results showed that 0W20 oils can help reduce carbon dioxide (CO_2) emissions and improve average fuel consumption [5]. In 2021 Wang et al. used 5w30 as the base oil and three different 0W20s to test parameters such as oil viscosity, ash content and element content. The test results showed that the impact of low-viscosity oil on exhaust emission reduction was mainly concentrated in the low-speed and high-speed stages. Reduced carbon monoxide (CO), total hydrocarbons (THC), and non-methane hydrocarbons (NMHC) emissions were found during low-speed starts [6]. In this study three different brands of engine oil were used in two vehicles with different mileages to evaluate the effect of the oil on the fuel economy and exhaust emissions.

II. PROCEDURESAND METHODS

This section describes the experimental procedures and methods. Three oil brands at three viscosity levels were used to test fuel economy and exhaust emissions for two vehicles with different mileages. The fuel economy and exhaust emission were measured using the three brands of oil at three different viscosities. The measured values would then be analyzed and interpreted to understand the impact of various viscosities on exhaust emissions and fuel economy.

2.1 Procedures

The experimental procedures are shown in Fig. 1. The three different brands and viscosities were chosen.

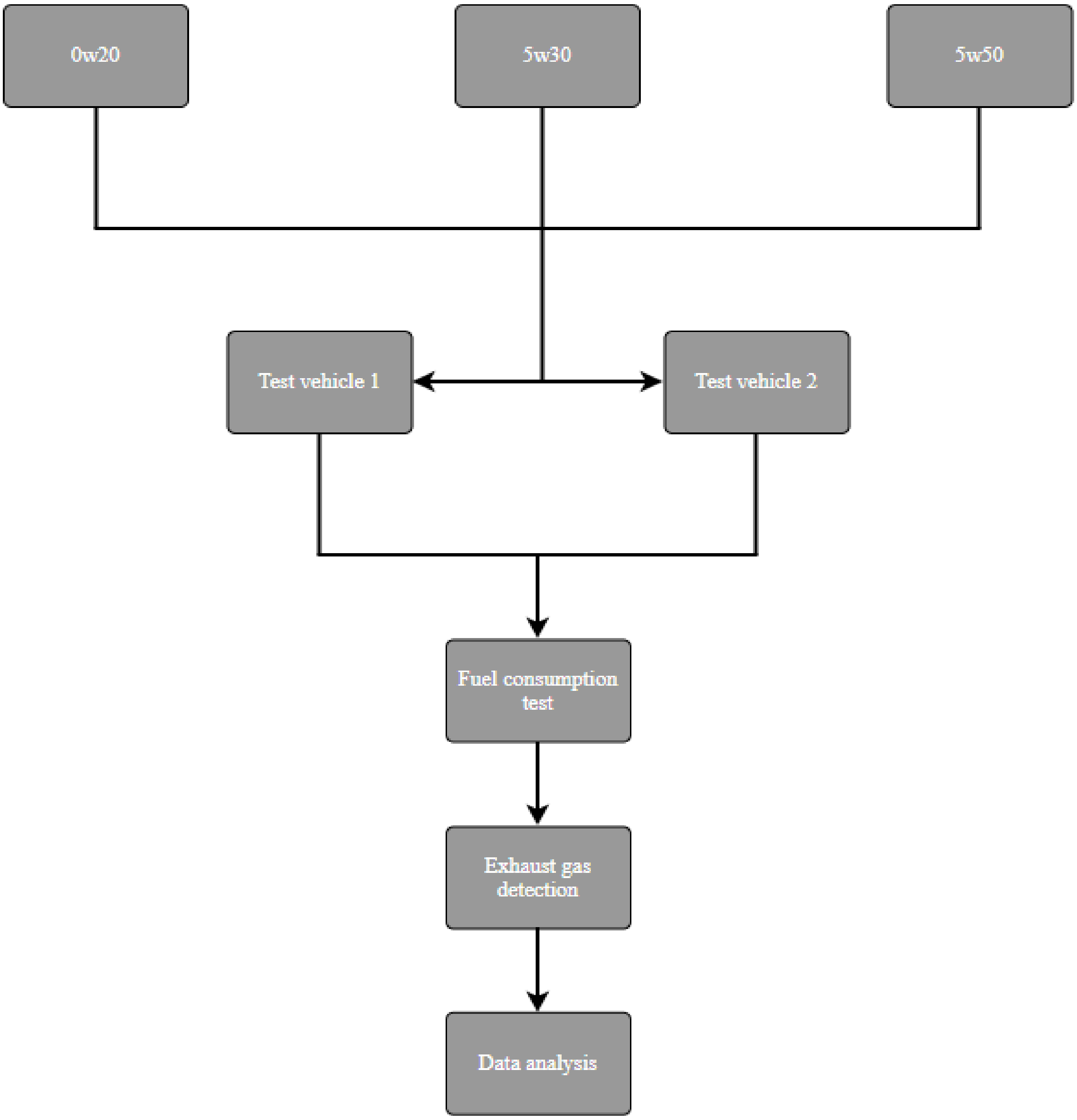

Figure1: Experimental procedures

2.2 Methods

First of all, before starting the experiment, the weather temperature and wind speed of the day should be considered for the test. The weather conditions for the test were collected, as shown in Table I below. The temperature was about 29~31℃and the wind speed was 1~2 level.

***Table I.* The weather conditions for the test**

Date	May 11th	May 17th	June 3th
Temperature of the day	29℃	31℃	31℃
Wind speed of the day	1~2 level	1~2 level	1~2 level

After the weather condition was confirmed, the oil change for the first test vehicle was carried out in the evening as shown in Fig. 2. The test route included highway, expressway and surface street as shown in Fig. 3.

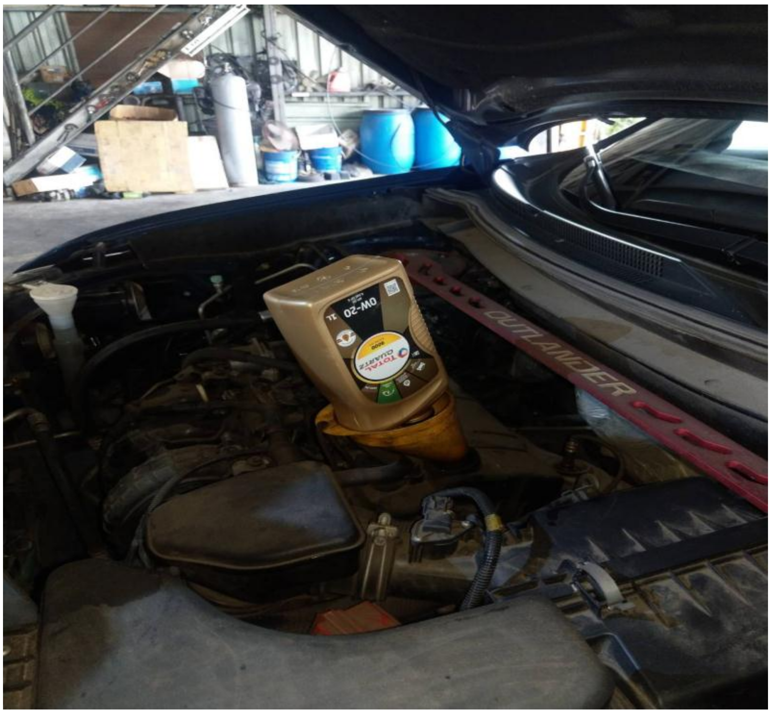

Figure 2: Engine oil change

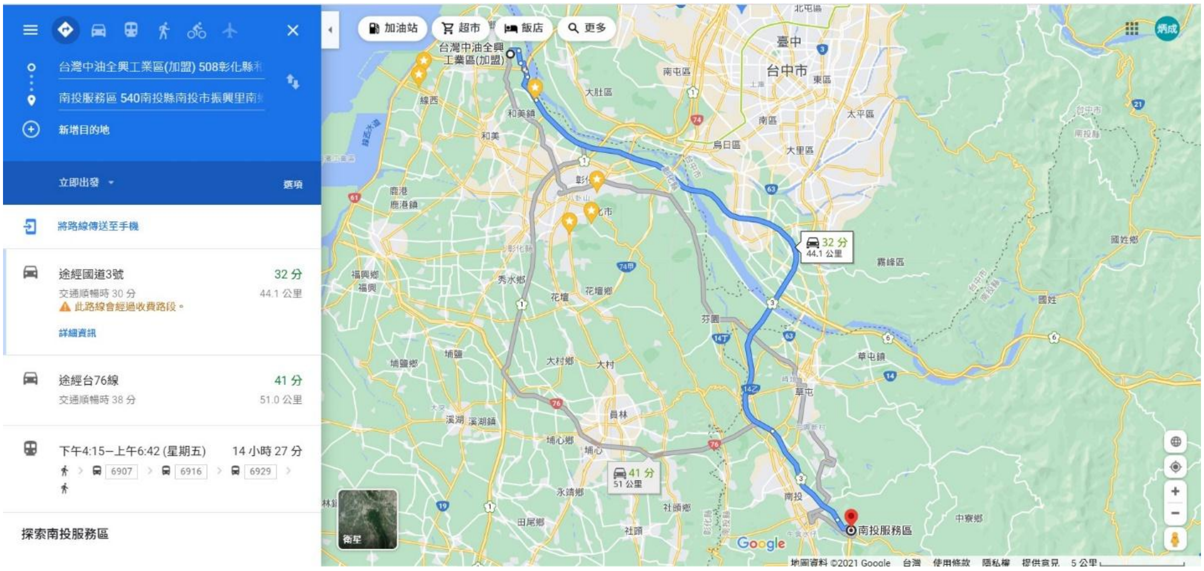

Figure 3: Test route

In order to prevent the measured data from being affected by certain external factors, some factors would not be changed such as vehicle speed and air-conditioning temperature.When returning to the gas station, the fuel economy data was recorded. The fuel economy data included the average fuel consumption from OBD, ECU, and actual fuel consumption as shown in Table II. After recording the fuel economy data, the exhaust emissions were measured the next morning as shown in Fig. 4 and Fig. 5.

Table II. Fuel economy data

Average fuel consumption (OBD)	14.5km/L
Average fuel consumption (ECU)	15.6km/L
Average fuel consumption (actual fuel consumption)	18.1km/L

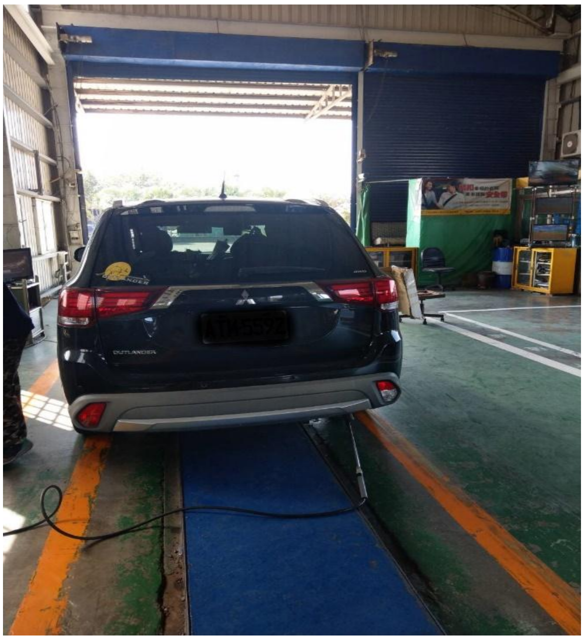

Figure 4: Exhaust emission measurement

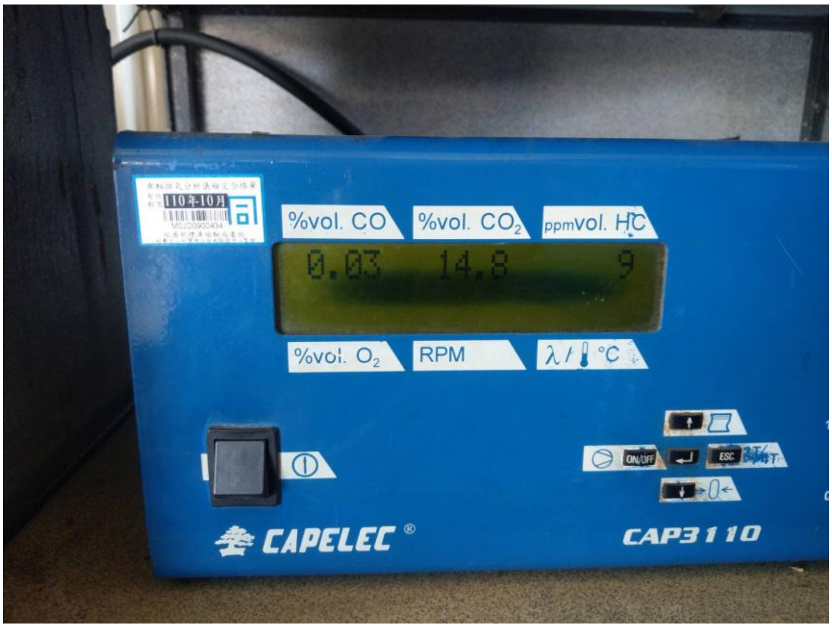

Figure 5:The value of exhaust emission data

The experimental test vehicles were Outlander models. The year and month for these vehicles were November 2017 and December 2017, respectively. The vehicle mileage for the December 2017 vehicle was about 160,000 kilometers. The mileage for the November 2017 vehicle was about 50,000 kilometers. The test vehicle specifications were shown in Tables III.

***Table III.*Test vehicle specifications**

Vehicle type	Outlander
Year, month	December 2017 and November 2017
Engine type	Naturally aspirated, inline 4-cylinder, SOHC single camshaft, 16-valve
Engine displacement	2359c.c.
Maximum horsepower	168hp/6000rpm
Maximum torque	22.4kgm/4200rpm
Compression ratio	10.5
Gearbox	CVT (continuously variable speed)
Mileage	160000 km and 50000 km

III. RESULTS AND DISCUSSIONS

This section presents some experimental results of fuel economy and exhaust emissions.

3.1 Fuel economy

The fuel economy data of the vehicle with longer mileage for the brand A engine oil with three viscosities 0w20, 5w30, and 5w50 are shown in Fig. 6.

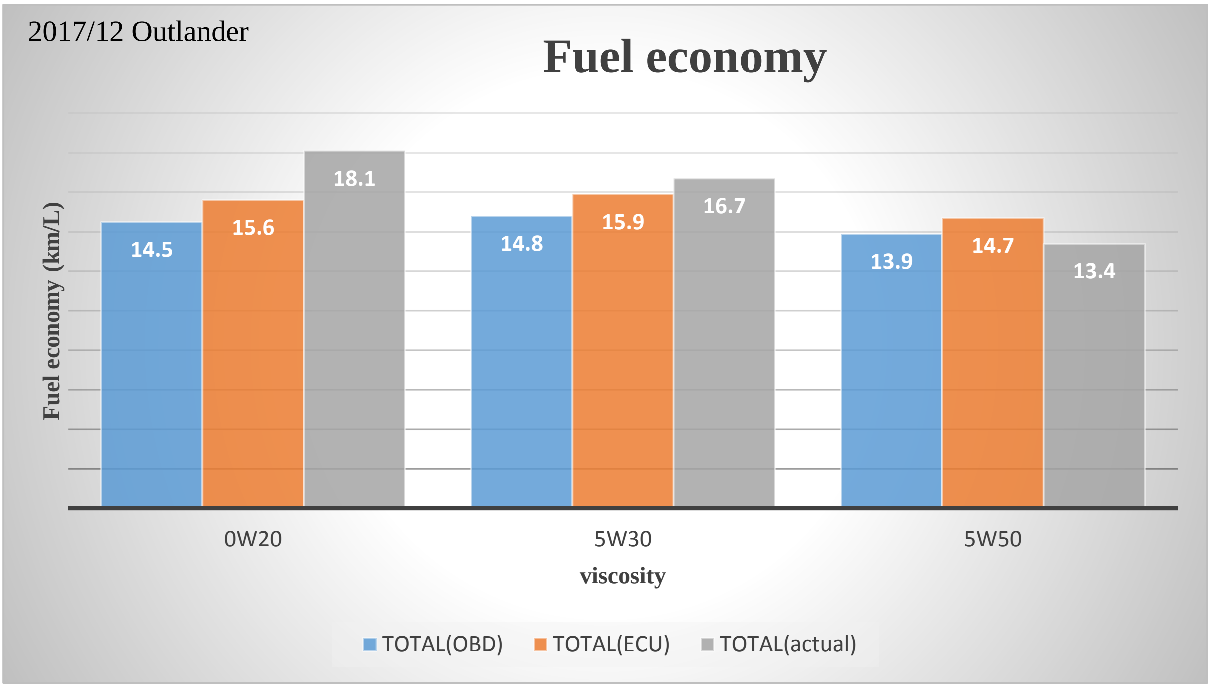

Figure 6: The fuel economy data of the vehicle with longer mileage for the brand A engine oil with three viscosities

From the figure, it can be seen that the ECU fuel economy for the engine oil with 5w30 viscosity seem to be the best. The possible reason is that the mileage of this test vehicle has already reached 160,000 kilometers. When the mileage of a vehicle has reached 160,000 kilometers, it actually means that the engine clearance is very large. Because the oil film thickness of 5w30 oil is thicker than that of 0w20 oil, it fills the gap in the engine clearance and makes its combustion efficiency better. Therefore, the fuel economy would be better than that with 0w20 oil. However, after testing 5w50 engine oil, it was found that engine oil with 5w50 viscosity is too viscous. Although its oil film thickness is enough to fill the gap, the high viscosity oil has poor fluidity and great running resistance. This would lead to poor combustion efficiency and poor fuel economy.

The fuel economy data of the vehicle with longer mileage for the brand B engine oil with three viscosities 0w20, 5w30, and 5w50 are shown in Fig. 7.

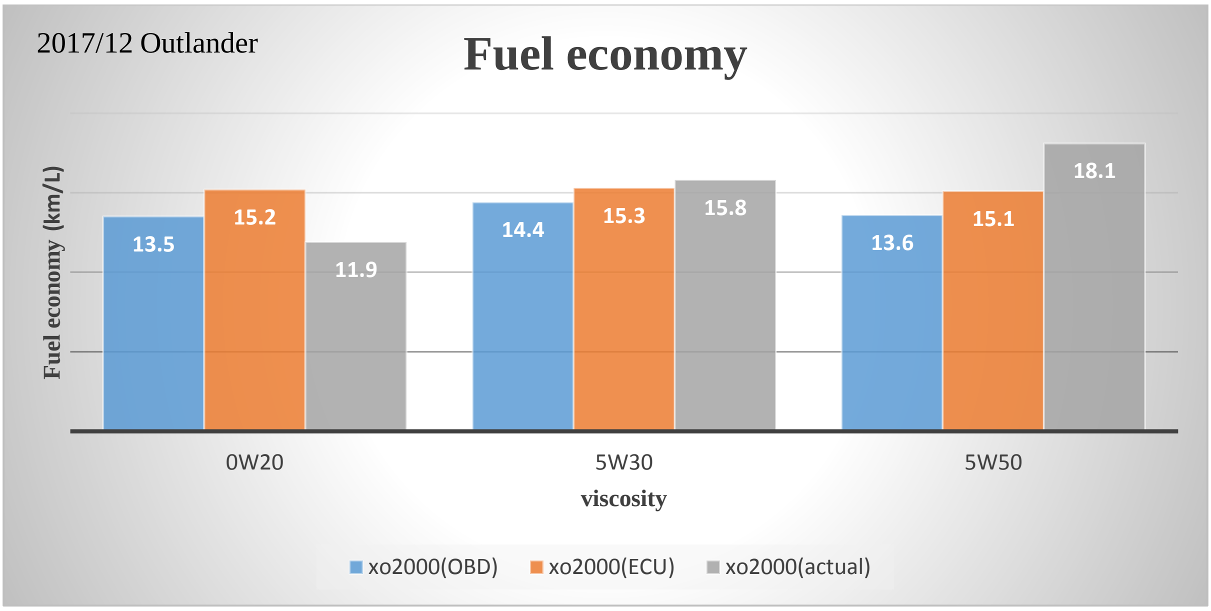

Figure 7: The fuel economy data of the vehicle with longer mileage for the brand B engine oil with three viscosities

From the above data, it can be seen that the three oil viscosities for engine oil B do not change the ECU fuel economy data much. This does not mean that the exhaust emissions would be relatively small.The fuel economy data of the vehicle with longer mileage for engine oil C for the three oil viscosities is shown in Fig. 8.

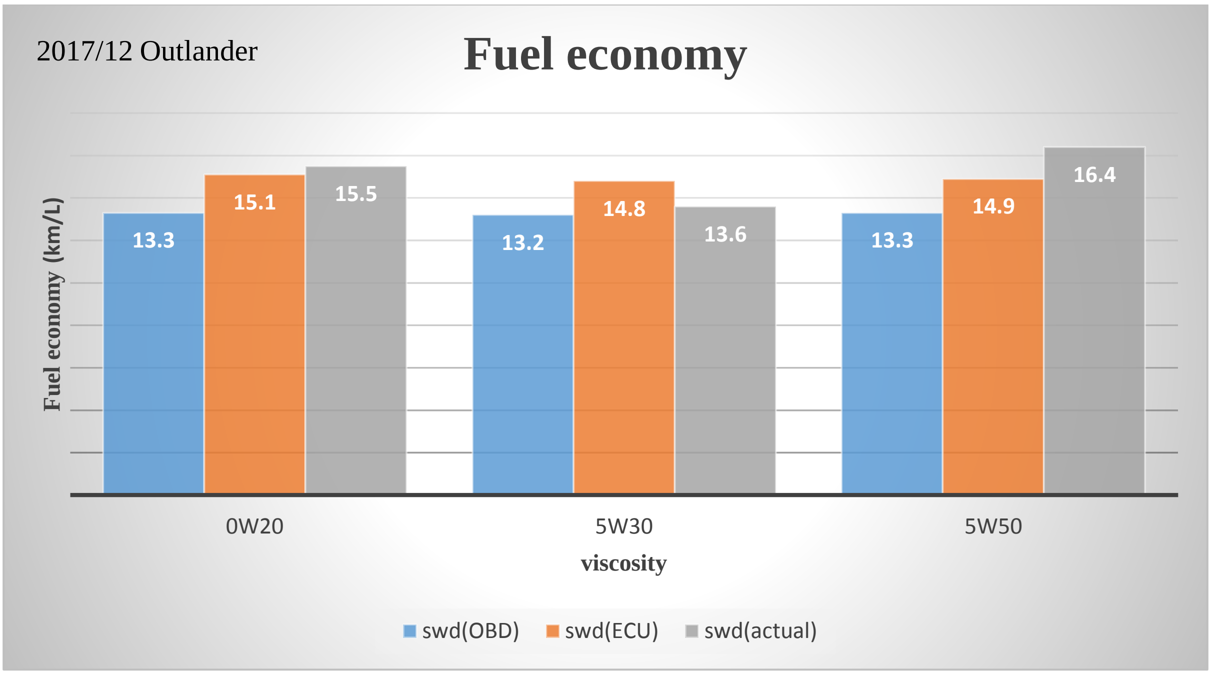

Figure 8: The fuel economy data of the vehicle with longer mileage for the brand C engine oil with three viscosities

From the figure above it can be seen that the ECU fuel economy for the engine oil C with 0w20 oil is better than that with 5w30 and 5w50 oil. This is because brand C engine oil with 0w20 viscosity would probably fit the engine clearance better. The fuel economy data of the vehicle with shorter mileage for the brand A engine oil with three viscosities is shown in Fig. 9. As can be seen from the figure the ECU fuel economy for the engine oil A with 0w30 viscosity is better than that with 5w20 and 5w50 oil. This is because brand A oil with 0w30 viscosity would probably fit the engine clearance better.

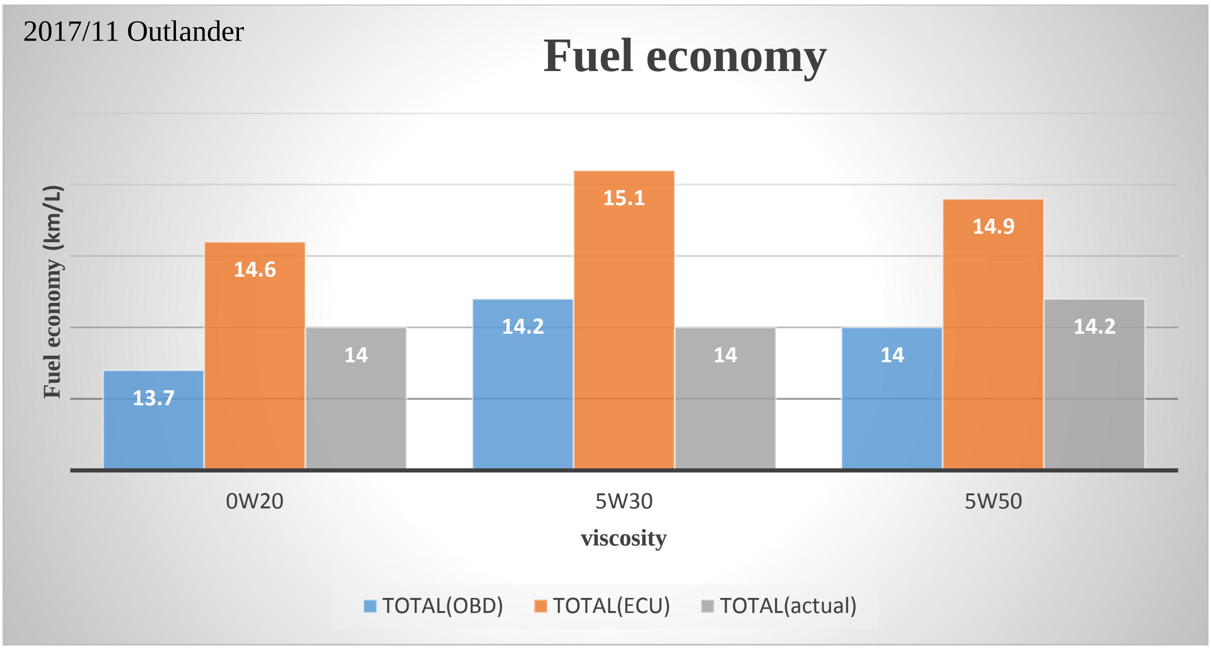

Figure 9: The fuel economy data of the vehicle with shorter mileage for the brand A engine oil with three viscosities

The fuel economy data of the vehicle with shorter mileage for the brand B engine oil with three viscosities is shown in Fig. 10. It can be seen that the ECU fuel economy for the engine oil B with 0w30 viscosity is better than that with 5w20 and 5w50 oil. This is because brand B oil with 0w30 viscosity would probably fit the engine clearance better.

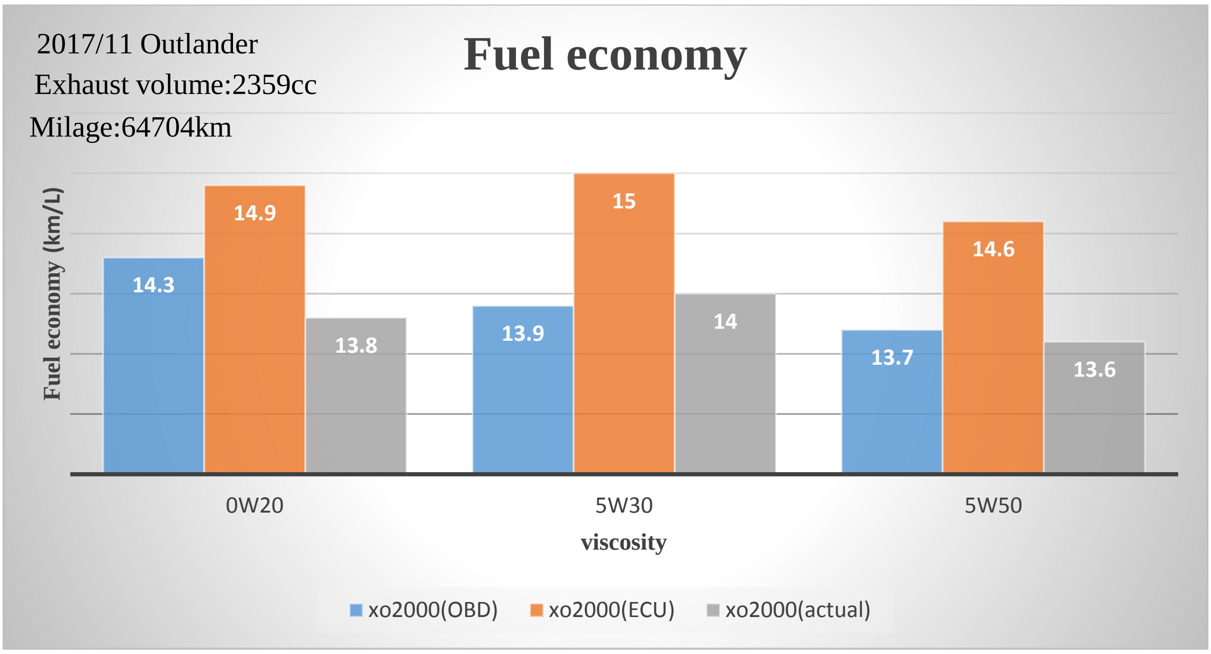

Figure 10: The fuel economy data of the vehicle with shorter mileage for the brand B engine oil with three viscosities

The fuel economy data of the vehicle with shorter mileage for the brand C engine oil with three viscosities is shown in Fig. 11. From the figure we can see that the ECU fuel economy for the engine oil C with 0w20 viscosity is better than that with 5w30 and 5w50 oil. This is because brand A oil with 0w20 viscosity would probably fit the engine clearance better.

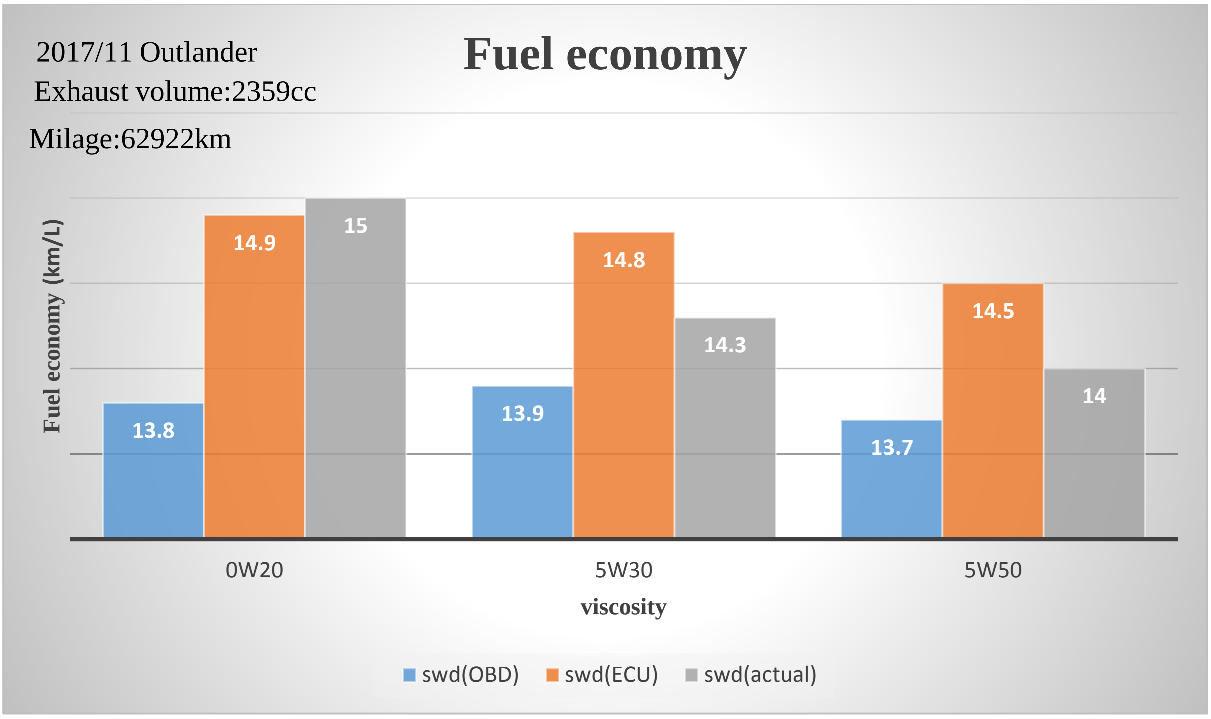

Figure 11: The fuel economy data of the vehicle with shorter mileage for the brand C engine oil with three viscosities

From the above figures, it can be seen that the fuel economy of the vehicle depends on the brand of the engine oil and the vehicle mileages. However, we can conclude that engine oil with 5w30 viscosity works better for the fuel economy.

3.2 Exhaust emission

In the experiment the effect of the different bands of the engine oil with different viscosities on the exhaust emissions of the vehicle with different mileages has been also investigated. Figs. 12, 13, 14, 15 show the CO and HC emissions of the vehicle with longer and shorter mileages for different brands of the engine oil with different viscosities. As can be seen from the figures the engine oil with 5w30 viscosity could work better for the CO and HC emissions.

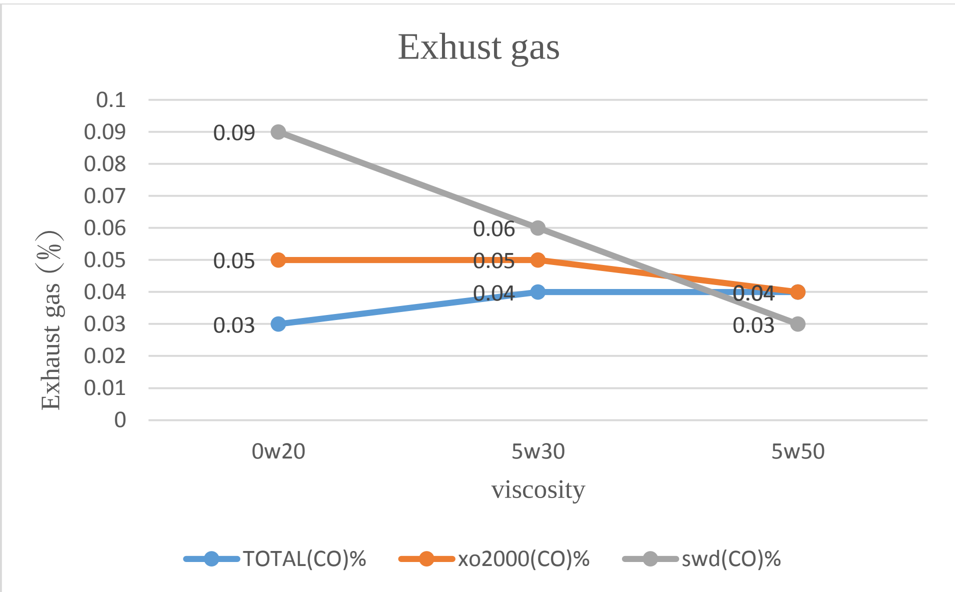

Figure 12: CO exhaust emissions of the vehicle with longer mileage for the different brand engine oil with different viscosities

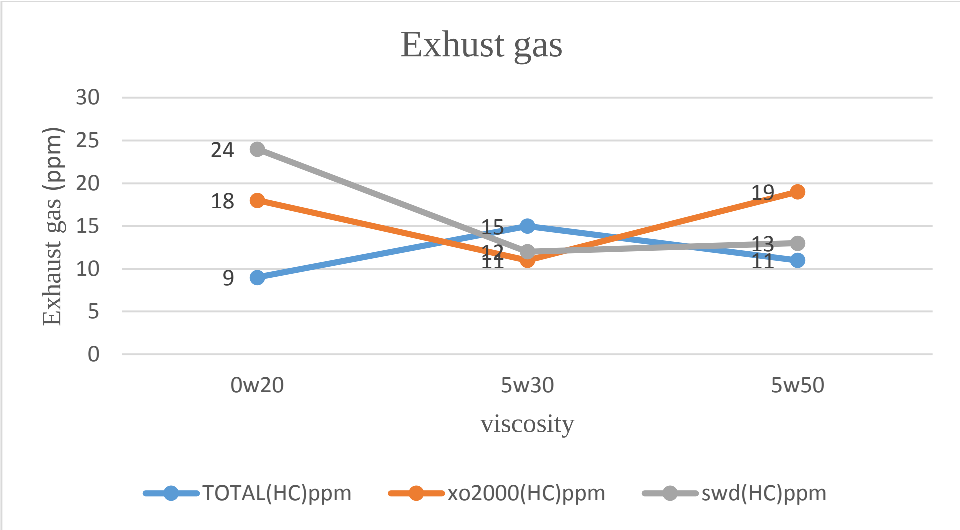

Figure 13: HC exhaust emissions of the vehicle with longer mileage for the different brand engine oil with different viscosities

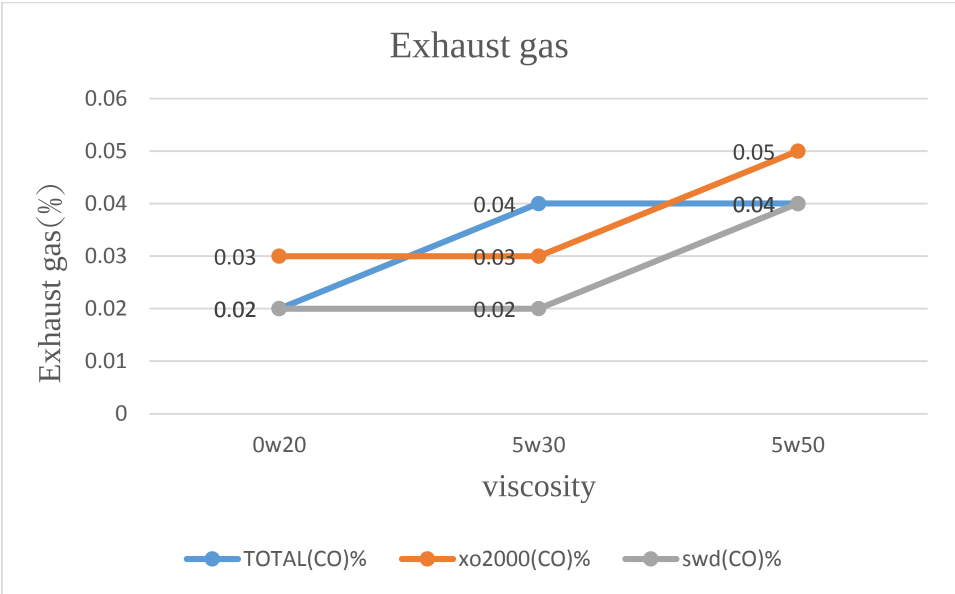

Figure 14: CO exhaust emissions of the vehicle with shorter mileage for the different brand engine oil with different viscosities

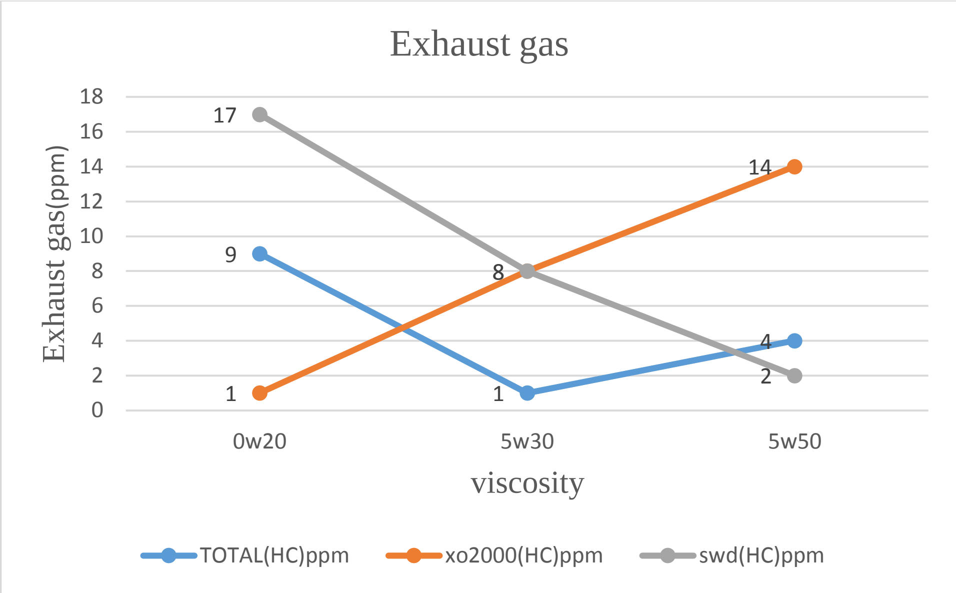

Figure 15: HC exhaust emissions of the vehicle with shorter mileage for the different brand engine oil with different viscosities

IV. CONCLUSIONS

This study investigated the effect of the different brand engine oil with different viscosities on the fuel economy and exhaust emissions for the vehicle with longer and shorter mileages. The results showed that the engine oil with 5w30 viscosity could work better for the CO and HC emissions. Although the fuel economy of the vehicle depends on the brand of the engine oil and the vehicle mileages. However, we can conclude that engine oil with 5w30 viscosity works better for the fuel economy. Therefore, the engine oil with 5w30 viscosity could work better not only for the fuel economy but also for the exhaust emissions.

REFERENCES

[1]. G. Fontaras, E. Vouitsis, and Z. Samaras, (2009). "Experimental evaluation of the fuel consumption and emissions reduction potential of low viscosity lubricants", SAE Technical Paper, 6 (2), 16-24.

[2]. J. Jang, Y.-J. Lee, O. Kwon, M. Lee, and J. Kim, (2014)."The effect of engine oil on particulate matter, emissions and fuel economy in gasoline and diesel vehicle", SAE Technical Paper, 3 (2), 32-38.

[3]. S. K. Singh, S. Singh, and A. K. Sehgal, (2016)."Impact of low viscosity engine oil on performance, fuel economy and emissions of light duty diesel engine", SAE Technical Paper, 4 (1), 12-19.

[4]. V. Premnath, I. Khalek, P. Morgan, A. Michlberger, M. Sutton, and P. Vincent, (2018). "Effect of Lubricant Oil on Particle Emissions from a Gasoline Direct Injection Light-Duty Vehicle", SAE Technical Paper, 7 (3), 25-32.

[5]. Y. Mo, J. Wang, Y. Hong, X. Yang, and J. Lv, (2020)."Study on the Influence of Low-Viscosity Engine Oil on Engine Friction and Vehicle Worldwide Harmonized Light Vehicles Test Cycle Fuel Economy", SAE Technical Paper, 6 (3), 21-28.

[6]. J. Wang, Y. Mo, Y. Hong, Q. Liu, and J. Lv, (2021)."On the Effect of Low-Viscosity Oil on Automobile Pollutant Emissions Based on Worldwide Harmonized Light Vehicles Test Cycle", SAE Technical Paper, 2 (3), 22-29.

[7]. R. D. Whitby, (2005)."New European ACEA engine oil specifications", Tribology & Lubrication Technology, vol. 61, no. 3, 56-68.

[8]. D. Waldron, (2006). "IPCC Guidelines for National Greenhouse Gas Inventories–Chapter 3: Mobile Combustion", Energy, Volume 2, 58-70.

[9]. P. Terrie and K. Boguski, (2006). "Understanding units of measurement", Environmental Science and Technology Briefs for Citizens., Volume 5, 23-35.

[10]. M. Fischer, P. Kreutziger, Y. Sun, and A. Kotrba, (2017). "Clean EGR for gasoline engines–innovative approach to efficiency improvement and emissions reduction simultaneously", Energy, Volume 3, 15-26.

[11]. T. Johnson and A. Joshi, (2018). "Review of vehicle engine efficiency and emissions", SAE International Journal of Engines, vol. 11, no. 6, 1307-1330,