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THE EFFECT OF EXHAUST EMISSIONS λ, O_2, CO, CO_2 AND HYDROCARBON FOR PERFORMANCE OF ALL NEW ERTIGA AUTOMOTIVE

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Abstract

The automotive with various and brands, both from Asia and Europe are all here. How much exhaust emissions are produced if each person uses the motor vehicle itself. The purpose of this study is to compare the quality of fuel used with the exhaust emissions of λ, O_2, CO, CO_2 and HC produced. The test method is conducting sampling tests on All New Ertiga and testing emissions using a Gas Analyzer Tester. The fuel variants used in the emission testing process are pertamax, pertamax + octan booster, pertamax turbo and pertamax turbo + octan booster. With several variants of fuel used, can find effect λ, O2, CO, CO_2 and HC produced on these automotive. The best engine performance at 115 Nm of torque with emissions are still below TLV (threshold limit value) for pertamax, while for pertamax turbo the best performance at 120 Nm with emissions below TLV.

Keywords: *Fuel, Emission, Engine Performance*

1. INTRODUCTION

Exhaust emissions are an environmental issue of global concern in the last decade. Emissions from automotive that use are one of the main sources of air pollution in cities around the world. Exhaust emissions contain various harmful compounds, such as hydrocarbons, nitrogen oxides, carbon monoxide, and other small particles, these emissions have an impact on air pollution, climate change, and public health impacts [1]–[3]. To reduce its negative impact, many countries have adopted strict regulations related to exhaust emissions, as well as encourage the development of more environmentally friendly automotive technology. However, despite efforts, the problem of gasoline exhaust emissions remains a significant and relevant issue in the context of environmental protection and public health and safety [4], [5].

The development of technology in the automotive industry as a supporting tool can provide convenience and comfort for human needs. In the field of transportation, especially land transportation, automotivies are a very important means of transportation both with gasoline and diesel engines. Since the invention of the gasoline engine and diesel engine by Nikolas Otto with Rudolph Diesel in 1876, the automotive world has developed rapidly to this day [6]. A gasoline engine is an engine that uses air mixed with gasoline to generate power in today's automotive. In gasoline engines, air and fuel are generally mixed before entering the combustion chamber, and the mixing of air and fuel is carried out by a carburetor or injection

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system. Fuel mixed with air flows into the combustion chamber and is compressed in the combustion chamber, then produced by an electric spark from the spark plug [7], [8].

Currently a trend among vehicle owners, emission tests are carried out to determine the performance of their vehicles. Good vehicle performance is low fossil oil consumption with very low pollution levels. Engine with fossil oil specifications pertamax and pertamax turbo if using fosiI oil below Ron 92, then engine performance is not good, but if the vehicle with small compression fuel fosil pertamax Ron 98, then performance has no effect it's just the temperature mes [9].

Several studies related to the performance of vehicles or internal combustion automotive engines by previous researchers [10–15], While the purpose of this study is to determine the ratio of exhaust gas output if using pertamax and pertamax turbo fossil oil, knowing the comparison of exhaust gas output if using pertamax fossil oil, pertamax turbo which each of which is added addictive substances and to determine the feasibility of using fossil oil against the emission threshold produced, examination emission includes λ, O_2, CO, CO_2 and HC (lamda, oxigen, carbon monoxide, carbon dioxide and hydrocarbon). While the benefits of this study are provide information that the use of good quality fuel can minimize exhaust emissions released.

2. MATERIALS AND METHODS

The location of data collection was carried out in the periodic testing of the Sidoarjo Regency Transportation Office, Jalan Raya Candi number 107, Sidoarjo - East Java, which was carried out in December 2023. While the fuel used in this experiment are pertamax, pertamax turbo mixed with octane booster. Pertamax is known as a high-octane gasoline, used for engines with a higher compression level, Pertamax has an octane of about 92 or more, which means this fuel has a better ability to withstand detonation. The use of pertamax can help improve engine efficiency and performance. Pertamax turbo is designed to improve engine performance and reduce exhaust emissions. Pertamax turbo also contains detergent additives that help clean fuel injectors and vehicle fuel systems that can improve combustion efficiency. Octane booster is a chemical additive added to fuel, especially gasoline, to increase the octane number.

2.1. Experimental apparatus

The study was conducted to determine the comparison of λ, O_2, CO, CO_2 and HC emissions released by automotivies. The data used to determine the feasibility of exhaust emissions will be associated with the TLV (threshold limit value) by the Ministry of Environment, the mechanism of the data retrieval image scheme as shown in Figure 1.

a. Examination for measure the levels of λ, O_2, CO, CO_2 and HC and engine capabilities. The tools used are CO HC Tester certus brand and Speedometer tester brand Iyasaka owned by the Periodic Automotive Testing of the Sidoarjo Regency Transportation Office.

b. Instrumentations and Materials Preparation.

   Before examination, provide automotive and ensure that the All New Ertiga has been given regular service and there are no problems. Researchers also ensure that the test equipment to be used has been calibrated as evidenced by a Certificate of Statement, issued by the Ministry of Transportation..

c. Process of Examination and Data Retrieval.

   The first test process was using the pertamax with an engine 800 rpm. Examinations with several variants of rotating for 1500, 3000, 4500 and 5500 rpm. When testing the front

automotive wheels put on the Roller Speedometer Tester and wait until the front wheels go down. Once ready then insert the prop λ, O_2, CO, CO_2 and HC of tester into the automotive. Once the test equipment is ready and the automotive is ready to examinations. Subsequent tests used the same fuel but the fuel used was mixed using octane booster. The final testing used pertamax turbo and was the same as in the first and second tests. Each test that has been carried out is recorded and collected and carried out a thorough analysis.

d. Data Processing

The processing of data that has been collected is summarized based on groups and made a summary to answer the benefits and benefits obtained from the research that has been carried out.

e. Decision and Conclusion

The conclusion of the data obtained by the researcher refers to the Regulation of the Minister of Environment and Forestry number 08 year 2023 concerning the application of automotive emission quality standards for category M, category N, category O, and category L.

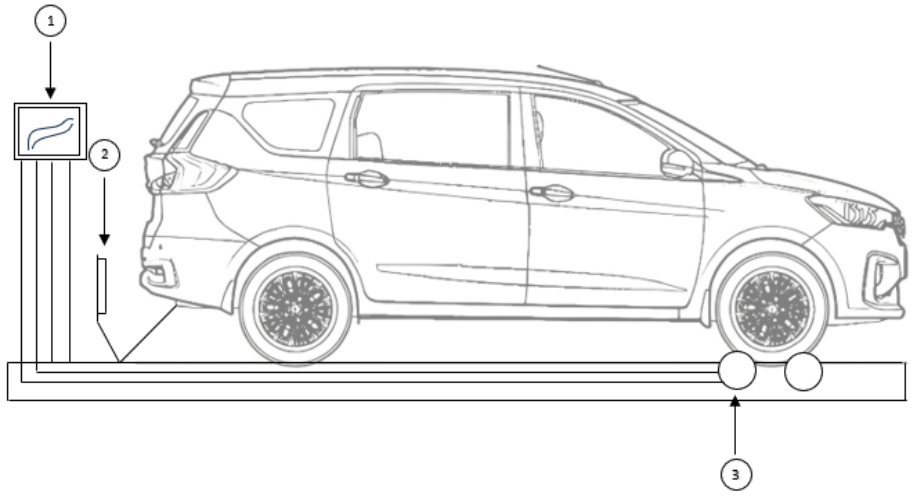

Figure 1. Torque, power and exhaust emission scheme examination, 1) monitor dynamometer, 2) emission monitor, 3) roll dynamometer.

The combustion process in the cylinder will produce pressure for the piston, this pressure will convert it into a force that will cause the crankshaft to rotate causing rotational power or torque, the amount of torque is formulated as follows [6], [7]:

$$T = F \,.\, r \qquad (1)$$

Where T is torque (N.m), F is the force acting on the piston (N) and r is the length of the shaft arm (m). The shaft will drive the load so that the power used in the internal combustion engine is the shaft power, the magnitude of shaft power can be formulated as follows [6], [7]:

$$Ne = \frac{2\,.\pi.n.T}{60000} \qquad (2)$$

Where Ne is effective power (kW), T is torque (kg.m), n is engine speed (rpm), 1 Kw = 0.7457 HP, 1 PS = 75 Kg.m/s = 0.9863 Hp and 1 kg.m = 9.807 Nm.

2.2. Standar Operasional Prosedur

Data collection was carried out using standard operating procedures issued by the Automoive Periodic Testing Unit of the Sidoarjo Regency Transportation Office East Java Number: SOP-DlSHUB/PKB-02 dated January 1, 2007 concerning Guidelines for Conducting Automoive Exhaust Emission Tests, as for the data collection process as shown in Figure 2-4.

Figure 2. All New Ertiga Engine
Model K14B DOHC-VVT 4 Cylinder
16 Valve
Engine capacity 1.373 cc
Maximum Power 95 Ps / 6.000 rpm
Maximum Torque 130 Nm / 4.000 rpm

Figure 3.
Speed examination
equipment with
specifications:
Merk : Iyasaka
Type : SMT 1000

Figure 4.
Tools of equipment
λ, CO, CO_2, O_2, HC
Merk : Certus
Type : VMD400

3. RESULTS AND DISCUSSION

The following data can be obtained from tests conducted on the All New Ertiga at The Sidoarjo Regency Motor Vehicle Testing. The first study used Pertamax fuel with 5 tests on engine speeds of 800, 1500, 3000, 4500, and 5500 rpm with a test time of 60 (sixty) seconds, Data exampa on the first fuel levels of λ, O_2, CO, CO_2 and HC which were produced the greatest at 800 rpm engine speed with torque of 20 Nm as for the data as shown in Table 1 and Table 2.

This test is very good if at 5500 rpm the emission is smaller with more torque, O_2 that is produced tends to rise from engine speed 800 - 5500 rpm. While the test results carried out on the All New Ertiga with the first fuel of 60 seconds coupled with octane booster produced CO and HC levels of at most 0.85% and 130 ppm. Power generated at 5500 rpm of 76 PS is 100% greater than at 800 rpm of 6 PS.

In pertamax turbo fuel produces the least power of 7 PS by producing the largest emissions, namely CO by 0.75% and HC 130 ppm. This data is the opposite if the engine speed of 3000 rpm the power produced is greater 5 times by 35 PS. While the CO and HC produced are smaller than the 800 rpm test. Pertamax turbo fuel with an additional octane booster above 800 rpm which is carried out for 60 seconds produces 88.9 Nm of torque with an HC of 57 ppm. While the next rotation of torque produced is greater and the power is greater than 100% than the 800 rpm rotation. Testing at 5500 rpm the power produced 80 PS with the lowest emission output at 0.60% with HC 97 ppm.

Table 1. Result test performance with fuel of pertamax and pertamax turbo

Rpm	Torque Nm	Power PS	λ	CO %	CO_2 %	HC ppm	O_2 %
Pertamax							
800	20	6	0.995	0.85	10.9	135	5.4
1500	49	16	1.005	0.70	10.9	120	5.6
3000	114	32	1.000	0.65	12.1	110	6.1
4500	110	51	0.998	0.63	12.5	105	6.2
5500	100	75	0.992	0.60	13.2	100	7.0
Pertamax turbo							
800	24	7	0.990	0.75	11.0	130	5.5
1500	53	19	1.010	0.70	11.2	118	5.7
3000	118	35	1.007	0.63	12.5	107	6.0
4500	113	65	1.002	0.60	12.8	100	6.2
5500	105	79	0.997	0.55	13.7	95	7.1

Table 2. Result test performance with fuel of pertamax and pertamax turbo with octane booster

Rpm	Torque Nm	Power PS	λ	CO %	CO_2 %	HC ppm	O_2 %
Pertamax with octane booster							
800	21	6	0.999	0.85	11.0	130	5.5
1500	51	18	1.002	0.77	11.3	120	5.6
3000	115	32	1.005	0.70	12.1	110	6.2
4500	111	52	0.998	0.67	12.7	107	6.5
5500	102	76	0.998	0.66	13.5	100	7.0
Pertamax turbo with octane booster							
800	26	9	0.992	0.80	11.0	128	5.6
1500	55	20	0.997	0.73	11.5	115	5.8
3000	120	36	1.005	0.67	11.7	105	6.3
4500	116	66	1.002	0.65	12.5	100	6.5
5500	110	80	0.998	0.60	12.8	97	7.2

3.1. Pertamax and Pertamax Turbo Data Analysis

Tests conducted with pertamax and pertamax turbo fuel can be compared with the results that have come out in the form of torque, power, λ, CO, CO_2, HC and O_2 in shown Figure 5-18:

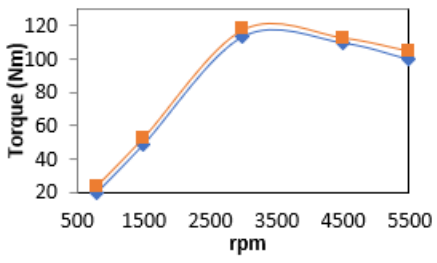

Figure 5. Torque of pertamax (♦) and pertamax turbo (■)

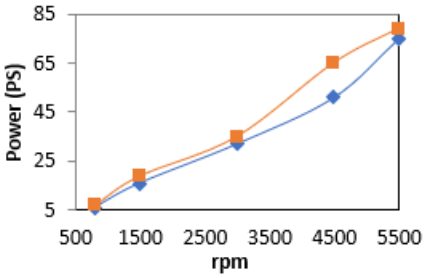

Figure 6. Power of pertamax (♦) and pertamax turbo (■)

Figure 5 shows the difference in torque between pertamax fuel and pertamax turbo. The octane of each fuel affects the torque produced. The octne of pertamax turbo (98) is greater

than pertamax (95) so that the fuel is more resistant to pressure in the combustion chamber. Figure 6 shown the power generated can be seen from the comparison graph. The graph above shows that the engine speed of 3000 to 4500 experienced a very significant increase when compared to the rotation of 800 to 1500, this happened because of the difference in torque produced in the previous graph.

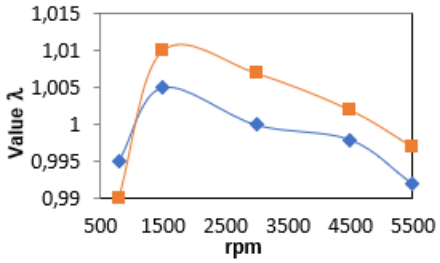

Figure 7. Value λ of pertamax (♦) and pertamax turbo (■)

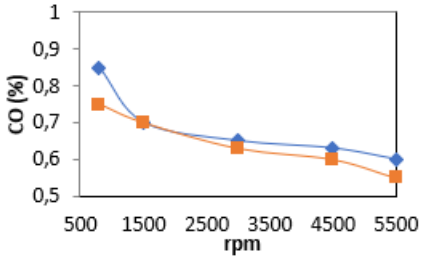

Figure 8. Contaminant CO of pertamax (♦) and pertamax turbo (■)

The value of λ (lamda) is a mixture of air and fuel [16], Figure 7 of the data above shows that λ which is produced 800 rpm engine speed tends to rise more than the value of 1 both pertamax and pertamax turbo, while the next engine speed both decreases at 3000 rpm, λ which is produced decreases by 0.005 in the first fuel but on the 2nd fuel only decreases at 0.003. λ decreased to 0.997 on pertamax turbo and 0.998 on pertamax, while the last test, which is at 5500 rpm engine speed, is only a difference of 0.001. Figure 8 shows that the engine speed is 800 rpm, CO emissions are 10% more than the pertamax from the pertamax turbo. In the 2nd test, the same CO was 0.7%. Next engine speed 3000 rpm down 0.05 on pertamax and down 0.07 on first turbo fuel. When viewed from Figure 8 above, the CO released by each fuel goes down continuously to the bottom.

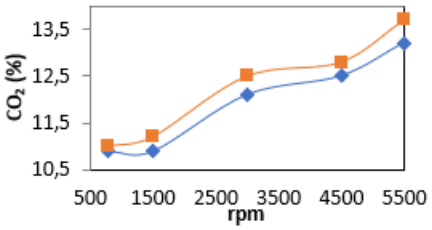

Figure 9. Contaminant CO_2 pertamax (♦) and pertamax turbo (■)

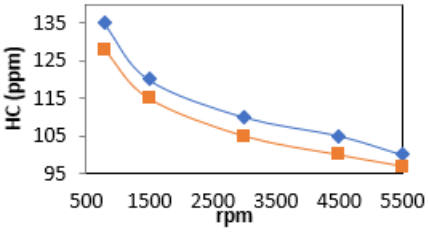

Figure 10. Contaminant HC pertamax (♦) and pertamax turbo (■)

CO_2 emissions produced tend to increase from 10.9% in pertamax to a value of 13.2% as shown in Figure 9. The percentage of CO_2 output produced is greater at 0.24%, while the engine speed of 3000 rpm CO_2 emissions released by pertamax is 12.1%, this emission is smaller than in pertamax turbo which is 12.5%. In Figure 10 at 800 rpm engine speed, the HC results issued are 135 ppm on pertamax and 128 ppm on pertamax turbo. The resulting difference is quite high in pertamax than in pertamax turbo. At 1500 rpm engine speed the first fuel drops 15 ppm from 135 to 120 ppm, unlike the pertamax turbo fuel, it dropped 13 to 115 ppm.

3.2. Data Analysis of Pertamax + Octan Booster and Pertamax Turbo + Octan Booster

Pertamax and pertamax turbo with addition octan booster were tested on the All New Ertiga to be able to know the ratio of torque, power, λ, CO, CO_2, HC and O_2, In the graph above shows a fairly large torque difference from the pertamax and pertamax turbo. At 800 rpm,

the torque produced by the pertamax is at 21 Nm, a difference of 5 Nm from the pertamax turbo at 26 Nm as shown in Figure 11.

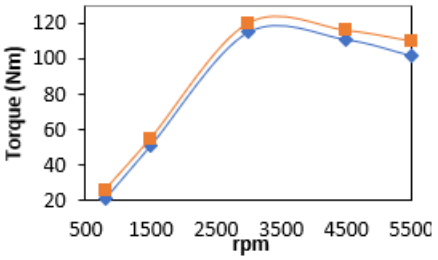

Figure 11. Torque of pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

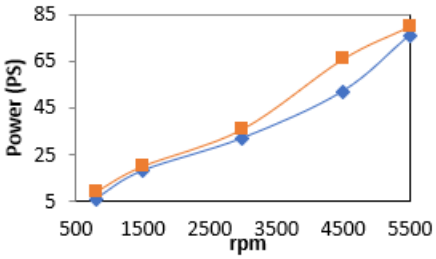

Figure 12. Power of pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

At 3000 rpm engine increase from 51 - 55 Nm to 115 - 120 Nm. At 4500, 5500 rpm the torque produced to decrease because the All New Ertiga engine maximum torque produced when viewed from the specifications of the manufacturer at 4000 rpm engine speed as shown in Figure 11. In Figure 12 shows that pertamax mixture at 800 rpm produces 6 PS less power 3 PS than the first fuel mixture. But when the engine speed is increased from 3000 - 4500 rpm the power produced is greater than using the first mixture. This proves that pertamax turbo with higher octane is able to slightly increase the power on the automotive.

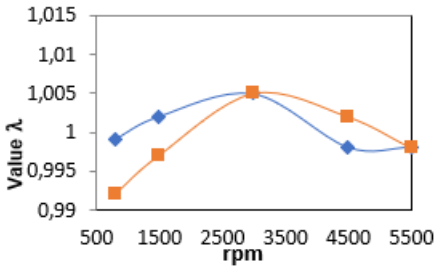

Figure 13. Value λ pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

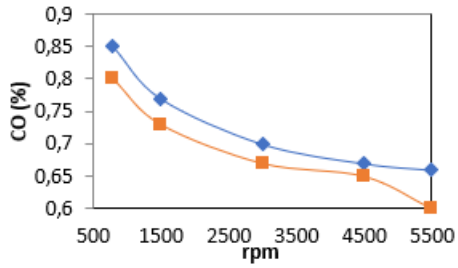

Figure 14. Contaminant CO pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

Figure 13 shows that λ at the first 800 rpm rotationx mixture of 0.999 which is almost said to be complete combustion when compared to the use of the first x turbo mixture, but at engine speed 3000 - 5500 rpm λ produced from both fuels both drops. Figure 14 shows that the engine speed of 800 rpm CO is the largest at 5500 rpm, this shows that at that speed the engine produces the greatest emissions. The use of pertamax turbo mixed fuel was able to reduce emission levels.

In Figure 15 the CO_2 content produced in the first x mixture with the first x turbo mixture at 800 rpm engine speed produces 11%. At the next rotation, which is 1500 rpm, the first fuel increases by 2% from the second fuel, which is a value of 4%. But at 3000 rpm Pertamax experienced an increase of 7% different from 1% in pertamax turbo which was at 6%. In Figure 16 above shows that the first use, HC emissions produced are greater by 1.5%. The use of pertamax turbo mix at 4500 rpm resulted in a 6% decrease in 5500 rpm to be engine speed is 3%.

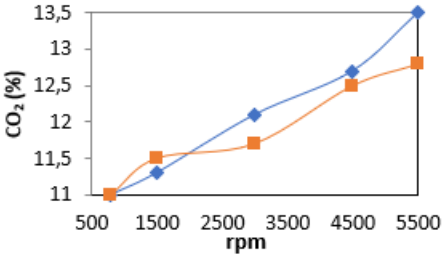

Figure 15. Contaminant CO_2 pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

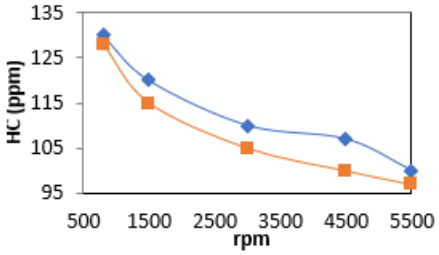

Figure 16. Contaminant HC pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

Figure 17 shows that O_2 produced by 2 fuels does not experience much difference. When viewed at 800 - 3000 rpm engine speed, the two fuels are only 0.1% difference. At 4500 rpm, the O_2 produced by both fuels is 6.2%, this result increases by 12% and is smaller when compared to pertamax turbo which increases by 14%. While Figure 18 shows the O_2 content produced using the first fuel x mixture with the first x turbo mixture there is no significant difference, at 800 rpm engine speed the first fuel is 5.5% and in both fuels it is 5.6%. But when viewed from the engine speed of 4500 rpm produces the same O_2 which is at 6.5%.

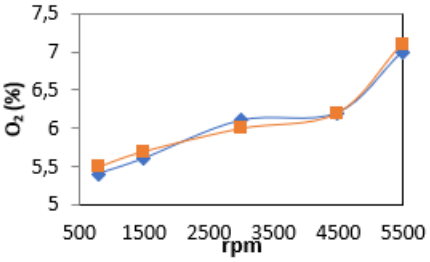

Figure 17. Contaminant O_2 of pertamax (♦) and pertamax turbo (■)

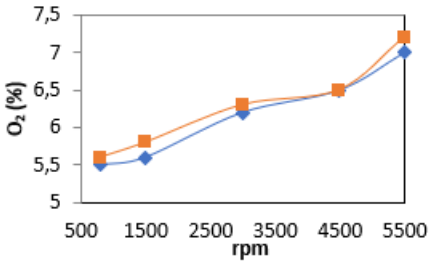

Figure 18. Contaminant O_2 of pertamax + octane booster (♦) and pertamax turbo + octane booster (■)

3.3. Data analysis and threshold limit values

The content of λ, CO CO_2 and HC resulting from incomplete combustion of hydrocarbons causes torque and power is not optimal, the engine becomes heavy, not powerful and fuel becomes wasteful [16], [17]. The analysis is in accordance with the thresholds set in the Regulation of the Minister of Environment and Forestry number 08 of 2023 concerning the application of motor vehicle emission quality standards for category M, category N, category O, and category L. Category M is a four-wheeled motor vehicle or more used to transport people. The analysis that has been done can be seen the exhaust gas emissions produced from the test using Pertamax and Pertamax turbo fuel, the 2 fuels are declared to have passed the emission test, but in the first fuel, HC and CO levels almost exceed the existing threshold. The percentage produced is also 11.7% adrift of the first fuel from the second fuel. For CO_2 levels not exceeding 5000 ppm, O_2 is not more than 23.5% which means it is safe according to the provisions of Regulation No. 5 of 2018 concerning Threshold Values of Hazardous Gases. Testing with Pertamax material plus octane booster and Pertamax turbo plus octane booster when compared with the government threshold is also declared to have passed the emission test. The CO value produced by Pertamax is 5% higher and the difference in HC produced is 1.5% greater than the first fuel.

4. CONCLUSIONS

The results of λ, CO, CO_2 and HC testing of the All New Ertiga using pertamax, pertamax + octane booster, pertamax turbo and pertamax turbo + octane booster can be concluded. The level of exhaust emissions produced from the first fuel is greater than the first fuel than using pertamax turbo fuel. If using pertamax turbo fuel with an additional octane booster produces lower emission levels than pertamax with an additional octane booster. The best engine performance at 115 Nm of torque with emissions are still below TLV (threshold limit value) for pertamax, while for pertamax turbo the best performance at 120 Nm with emissions below TLV (threshold limit value). From the four tests carried out above, it can be concluded that the emissions incurred are still below the threshold of the Minister of Environment and Forestry Regulation number 08 of 2023 concerning the application of motor vehicle emission quality standards for category M, category N, category O, and Category L and can be declared to have passed the test.

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