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Analysis of the impact of exhaust gas emissions on diesel-fueled vehicles in view from the year of manufacture (Case study on the Mitsubishi L 300 vehicle)

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Abstract: Air pollution is a condition caused by exhaust gas from motor vehicles operating on the highway. To minimize greater air pollution, the government is making preventive efforts by carrying out regular vehicle emission tests which are currently being carried out targeting transport vehicles. This is triggered by the increasing development of the automotive industry so that every year manufacturers produce these vehicles to meet the vehicle market, especially transport vehicles. With the increase in the number of vehicles every year, this is one of the causes of air pollution, so it needs to be controlled. This research aims to determine the effect of vehicle exhaust emissions on the year of vehicle production, in diesel-fueled vehicles. The method used is an experiment using two-way ANOVA analysis on the results of tests carried out on Mitsubishi L 300 vehicles with a total of 30 test samples, by testing vehicles produced in 2017-2022. The results of the research show that older vehicles will produce gas emissions. tall one. This is by the results of the ANOVA test which accepts the statement that there is at least one vehicle age that has a significant effect on smoke concentration, so it can be concluded that vehicles with an old age, in this case 2017, have the potential to produce high emission gases, therefore preventive efforts need to be taken. to vehicle engines.

Keywords: Smoke density; gas emissions; Rpm; ANOVA

1. INTRODUCTION

The ever-increasing growth of motorized vehicles in Indonesia has caused serious problems in terms of increasing air pollution. One type of motor vehicle that has a major impact on air pollution in Indonesia is a diesel engine motor vehicle [1],[2]. Diesel engines are a type of motorbike that is widely used by the public both as a means of transportation and in industry. The efficiency of a diesel motor is influenced by the perfection of the fuel combustion process in the diesel motor cylinder [3]. Diesel engines are a type of internal combustion engine (Internal Combustion Engine) [4]. An internal combustion engine is a driving engine that always utilizes heat energy from the burning process of fuel into motion energy. A diesel engine is an internal combustion engine where the ignition process is when the piston approaches the top dead center, then the fuel is sprayed into the combustion chamber through the nozzle, then combustion will occur in the combustion chamber and the air in the cylinder will reach a high temperature [5][6]. This diesel engine has a higher compression ratio compared to petrol motorbikes, this is because in petrol motorbikes the fuel ignition process is assisted by spark plugs so it does not require high compression. The compression ratio for diesel engines is between 15 – 30, while for petrol engines it is 6 – 12. With greater compression, the power produced by diesel engines is also greater when compared to petrol engines.

The development of technology in the automotive world will produce vehicle products with large engine capacities. Vehicles that have a large engine capacity must be balanced by using appropriate fuel and minimal combustion results [7]. If the fuel used does not match the needs of the engine being used, it will disrupt the combustion process, which can result in knocking or destocking symptoms. Currently, the fuel sold on the market generally has a low cetane number and tends not to match the engine capacity used [8]. Cetane Number is a measurement that shows the quality of fuel for diesel [9]. Large engine capacity but using fuel with a low cetane number can result in excessive fuel consumption. Fuel consumption levels are influenced by fuel or engine temperature, engine load, and also the cetane number in the fuel. Each fuel has different characteristics and combustion values. These characteristics determine the properties in the combustion process, where unfavorable properties can be improved by adding chemicals to the fuel [10].

Diesel is a fuel used for diesel-engined motor vehicles, apart from diesel fuel it can also be used as a lubricant for engine components. Diesel oil comes from Gas Oil, which is a petroleum fraction with a boiling point range between 2500ºC to 3500ºC which is also called middle distillate. The composition consists of hydrocarbon and non-hydrocarbon compounds. Hydrocarbon compounds found in diesel oil include paraffinic, naphthenic, olepines, and aromatics [11]. Meanwhile, non-hydrocarbon compounds consist of compounds containing non-metal elements, namely sulfur, nitrogen, and oxygen as well as metal elements such as vanadium, nickel, and iron. The ideal characteristic of diesel fuel is perfect viscosity (not high and not too low, the percentage of water, ash, sulfur, and carbon residues must be low) [12]. The higher the cetane number, the easier it is for diesel fuel to burn [13]. Diesel fuel with this content, when used for the combustion process in diesel engines, can produce toxic exhaust gases [14]. Concentrated diesel engine exhaust gas can cause visual disturbances and health problems [15]. Opacity/density of exhaust gas smoke can appear as a result of damage to the engine or improper adjustment errors, resulting in engine performance not being optimal. Not only that, inappropriate fuel can also be one of the causes of smoke opacity/density [16].

Pollutants from motor vehicle emissions have a significant impact on ecological systems and human health [17]. The use of diesel as fuel for diesel engines produces exhaust emissions containing soot/black smoke, CO, CO2, NOx, SOx, hydrocarbons, and particulates [18]. The problem of exhaust emissions can be overcome by improving the quality of the fuel used [19]. Good fuel quality can make the combustion process more perfect. A perfect combustion process can produce optimal power and more efficient exhaust emissions. The pollutants or exhaust emissions produced by each vehicle each year have different qualities, this can be caused by technological developments in the automotive world [20]. With this background, the author intends to conduct research and research on the thickness of smoke in exhaust emissions from diesel vehicles from 2017 to 2022. Where the results of the research will be concluded to review developments in efficiency and quality of engine performance from year to year.

2. METHOD

In this research, the authors carried out tests and observations on four-wheeled diesel engine motorized vehicles with years of manufacture from 2017 to 2022 that use diesel fuel. The total samples or vehicles tested are 5 vehicles from each year, so the total number of vehicles tested is 30 vehicles. The analysis method uses SPSS version 27 processing, while the data processing technique uses descriptive techniques based on experimental results. Calculations will be carried out during processing to determine the level of emissions resulting from the tests carried out. The resulting data will be tested using One Way Anova analysis.

3. RESULTS AND DISCUSSION

3.1 Test data decryption

A. Recapitulation of smoke concentration test data

The following is recapitulation data of smoke density testing for 30 vehicles at the Sidoarjo Regency Transportation Department's Motor Vehicle Testing UPT. The test results on the level of exhaust smoke concentration produced by the L300 vehicle [21], reviewed from the year of vehicle production, can be seen in the following Table 1.

Table 1. Smoke density test results based on vehicle production year

Vehicle Production Year	Smoke thickness (%)	Year of Vehicle Production	Smoke thickness (%)	Vehicle Production Year	Smoke thickness (%)
2017	35	2018	57	2020	34
2017	61	2018	49	2021	13
2017	65	2019	26	2021	19
2017	68	2019	33	2021	18
2017	40	2019	64	2021	23
2017	45	2019	38	2021	30

Vehicle Production Year	Smoke thickness (%)	Year of Vehicle Production	Smoke thickness (%)	Vehicle Production Year	Smoke thickness (%)
2017	50	2019	44	2022	7
2018	53	2020	17	2022	11
2018	30	2020	16	2022	12
2018	37	2020	21	2022	15
2018	43	2020	26	2022	21

Table 1 Represents the results of tests carried out on 33 units of Mitsubishi brand L300 cars with diesel fuel, which have taken part in exhaust gas emission tests, in this case, the smoke density test. Referring to the provisions of the ministry of environment no. 5 of 2006, the level of opacity in diesel vehicles for years above 2010 is 40% HSU overall emission tests showed that 26 vehicles had passed the test and 7 vehicles declared not to have passed the test. The distribution of data regarding failure to pass the test is distributed throughout almost all years of manufacture, namely 2017 with the highest smoke thickness level reaching 68% and the lowest thickness level at 35%, then in 2018 the highest thickness level reached 53% with the lowest thickness level 30%. Furthermore, in 2019, the highest level of smoke thickness was 64% and the lowest was 26%, then 2020, 2021, and 2022 were relatively safe in terms of smoke thickness levels, this can be seen at the highest thickness levels of 34%, 30%, and 21% respectively. The lowest levels of smoke thickness are 16%, 13%, and 7% respectively.

B. Exhaust gas emission quality

The quality of exhaust emissions produced by a vehicle can be determined from the results of emissions tests carried out on a vehicle. In this research, exhaust gas tests were carried out on diesel-powered Mitsubishi L300 cars, with tests grouped by year of production and carried out on 33 L300 vehicles produced in 2017-2022. The test results are illustrated in tabular form, which are grouped by year, number of vehicles tested, and the groupings of pass or fail which are described in the test result data can be seen in Table 2.

Table 2. Smoke concentration test results for L 300 car vehicles

Vehicle Production Year	Amount	pass the test	Didn't Pass the Test
2017	7	4	3
2018	6	4	2
2019	5	4	1
2020	5	5	0
2021	5	5	0
2022	5	5	0

Referring to Table 2. The smoke concentration test results for L300 vehicles, from 5 tests on samples, show that 4 L300 vehicle samples were declared to have passed the test and 1 was declared not to have passed the test.

C. Test result

Testing was carried out using one-way ANOVA analysis, to test the research hypothesis, namely:
H0: All years of vehicle manufacture, namely 2017, 2018, 2019, 2020, 2021, and 2022, have no significant effect on smoke concentration
H1: There is at least one vehicle age that has a significant effect on smoke concentration

Variation analysis requires the fulfillment of three assumptions, namely identical, independent, and normally distributed. that is:

a. Normality test
The Normality Test aims to determine the results of normally distributed tests, Table 3 is the results of tests of normality, which are explained as follows:

Table 3. Tests of normality

Tests of Normality		
	Vehicle Year	Shapiro-Wilk [a] Sig.

Smoke Concentration Test Results	2017	,563
	2018	,887
	2019	,609
	2020	,487
	2021	,876
	2022	,872

Table 3. Tests of Normality show that the significance of the smoke concentration test results for vehicles in 2017 was 0.563, then in 2018 it was 0.887, in 2019 it was 0.609, in 2020 it was 0.487, in 2021 it was 0.878 and finally in 2022 it was 0.872. The overall results show that the significant value for all years of vehicle manufacture has a value greater than 0.05, so it can be concluded that the data is normally distributed.

b. Output test of homogeneity of variances
This test aims to test whether there are assumptions for Anova, this can be seen from the probability or significance value in the normality test. This can be seen in Table 4. Tests of Homogeneity of Variance.

Table 4. Test of homogeneity of variances

Homogeneity of Variances

		Levene Statistics	df1	df2	Sig.
Smoke Concentration Test Results	Based on Mean	1,841	5	27	.138
	Based on the Median	1,316	5	27	,287
	Based on Median and with adjusted df	1,316	5	16,932	.304
	Based on trimmed mean	1,806	5	27	,145

In Table 4. Tests of Homogeneity of Variance, show that the significant value is 0.138, which means it is greater than 0.05. Thus H0 is rejected. The statement that all years of vehicle manufacture, namely 2017, 2018, 2019, 2020, 2021, and 2022, have no significant effect on smoke concentration, is accepted.

c. ANOVA test

The ANOVA test is the final test, it is used to determine whether the resulting value for the hypothesis is accepted or rejected. The determination of H0 or H1 that is accepted must meet the following conditions:

1) If the Fcount value > Ftable, H0 is declared Rejected
2) If the Fcount value < Ftable, H0 is declared Accepted
3) And if the significant value or probability is >0.05, H0 is declared Accepted
4) And if the significant value or probability is <0.05, H0 is declared Rejected

The following are the results of the ANOVA test as in Table 5. ANOVA:

Table 5. Tests ANOVA

ANOVA

Smoke Concentration Test Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6905.336	5	1381.067	13,159	,000
Within Groups	2833.633	27	104,949		
Total	9738.970	32			

Table 5. Anova test above, the $_{\text{calculated F value}}$ is 230.881, and F $_{\text{table}}$ with df1 value: 4 and df2 value: 145, then the $_{\text{calculated F value}}$ is 2.43, which means $_{\text{calculated F}}$ > than F $_{\text{table}}$ which means H0 is rejected. Meanwhile, the probability or significant value is 0.000, which means that 0.000 < 0.05, thus the null hypothesis (H0) is rejected. This shows that there is at least one vehicle age that has a significant effect on smoke concentration.

d. *Post hoc test*

The Post Hoc test functions to find different groups, which are indicated by differences in $_{calculated}$ F concerning the rejected null hypothesis (H0). To explain the $_{calculated}$ F value, it is necessary to display *the output* descriptive statistics. The following is *the output* descriptive statistics and the results of the Post Hoc test:

Table 6. Descriptive statistics

Descriptives

Smoke Concentration Test Results

	N	Mean	Std. Deviation	Std. Error	5% Confidence Interval for Mean		Minimum
					Lower Bound	Upper Bound	
2017	7	52,0000	12.85820	4.85994	51.6823	52.3177	35.00
2018	6	44.8333	10.16694	4.15064	44.5597	45.1069	30.00
2019	5	41,0000	14.45683	6.46529	40.5686	41.4314	26.00
2020	5	22,8000	7.39594	3.30757	22.5793	23.0207	16.00
2021	5	20,6000	6.34823	2.83901	20.4106	20.7894	13.00
2022	5	13.2000	5.21536	2.33238	13.0444	13.3556	7.00
Total	33	33.9697	17.44542	3.03686	33.7778	34.1616	7.00

Table 6. Output descriptive statistics, explains the results of descriptive statistical data which contains the mean, standard deviation, lowest and highest numbers, and standard error. The data displayed comes from testing the results of smoke concentration tests that have been carried out. From this table, it can be seen that there is a difference in the mean of the year of vehicle manufacture in 2017 versus 2018 of 7.16667 which is obtained from the mean value in 2017 being 52 and the mean in 2018 being 44.8333 (table 5. *output* descriptive statistics) and the difference in the mean in 2017 versus 2019 is 11 ((table 5. *output* descriptive statistics). This calculation step is used to determine post hoc mean differences by looking for equal variances assumed through Tukey and Bonferroni values.

3 CONCLUSION

Testing of vehicle year on exhaust emissions in L300 diesel vehicles shows that the year of the vehicle influences on the exhaust emissions produced. This was proven by the results of the ANOVA analysis test which stated that all years of vehicle manufacture did not have a significant effect on smoke density, which was not proven, while the statement which stated that there was at least one vehicle age that had a significant effect on smoke density was declared proven. However, the average content of exhaust emissions produced is one of the determining factors in the year of production, so the need for regular maintenance is one solution to maintaining the condition of the vehicles you own, especially L300 vehicles.

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