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Effect of Dual External Exhaust System with Activated Charcoal and Reheater on Diesel Engine Exhaust Emissions

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Abstract

The increase in the mass and widespread use of diesel engines can lead to an increase in exhaust emissions, which can have a negative impact on the environment and human health with an increase in the number of vehicles and activities in workshops and test sites, there is a need to minimize the emission of exhaust gases during the process, The need for additional alternative methods that can help reduce emissions in places where there are potentially many vehicles in vehicle repair shops vehicle repair shops, at vehicle test sites and light vehicle practice places of automotive vocational high schools,, the development of additional equipment that is attached or added to an object without changing from that object or *after treatment tools* It is still rarely found, especially in ordinary workshops, even official workshops are still uneven and not optimal, reducing exhaust gas levels when the vehicle stops or is static. This study uses an experimental method by making after *treatment tools* in the form of dual external exhaust systems that are attached to vehicles during emission testing and testing that emit smoke or vehicle exhaust emissions as an alternative effort in handling vehicle emissions, especially diesel engines. The tool in the form of a dual external exhaust system with activated charcoal and *a reheater* with temperature variations from the reheater at temperatures of 100 °C, 150 °C, and 250 °C is used in conventional diesel vehicles and common rail diesel vehicles. Tests are taken 3 times on each specimen/variation. The results of this study show that first, there is an effect of dual external exhaust systems with activated charcoal and reheater on the exhaust gas emissions of conventional diesel engines, the effect obtained is a decrease in CO emission results from 0.47 to 0.10 with a percentage decrease of 78% and Opacity from 82 to 46 with a percentage of 44%. Then the second is the influence of dual external exhaust systems with activated charcoal and reheaters on the exhaust gas emissions of *common rail* type diesel engines. The effect obtained was a decrease in CO emission results from 0.05 to 0.01 with a percentage decrease of 80% and Opacity from 32 to 23 by 28%

1 Introduction

In the era of rapid technological and industrial development, diesel engines have become one of the irreplaceable resources in the world of transportation, industry, and power generation. The use of diesel motors in big cities is no less important, judging by the large number of passenger buses, loaded vehicles such as trucks and other industrial machines, in addition to its advantages of large power and low fuel consumption, while the disadvantage is that the exhaust emissions produced are very dangerous [1].

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With the increasing number of vehicles and activities at workshops and test sites, there is a need to minimize the discharge of emitted gases during the process and deepen the understanding of the impact of excessive discharged emissions directly on-air quality which adversely affects air pollution in the environment. There is a need for alternative emission reduction devices that are intended to reduce smoke and emissions released by vehicles that are applied outside the vehicle and can be applied in workshops or vehicle emission testing sites. Focuses on discussing the effect of dual reheater systems on diesel engine exhaust emission output. The desired emission level can only be achieved through the after-treatment emission control system. Vehicles are equipped with emission control systems to meet actual emission standards and requirements. With an emission control system, pollutants from the exhaust can be removed after exiting the engine, shortly before being emitted into the air [2]. The need for an alternative emission reduction tool that is intended to reduce smoke and emissions released by vehicles that are applied outside the vehicle and can be applied in workshops or vehicle emission testing sites.

According to [3] With after treatment emission control systems, it is possible to reduce the damage of pollutant emissions to air pollution, to meet emission standards and requirements, and to prevent harmful effects of pollutant emissions on the environment and human health. Because of these problems, the after-treatment emission control system was selected to reduce the pollution emissions from diesel engines. Further study and research on after treatment emission control systems should be intensified and continued. The use of a catalytic converter with activated carbon and nickel oxide powder as adsorbents can reduce CO gas content. The CO content of the test results without a catalytic converter is obtained at 707 ppm, then decreases in CO content along with the installation of a catalytic converter that has been made. Emission testing was carried out for 12 minutes with an interval of 3 minutes and obtained a CO content of 307 ppm. From testing at minute 3 to 12 the average carbon monoxide (CO) content obtained relatively decreased. This is in accordance with the theory described by [4] which shows that the oxidation reaction of CO to CO_2 occurs in the exhaust gas installed by the catalytic converter in the exhaust gas channel. This happens because the catalyst in the catalytic converter makes the oxidation reaction process of CO gas into CO_2 take place faster with the chemical reaction as: $2\ CO + O_2 \rightarrow 2\ CO_2$. Based on the results of research conducted (Yusuf et al., 2015) on four-wheeled motorized vehicles, it can be concluded that four-wheeled vehicles are one of the contributors to exhaust emissions with high concentrations and activated carbon from activated bagasse has the potential to absorb gas emissions produced by four-wheeled vehicles, one of which is CO.

Activated carbon from bagasse which has a variation in the temperature of making activated charcoal has a high level of adsorption which is activated carbon activated at 500 ° C with absorption of CO gas by 47.7%, this shows a reduction in emissions after combustion or after treatment through a catalytic converter with additional activated carbon charcoal adsorber media can be done.

Tailored to the environment and conditions of the place used after treatment emission control system, with the use of activated carbon adsorber placed in the muffler tube outside the exhaust and emissions that have passed through the carbon adsorber and minimized the content of harmful exhaust gases and then after that just flowed into the free air after being processed first, allows to reduce the damage of pollutant emissions to air pollution, to meet emission standards and requirements, and to prevent the harmful effects of pollutant emissions on the environment and human health.

Because of this mission, emission control systems are of great importance worldwide. For the complete destruction of pollution emissions from diesel engines, further study and research on after treatment emission control systems should be intensified and continued [5].

The purpose of this study is to determine whether there is an effect of using the addition of a dual external exhaust system with activated charcoal and a reheater on the exhaust emissions of conventional diesel engines and to determine whether there is an effect of using the addition of a dual external exhaust system with activated charcoal and a reheater on the exhaust emissions of conventional diesel engines common rail type diesel engines.

2 Research Methods

The method used in this research is the experimental method. The experimental method is a method that aims to examine the effect of a particular treatment on the symptoms of a particular variable compared to other variables that use different treatments [6].

There are four tests carried out in this study, namely: CO emission testing and standard opacity of conventional type diesel vehicles, CO emission testing and standard opacity of common rail type diesel vehicles, testing with additional dual external exhaust system tools with activated charcoal and reheater (reheater temperature variation of 100°C, 150°C and 250°C) to the exhaust emissions of conventional type diesel engines, testing with the addition of dual external exhaust systems with activated charcoal and reheaters (variations in reheater temperatures of 100°C, 150°C, and 250°C) to the exhaust emissions of conventional type diesel engines.

The tools used in this study are: Heshbon 520 4 Gas Analyzer Emission Test Equipment is useful for measuring Carbon Monoxide, CO and Diesel Smoke meter CGO levels 600, To analyses and measure the results of smoke density from combustion in diesel engines. The vehicles used for testing are Mitsubishi Colt Diesel l300 for conventional type diesel vehicles and Inova Reborn Diesel 2.4 Q A/T for common rail type diesel vehicles. The CO and opacity testing process was carried out using the Heshbon 520 4 Gas Analyzer and Diesel Smoke meter CGO 600 on two Mitsubishi Colt Diesel l300 vehicles for conventional type diesel vehicles and Inova Reborn Diesel 2.4 Q A/T for common rail type diesel vehicles. illustrated as shown below:

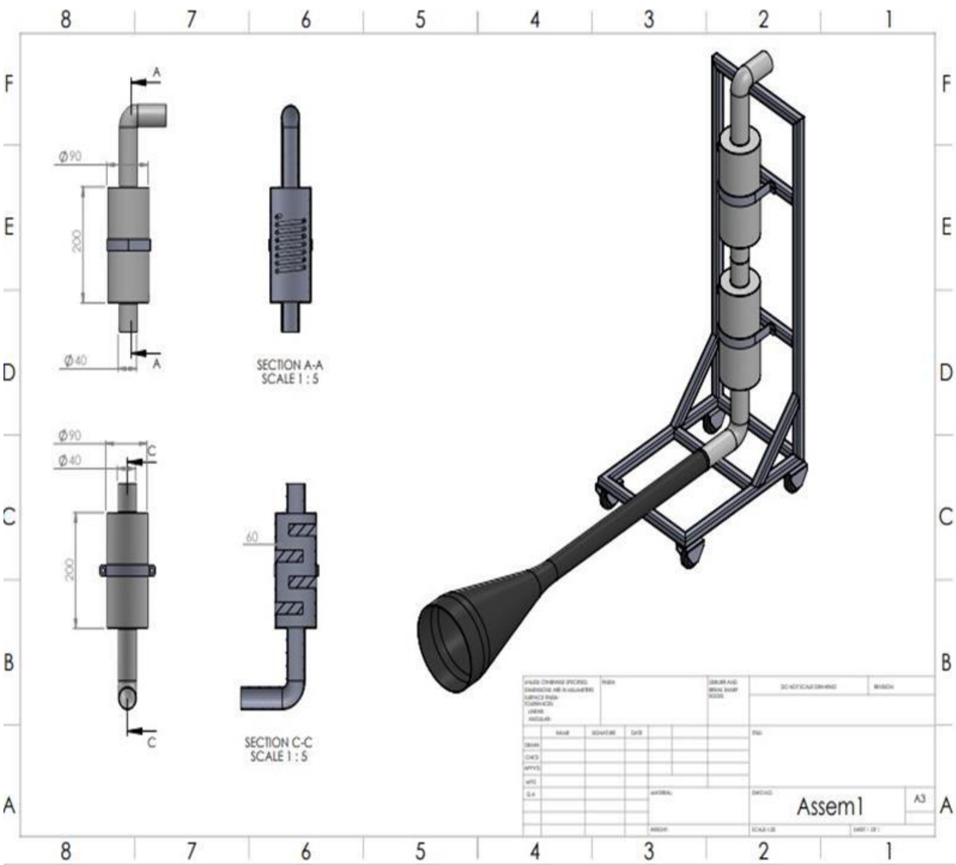

Figure 1. 2D design of aftertreatment attachment Dual external exhaust tubes Dual exhaust tubes/mufflers Activated charcoal adsorber (down tube) coupled with exhaust tube/muffler Reheater (up tube)

Figure 2. Standard diesel emission testing

Figure 3. Testing with additional dual system equipment external exhaust with activated charcoal and reheater

The first test is standard emission testing, testing directly from diesel vehicles (conventional and common rail) to hesbon and smoke meter emission test equipment. 3x standard is taken. In this test testing CO emissions (3x) and opacity (3x) on conventional type diesel vehicles (Mitsubishi colt l300), then continued testing CO emissions (3x) and opacity (3x) common rail type diesel vehicles (Toyota Innova reborn).

The second test is testing using an additional dual external exhaust system with activated charcoal and reheater. Testing using dual systems, from the vehicle connected and passing through the last new dual system to the hesbon and smoke meter emission test equipment (dual system equipment is paired in the middle, between the vehicle and the hesbon and smoke meter emission test equipment), also taken 3x at each reheater temperature variation.

The research data that has been generated in this study is then processed with descriptive analysis techniques. Descriptive analysis techniques display data in graphs or diagrams, then conclusions are made according to the graphs or data diagrams that have been displayed.

3 Result and Discussion

This research is a type of experimental research. The method used to determine the relationship between the independent variable and the dependent variable. The independent variable in this study is temperature variation in the addition of reheater. The dependent variables in this study are CO exhaust emissions and smoke opacity. Tests were conducted to determine how the heater temperature added to the reheater on the external exhaust impacted and activated charcoal as an adsorber of conventional and common rail diesel engine emissions. In data collection, three times were taken in each condition to facilitate the validity of the test data. The test results are shown in the table below

Table 1. Standard diesel emission testing

Standart	Output Diesel Emissions	
	CO %	**Opasity%**
Mitsubishi	1. 0.60 %	1. 94.8%
Colt L300 Diesel	2. 0.40 %	2. 76.4%
Conventional	3. 0.40 %	3. 76.4 %
Toyota	1. 0.06 %	1. 32.2 %
Innova Reborn	2. 0.06 %	2. 32.2 %
Common rail	3. 0.03 %	3. 32.2 %

The table above is the result of testing Co and opacity standard diesel vehicle Mitsubishi l300 (conventional diesel) with average test results on CO average standard = 0.47% and opacity average standard = 82.5 rounded up to 82% and Toyota Innova reborn (diesel common rail). with the results of CO average standard = 0.05%. opacity average standard = 32.2 rounded up to 32%.

Table 2. Test results with additional dual device external exhaust system with activated charcoal and reheater

Dual System Tools		Output Diesel Emissions	
		CO %	**Opasity %**
Mitsubishi	100°C	1. 0.20%	1. 50.7 %
Colt L300		2. 0.20%	2. 50.7 %
Diesel			
Conventional		3. 0.0%	3. 50.7 %
	150°C	1. 0.10%	1. 50.7 %
		2. 0.0%	2. 50.7 %
		3. 0.0%	3. 50.7 %
	250°C	1. 0.00%	1. 35.8 %
		2. 0.0%	2. 35.8 %
		3. 0.00%	3. 35.8%
Toyota	100°C	1. 0.01%	1. 26.2 %
Innova Reborn		2. 0.0%	2. 26.2 %
Common rail		3. 0.0%	3. 26.2 %

150°C	1. 0.0%	1. 26.2 %
	2. 0.0%	2. 26.2 %
	3. 0.0%	3. 26.2 %
250°C	1. 0.0%	1. 18.1%
	2. 0.0%	2. 18.1 %
	3. 0.0%	3. 10.1 %

The table above is the result of Co and opacity testing results of conventional diesel testing with the addition of dual tools external exhaust system with activated charcoal and reheater, CO average by using additional dual system tools with activated charcoal and reheater = 0.10%. And the average opacity % by using the additional dual system tool with activated charcoal and reheater = 46%.

Then the test results of Co and opacity of common rail diesel with additional tools dual external exhaust system with activated charcoal and reheater, CO% average by using additional tools dual external exhaust system with activated charcoal and reheater (temperature variation 100 ° C): 0.01% Average % capacity by using additional tools dual external exhaust system with activated charcoal and reheater = 22.6. rounded to 23%.

Table 3. Test results of Mitsubishi Colt L300 Conventional Diesel

Mitsubishi Colt L300 Conventional Diesel			
Standard		Using Additional Tools Dual External Exhaust System with Activated Charcoal and Reheater	
CO %	OPASITY %	CO %	OPASITY %
0.47	82	0.10	46

Table 3 shows the results of CO emissions % and opacity % on Mitsubishi L300 diesel conventional type At a temperature of 100 ° C 150 ° C the results of CO emissions are read and come out results while at a reheater temperature of 250 ° C the test results display 0%, no CO emissions can be read, the highest CO value is 0.60% In standard testing. While the lowest CO value in testing dual external exhaust systems with activated charcoal and reheaters with a reheater temperature of 150 ° C was 0.10%. The results of the smoke density opacity % of conventional type diesel vehicles, namely Mitsubishi Colt L300, show in the graph read in the standard test results appear the highest 94.8%.

Then in the test with the addition of dual external exhaust system with activated charcoal and reheater every variation of reheater 100 ° C reheater temperature 100 ° C and 150 ° C read 50.7% and at the reheater temperature to 250 ° C appeared and read 35.8% conventional diesel opacity value. first test standard average CO standard = 0.47%. opacity % average standard = 82.5 rounded 82%.CO% average by using additional dual system tools with activated charcoal and reheater = 0.10%. Opacity % average by using additional tools dual system with activated charcoal and reheater = 46%.

Table 4. Average on CO output and opacity in common rai diesel

Toyota Innova Reborn Diesel Common Rail Type

Standard		Using Additional Tools Dual External Exhaust System with Activated Charcoal and Reheater	
CO %	OPASITY %	CO %	OPASITY %
0.05	32	0.01	23

Table 4 is the average test results on CO output and opacity on common rail diesel. CO average standard = 0.05%. Opacity average standard = 32.2 rounded to 32%.CO% average by using additional tools dual external exhaust system with activated charcoal and reheater (temperature variation 100 ° C): 0.01% opacity % average by using additional tools dual external exhaust system with activated charcoal and reheater = 22.6. rounded to 23%.

Table 5. Comparison of Conventional Diesel Type with Common Rail Diesel Type

Standard				Using Additional Tools Dual External Exhaust System with Activated Charcoal and Reheater			
Mitsubishi Colt L300 Conventional Diesel		Toyota Innova Reborn Diesel Common Rail Type		Mitsubishi Colt L300 Conventional Diesel.		Toyota Kijang Innova Reborn Diesel Common Rail Type	
CO %	OPASITAS %	CO %	OPASITAS %	CO %	OPASITAS %	CO %	OPASITAS %
0.47	82	0.05	32	0.10	46	0.01	23

Table 5. is a comparison data of conventional type diesel with common rail type diesel. It is known that the highest CO value in standard test results is 0.47% co value of conventional type diesel. and the lowest CO value is 0.01% CO value found in tests using additional dual tools external exhaust system with activated charcoal and reheater. While the highest opacity value in standard test results is 82% in conventional type diesel. And the lowest opacity value is 23% found in tests using additional tools dual external exhaust system with activated charcoal and reheater. To facilitate the analysis of the comparison, the data from table 4.3 is presented in the form of graphical diagrams in the discussion.

This study discusses how the effect of the addition of dual external exhaust systems with activated charcoal and reheaters on conventional type diesel vehicles and common rail type diesel, which are installed on external exhaust whether it affects the output of exhaust emissions on conventional type diesel vehicles and common rail diesel. The percentage of influence, decrease and difference from the test results that have been analysed and then discussed in the discussion is divided into 2, based on whether there is an influence on conventional type diesel vehicles and diesel type common rail from the research that has been done. This study discusses how the effect of the addition of dual external exhaust systems with activated charcoal and reheaters on conventional type diesel vehicles and common rail type diesel, which are installed on external exhaust whether it affects the output of exhaust emissions on conventional type diesel vehicles and common rail diesel. The percentage of influence, decrease and difference from the test results that have been analysed and then discussed in the discussion is divided into 2, based on whether there is an influence on conventional type diesel vehicles and common rail type diesel vehicles.

Figure 4. Comparison of conventional diesel test results

Figure 4 shows the test results of the comparison of the test results graph on conventional diesel vehicles (Mitsubishi l300) shows the difference in difference. from the standard CO test results and test results by using additional dual tools external exhaust system with activated charcoal and reheater of 0.47% to 0.10% difference in the value of conventional diesel vehicle CO results there is a difference of 0.37% CO value. Conventional diesel opacity results also show the difference in the difference from the standard CO test results and test results by using additional dual external exhaust systems with activated charcoal and reheaters of 82% to 46% difference there is a difference of 36% opacity value / smoke density value.

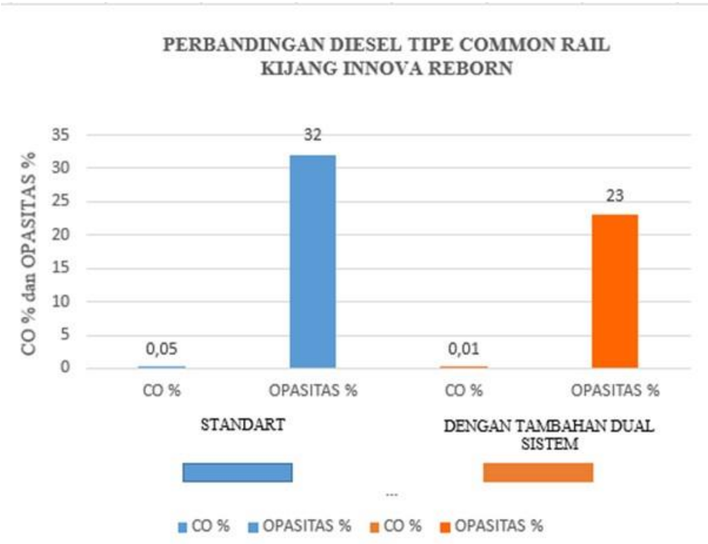

Figure 5. Comparison of common rail diesel test results

Figure 5. displays the research data comparison graph of test results on diesel vehicles Toyota Innova reborn common rail type shows the difference in difference. from the standard CO test results and test results by using additional tools dual external exhaust system with activated charcoal and reheater from 0.05% to 0.01% difference in the value of conventional diesel vehicle CO results there is a difference of 0.04% CO value. Conventional diesel opacity results also show a difference in the difference from the standard CO test results and test results using additional dual external exhaust systems with activated charcoal and reheaters of 32% to 23% difference there is a difference of 9% opacity value / smoke density value.

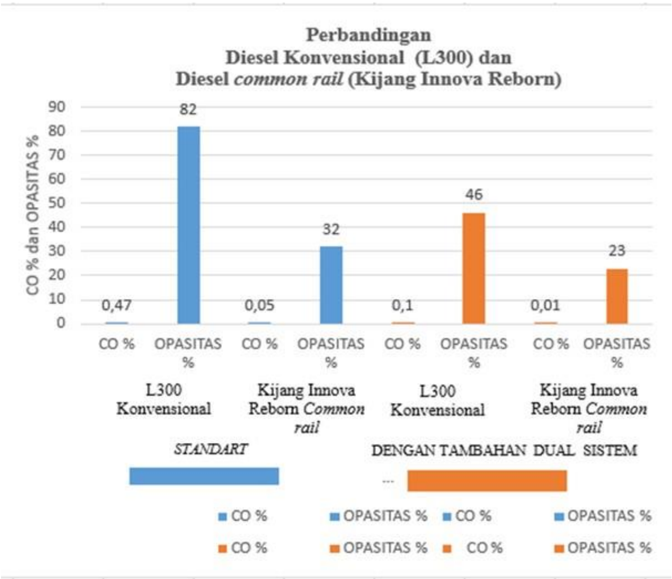

Figure 6. Comparison of common rail diesel test results

The emission results of conventional type diesel vehicles show a difference of 0.37%, in the CO results of 0.47% standard emission testing changed to 0.1% (0.10%) when testing using additional tools dual external exhaust system with activated charcoal and reheater. The difference results show a change and difference in CO results of 0.37% due to the use of additional dual external exhaust system tools with activated charcoal and reheater when testing conventional diesel CO emissions.

The opacity of conventional type diesel vehicles also shows a difference of 0.36%, at 82% opacity results of standard emission testing changed to 46% when testing using additional dual tools external exhaust system with activated charcoal and reheater. The opacity difference results show a change and difference of 0.36% due to the use of additional dual external exhaust system tools with activated charcoal and reheater when testing conventional diesel opacity emissions.

The CO value of common rail diesel vehicles also shows a difference in the standard CO emission test results of 0.05% changing to 0.01% when testing using additional dual external exhaust system tools with activated charcoal and reheater (100 ° C reheat temperature variation). The results of the opacity difference show a change and a difference of 0.04% due to the use of the addition of a dual external exhaust system with activated charcoal and a reheater when testing common rail diesel opacity emissions.

The opacity levels of common rail type diesel vehicles also have a difference from the standard emission test results of 32% opacity changing to 23% when testing using the addition of a dual external exhaust system with activated charcoal and reheater. The results of the opacity difference show a change and a difference of 9% because of using the addition of a dual external exhaust system with activated charcoal and a reheater when testing common rail diesel opacity emissions.

Effect of Dual External Exhaust System with Activated Charcoal and Reheater on Exhaust Emissions of Conventional Diesel Engine.

Based on the results of research that has been done and obtained after being analyzed, it shows that the highest CO emissions are 0.47% and the highest opacity is 82% in standard testing. While in the test using the dual external exhaust system with activated charcoal and reheater CO emissions produced 0.10% and opacity of 46%.

Based on the two test results, it shows that there is an influence when testing using additional dual external exhaust system tools with activated charcoal and reheater can affect the output value of CO exhaust emissions and opacity which affects the decrease in CO emission value from 0.47 to 0.10 with a percentage decrease of 78% and affects the opacity value from 82 to 46 with a percentage decrease of 44%.

This change is in line with research from [7–9] that CO levels from vehicle exhaust fumes can be reduced to non-toxic elements by heating CO (g) to C (s) + O2 (g). The use of minerals/rocks as adsorbents to overcome environmental pollution. In line with research [10–13] describes the application of a catalytic converter made from activated carbon to improve the quality of activity through its adsorption ability. the highest activity with a percentage of CO emission concentration reduction efficiency of 29.35%.

Effect of Dual External Exhaust System with Activated Charcoal and Reheater on Common Rail Diesel Engine Exhaust Emissions

Based on the research data obtained and then analysed, it shows that the highest CO value is 0.05% and the highest opacity level is 32% in the standard test of dual external exhaust system with activated charcoal and reheater. While in the test using dual external exhaust system with activated charcoal and reheater, the resulting CO emission value is 0.01% and opacity is 23%. Both test results show that testing using a dual external exhaust system with activated charcoal and a reheater (temperature variation of 100 ° C) can affect the results and output values of CO exhaust emissions and opacity where the CO emission value decreases from 0.05 to 0.01 with a percentage decrease of 80%. And opacity from 32 to 23 with a percentage reduction of 28%.

The change in emission value / decrease in emission value produced shows the effect on common rail type diesel vehicles. When viewed from the amount of CO (carbon monoxide) produced by diesel engines better than gasoline engines, where carbon monoxide is harmful to the human body. The CO common rail carbon monoxide produced is very little, which is up to 0.01%, these results show that common rail diesel is more efficient in the combustion process where harmful compounds are formed when there is fuel that does not burn, so that diesel engines are more minimal because their thermal efficiency is better, especially common rail type diesel.

In accordance with research from [14–15] that CO concentration and air temperature tend to be consistent in the form of a relationship. Then able to break down CO gas in the exhaust takes 3.4 minutes. In accordance with the law of Thermodynamics I, in systems where work is not done, all heat received by the system is converted into energy by the system. The activated carbon is one of the best adsorption materials because of its high porosity and capture capacity, when reacted with other reagents in the activation sequence.

4 Conclusion

Based on theory and data analysis, with reference to the formulation of the problem, conclusions can be drawn and drawn:

1. There is an effect of dual external exhaust system with activated charcoal and reheater on conventional diesel engine exhaust emissions. The effect obtained is a decrease in CO emission results with a percentage decrease of 78% and Opacity of 44%.
2. The effect of dual external exhaust system with activated charcoal and reheater on exhaust emissions of common rail type diesel engine. The effect obtained is a decrease in CO emission results with a percentage decrease of 80% and Opacity of 28%.

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