The use of fossil fuels in transportation equipment, especially motorized vehicles, will have an extraordinary effect on air pollution. Therefore, air pollution becomes very important problem today. The amount of percentage of air pollution from transportation sources in Indonesia is 70.5 % CO, 18.34 % HC, 8.89 % NOx, 0.88 % SOx, and 1.33 % particulate matter. Given the danger of exhaust emissions, especially carbon monoxide which can cause death for humans who inhale it, therefore efforts are needed to control air pollution from motorized vehicles. There are several methods that can be used, one of which is to use adsorbents. Activated carbon can be used as an adsorbent. One alternative that can be applied as an adsorbent is peat soil-activated carbon which is abundant and easy to make as an adsorbent. By utilizing the abundant peat-soil which is a great potential area of Banjarmasin, South Kalimantan.

In this experimental study; model l has a diameter of 20 mm, model 2 has an outside diameter of 20 mm and an inside diameter of 10 mm, and model 3 is without adsorbent. The length of this model is the same. Testing with a 2005 Honda Kharisma motor vehicle with an engine speed of 1000, 2000, and 3000 rpm. CO and HC emission tests using a gas analyzer were carried out. Testing was also carried out using a dyno test to determine the engine performance of a motorcycle that was installed with an adsorbent on the exhaust gas. The results showed that peat soil adsorbents with perforated circle designs can reduce CO gas emissions by 55 % compared to the others. Besides that, the use of peat soil adsorbents with hollow circle designs can also reduce HC gas emissions by 3.51 %. The results of the engine performance test showed that there was no significant effect of using this adsorbent on torque and power.

In conclusion, peat soil adsorbents used to reduce exhaust emissions in motorized vehicles can be applied

Keywords: peat soil adsorbent, variation of filter, CO, HC, gas analyzer

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IMPLEMENTATION PEAT SOIL ADSORBENT & VARIATION OF FILTER FOR REDUCE EMISSION IMPROVEMENT FROM MOTOR VEHICLE

Abdul Ghofur
Doctorate in Mechanical Engineering, Head of Department*
Syamsuri Syamsuri
Corresponding author
Doctor of Philosophy
Department of Mechanical Engineering
Institut Teknologi Adhi Tama Surabaya
Arief Rachman Hakim str., 100, Surabaya, Indonesia, 60117
E-mail: syamsuri@itats.ac.id
Aqli Mursadin
Doctor of Philosophy*
Agung Nugroho
Doctor of Philosophy, Professor**
Agung Cahyo Legowo
Magister of Industrial Engineering**
*Department of Mechanical Engineering***
Department of Agroindustrial Technology*
***Lambung Mangkurat University
Achmad Yani str., 36, Banjarmasin, Indonesia, 70123

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1. Introduction

There are still many transportations using fossil fuels. However, there is another reason why the use of fossil Energy especially petroleum for transportation should be limited: the amount of easily available, relatively cheap oil is limited. It has been exploring available and future oil resources and has concluded that these resources are very limited and the current maximum production level the so-called peak oil may have reached is the result of research conducted by [1]. There has been an increase in its use in the latest technology for fossil fuels [2]. Climate degradation and global warming are the main problems facing humanity today. Around 25–30 % of a country's total CO_2 emissions are caused by the transportation sector [3].

The problem of using fossil fuels which are generally used by means of transportation has an impact on; increase in air pollution; an increase in traffic jams on the road; and there are many vehicle accidents [4, 5]. There are several ways/methods used to solve this air pollution problem, one of which is by controlling exhaust emissions from motorized vehicles [6]. Little research has been done on emission control by coating exhaust gases with peat soil as an adsorbent.

Peat soil contains carbon ten times the amount of that element in mineral soil. Peat soil is formed through decomposition of organic materials causing the soil to have its dark brown color. As a comparison, 1 g of peat soil contains around 180 to 600 mg carbon while mineral soil of the same amount only contains 5 to 80 mg carbon [7]. The surface area of activated carbon determines its capacity of adsorbing gases or fluids. This capacity is about 25 to 100 percent of the corresponding activated carbon weight [7]. Activated carbon is also used as fuel in addition to being used as an adsorbent.

The production of activated carbon from various high-carbon sources depends on the activation process using activators which can increase the carbon surface area by opening up pores. The adsorbing property is selective, and

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it depends on the volume of the pores and the surface area. Activated carbon can be used as an emission adsorbent [8]. Adsorption technology is one technology that can control exhaust gas emission.

The air pollution levels due to transportation in Indonesia are 73.50 percent CO, 18.34 percent HC; 8.89 percent NOx; 0.88 percent SOx; 1.33 percent particles [9]. Considering the danger of exhaust gas emission especially carbon monoxide which can cause death in human, efforts are required for controlling air pollution caused by motor vehicles.

Efforts have been implemented for controlling air pollution such as modifying combustion engines, developing exhaust gas system reactors, and substituting the fuels. Approaches to reducing exhaust gas concentration may take form of adding activated carbon to exhaust pipes [8]. Such activated carbon acts as an adsorbent of the emission. One particular alternative as the carbon source is peat soil which is in some places is abundant. For example especially in Banjarmasin, South Kalimantan there are abundant peat soils, so it is easy to obtain and make adsorbents from these peat-soils. This is also included in the utilization of regional potential because in Banjarmasin there are lots of peat soils that are different from other regions.

Several studies have reported the adsorbent properties of soil which are activated both physically and chemically. A study from Malaysia by [10] showed that adsorbent derived from soil can be used to remove color and Fe from the soil layer. Peat soil active ingredients produce better adsorption performance for decolorization and COD adsorption of polluted river water which has been reported by [11]. However, information about the effect of filter variations with a hole circle peat-soil adsorbent, full circle with peat soil adsorbent, and without adsorbent installed in the muffler against HC and CO emissions has never been discussed. This determines the relevance of scientific research because the capabilities of peat-soil adsorbent are expanding due to its advantages which are effective, abundant, and easy to make as an adsorbent.

2. Literature review and problem statement

Combustion in a gasoline engine is initiated by an electric spark from the spark plug which occurs when a few degrees of the crankshaft before the piston reaches top dead centre, burning the air-fuel mixture that has been compressed by the piston movement from bottom dead centre to top dead centre. In general, there are only three important elements in fuel namely carbon, hydrogen and sulphur. In the combustion process, chemical energy is converted into energy in the form of heat where in each combustion, residual gas is always produced as a result of the combustion process which is called exhaust gas which includes several exhaust gas components including CO_2, NO_2, H_2O, SO_2 and CO [12]. There are several methods used to reduce exhaust emissions in motorized vehicles, especially gasoline engines. Ways to control Exhaust Emissions through several methods:

a) adsorption is a way of dealing with exhaust gases in the form of carbon monoxide, carbon dioxide, nitrogen oxides, and ammonia. In the adsorption method used solid materials that can absorb pollutants. There are various types of adsorbents used, including activated carbon and silicates. Adsorbents have saturation power so that they are always needed for replacement, which are disposal or disposable after being saturated, they are thrown away or re-coated with new material;

b) incineration (combustion), using a hot oxide process to destroy the gaseous hydrocarbons contained in the pollutant. The results of combustion are (CO_2) and (H_2O);

c) condensation, hydrocarbon gas will condense into a liquid;

d) absorption, flue gas reacts with liquid so that the hydrocarbon will dissolve;

e) chemical reactions, widely used in the emission of nitrogen and sulphur groups.

Usually, this way of working is in combination with other methods, only in cleaning air pollutants with predominant chemical reactions. Cleaning nitrogen gas, by injecting ammonia (NH_3) which will react chemically with NOx and form solid materials that precipitate. To clarify sulphur, copper oxide lime mixed with charcoal is used.

The adsorption method to control exhaust emissions has been carried out by [13]. Vehicles produce harmful gases such as Carbon Monoxide (CO) and Hydrocarbons (HC) and these gas emissions continue to increase every year. In 2018, there was an increase of up to 10 % from the previous year. This gas is harmful to humans and the environment. One way to reduce pollution from vehicle emissions is by adsorption. Adsorption is often used because of its large adsorption capacity reaching 95 %. Of the several types of adsorbents, activated carbon is the most developed because of its low price and high adsorption capacity. The use of commercial activated carbon has begun to be replaced with activated carbon made from biomass waste because it is cheaper and environmentally friendly. CO and HC gas molecules can be adsorbed well on activated carbon. To increase the adsorption ability of activated carbon, it is modified with Magnesium oxide (MgO) by the impregnation method. With modifications using activated carbon and MgO ratios of 70:30, 80:20, and 90:10 obtained surface areas of 1149.48 m^2/g, 890.23 m^2/g, and 859.91 m^2/g. CO and HC. Adsorption was carried out with inside tube variants of 3 cm, 4 cm, and 5 cm. This inner tube is used to place the adsorbent. The results showed that by increasing the inner length of the tube, the adsorption yield of CO increased from 78.68 to 99.14 % and HC from 64.54 to 87.73 %. So that the modification of AC with MgO has a significant effect on the adsorption of pollutant gases.

The condensation method in which gaseous hydrocarbons experience condensation to become a liquid in this study has been carried out by [14]. Exhaust gas recirculation (EGR) systems have been widely used in the automotive and heavy-duty truck sectors to reduce NOx, SOx, and other controlled emissions. Liquid-cooled or air-cooled heat exchangers are the main constituents of EGR systems. The heat exchanger lowers the temperature of the exhaust gas mixture flowing through the EGR channel and the lower temperature reduces the content of controlled gas emissions. Water vapor condensation is an unwanted by-product of the EGR system because in combination with the emission gases it forms corrosive sulfuric and nitric acids. The EPA in the US has advised that engine manufacturers turn off their EGR systems periodically to avoid the build-up of corrosive sulfuric and nitric acids. To accurately predict the corrosion process, a condensation model has been developed that investigated the rates of formation and diffusion of cold nitric and sulfuric acid tube surfaces. A three-dimensional computational fluid simulation (CFD) was performed for a typical EGR cooler during normal Tier 4 operating conditions on a heavy truck. A unified 1D heat and mass transfer model has also been developed to study the most important physical aspects of the condensation process. CFD and analytical results of condensation rates and local fluid properties are an important and inexpensive complement to more expensive experimental measurements and tests. The model can be used to improve the design and optimize the operating conditions of EGR systems and can be a valuable tool in the design and manufacture of the next generation of EGR systems for diesel engines. The developed model is general and technical and the numerical results of this research can be extended to engine reliability, corrosion reduction, and damage prevention of other industrial machines.

The absorption system is also carried out to reduce exhaust emissions [15]. This research describes an optical fiber sensor for the detection of NOx (NO_2 and NO) and CO_2 in the exhaust system of a road vehicle. The measurement is based on a free path interaction zone which is interrogated using UV and NIR light guiding optical fibers and collimated lenses. Results are presented of the absorption spectra of the gases in the UV region for the NOx gases and NIR region for CO_2. These demonstrate that using this method it is feasible to identify the individual CO_2, NO, and NO_2 species as well as other gases in the exhaust system. Measurement of concentrations to the level of 10's parts per million (ppm) has been demonstrated for the NOx gases.

To reduce exhaust emissions, some researchers also conduct research with the chemical reaction of ammonia, as has been done by [16]. The solid-SCR (selective catalytic reduction) system using ammonium carbamate (AC) is designed to increase the efficiency of reducing NOx emissions and compensate for the deficiency of UWS (urea aqueous solution). The SCR system is applied to marine diesel engines. The solid-SCR system is installed in the exhaust duct of a 1.1 MW engine for onboard power generation, and its emission reduction performance is compared to the existing UWS-SCR system. The NOx emitted from the engine is 9.2 g/kWh, and it reduces to 1.94 g/kWh when using the UWS-SCR system. Using a solid-SCR system significantly lowers NOx emissions to 0.3 g/kWh, which is 15 % of that of the UWS-SCR system. In addition, the solid-SCR system exhibits less ammonia slip characteristics than the UWS-SCR system. In solid SCR systems, ammonia gas is directly supplied in the exhaust, mixes well with exhaust gases, and reacts well with NOx in the SCR catalyst. The solid-SCR system endurance test was carried out for 210 hours during actual ship operation. NOx reduction efficiency was maintained at higher than 90 % for 210 hours. The air conditioner consumption rate is 1.7–4.3 kg/hour for the endurance test. Exhaust emission tests on motorcycles have been carried out by [17] using a catalytic converter.

The advantages of the adsorption method compared to the methods described above are a simple design, cost-effectiveness, excellent approach for removing organic pollutants, and simple process [18]. Therefore, the adsorption method was chosen and this study focused on the effectiveness of the form of briquettes made from peat soil as an adsorbent. Peat soil is used here because it is abundant in quantity and is a potential area especially in Banjarmasin, South Kalimantan of Indonesia. This peat soil adsorbent was installed in the exhaust of a motorbike and tested. The test is carried out using a dynamometric test chassis to obtain power and torque data. Besides that, it also tested its exhaust emissions.

Research on the potential of activated carbon from peat soils as an absorber of hydrocarbon and carbon monoxide emissions in motorized vehicles has been carried out by [19]. This method utilizes peat soil as a source of active carbon. The resulting activated carbon is then packed into an absorbent tube mounted on the muffler with a diameter of 30 mm and varying lengths of 60 mm, 70 mm, and 80 mm. This shows that the length of the absorbent pipe from the muffler affects the ability of absorption to reduce emissions.

But there were unresolved issues related to contact area and flow turbulence. Therefore, research is also carried out on the effect of filter variations related to the contact area and turbulent flow. The reason for this may be that some previous approaches were not equipped with a set of filters assembled in the muffler to expand the contact area and flow turbulence. A way to overcome these difficulties can be the variation of filters installed in the exhaust gas motor vehicle. However, all this suggests that it is advisable to conduct a study on the implementation of peat soil absorbent for reducing emission improvement for motor vehicles.

3. The aim and objectives of the study

The aim of the study is to determine the effect of peat soil adsorbents with a variety of filters installed on the exhaust of motorized vehicles on HC and CO emissions. The practical expectations of this result are that it is possible to obtain CO and HC emission reduction results and also increase engine performance.

To achieve this aim, the following objectives have been solved:

– to determine the effect of engine speed on CO emissions from the exhaust gas using peat soil adsorbent and filter variations by using a gas analyzer;

– in addition, to determine the effect of engine speed on HC emissions from the exhaust gas using peat soil adsorbent and filter variations;

– to see the effect of engine speed on the power & torque of motorized vehicles whose exhaust uses peat soil adsorbent and variation of filters by using a dyno test;

– to validate the results of this study with previous researchers.

4. Materials and Methods

4. 1. Research variables

The research variable is the object that is the center of attention in this study. There are some data used in this study, among others:

1) data validation with others research;

2) data emission HC and CO from motor vehicle using variation of filter and peat soil absorbent that install in the muffler. The rpm variation data in this study were 1000 rpm, 2000 rpm and 3000 rpm and using gas analyzer to measure CO emissions in percentage and HC emissions in ppm;

3) data on the performance of motorcycles using peat soil absorbent install in the muffler were also taken using Dyno Test VR-Tech V1.5. The performance data were also collected including: power and torque. Power in Nm and torque in hp were collected for every rpm change by using Dyno Test. The rpm variation data in this study were 3000 rpm, 3200 rpm, 3500 rpm, 3750 rpm, 4000 rpm, 4250 rpm, 4500 rpm, 4750 rpm, 5000 rpm, 5250 rpm and 5500 rpm. Furthermore, the data are plotted for the relationship between torque to rpm and power to rpm so on using Tecplot-360.

4. 2. Research methodology for the performance of motorcycle

4. 2. 1. Preparation phase

Preparation consists of field survey, setting up devices, collecting soil samples, preparing activated carbon specimens, and devising the adsorbing tubes. It also includes setting up the test engine and checking its condition.

4. 2. 2. Main phase

This includes making the activated carbon via carbonization and activation. The carbonization is conducted at 500 °C with the mesh size 50 for the soil articles. Two tests are carried out:

a) activated carbon testing.

This test is intended to identify the characteristics of peat soil as a source of activated carbon. It is important to determine the water content (*w*), ash content, the morphology and surface area of the activated carbon;

b) emission and performance testing:

1) here, the CO and HC emission and the motorcycle performance are measured without any activated carbon added. These results are required as the control for the coming experiment;

2) specimen of activated carbon (with the shape of a circle 20-mm in diameter and a coaxially-holed circle with a 20-mm outside diameter of and a 10-mm inside diameter) are installed in the exhaust pipe, the CO and HC emissions are measured, and the motorcycle performance is recorded.

The results will be analysis to determine the reduction in CO and HC emission. The reduction percentage is calculated through comparison between the average measurements before and after the adsorbent specimens is installed. Fig. 1 shows the schematic design of the experiment.

The complete procedure is shown in Fig. 2.

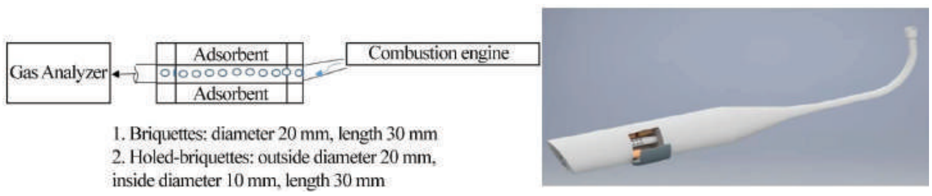


Fig. 1. Experimental design

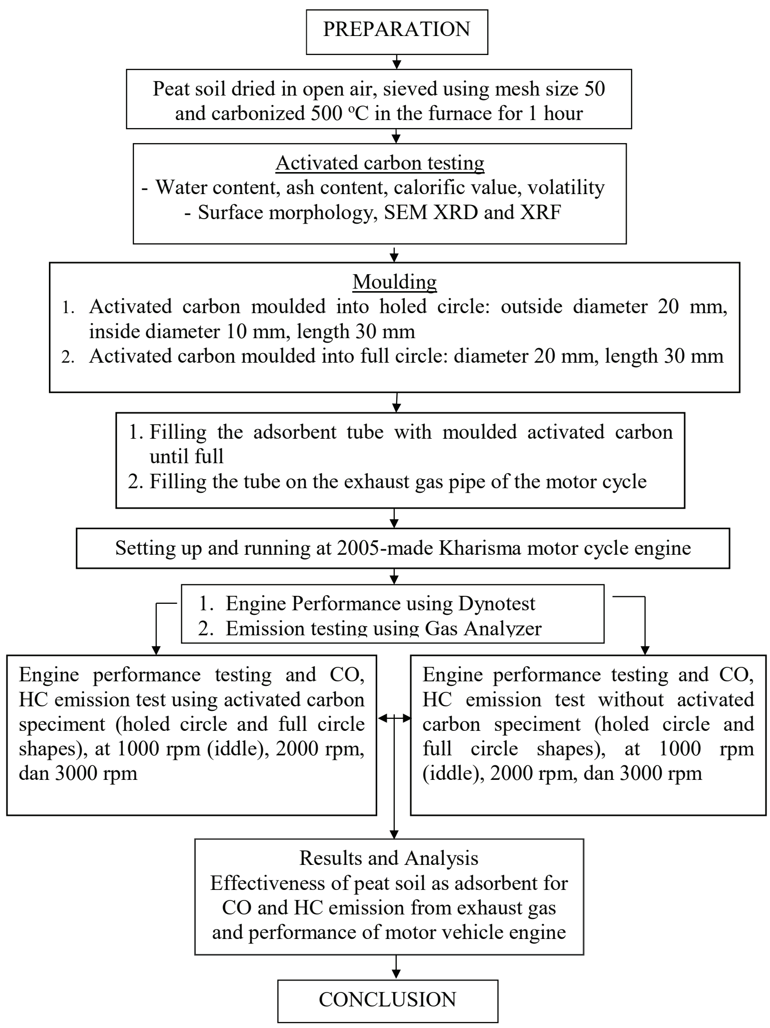


Fig. 2. Research procedure

The complete procedure for this study can be seen in Fig. 2 above. The initial stage is the peat soil is dried in free air then sieved with a size of 50 mesh and carbonized at 500 °C in a furnace for 1 hour. Next is testing activated carbon among other tests: moisture content, ash content, heating value, volatiles, the surface morphology of activated carbon SEM XRD and XRF. Then proceed with the molding process. Mold peat soil briquettes with circles with an outer diameter of 20 mm and an inner diameter of 10 mm and a length of 30 mm. Mold a full circle with a diameter of 20 mm and a length of 30 mm. Insert the activated carbon mold into the tube until it is full. Install the adsorbent tube on the motor vehicle exhaust. The final stage was testing the 2005 motorcycle. The first test was testing the motorcycle performance using the Dyno test. The second test is testing motor vehicle exhaust emissions with a gas analyzer.

5. Research result of determining the effect of peat soil adsorbent with variation of filter installed in the muffler of a conventional motor vehicle

5. 1. Relationship between engine speed on emission of CO

The effectiveness of peat soil as an adsorbent of emission from motor vehicles was studied based on tests using a 2005-made "KHARISMA" motor vehicle. Along with the emissions, the engine performance was also recorded. The engine was operated at 1000 rpm, 2000 rpm, and 3000 rpm. Table 1 summarizes the results.

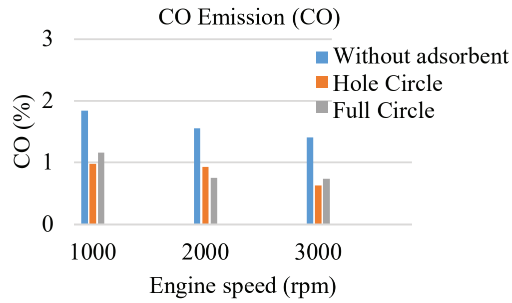
Table 1

Results from emission tests on the use of peat soil-based activated carbon as an adsorbent in a motor vehicle engine

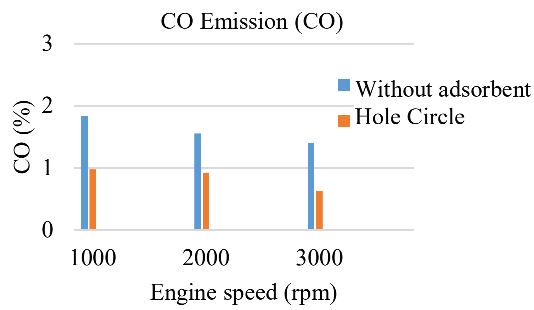
No	Engine Speed	Result					
		no Adsorbent		Hole circle		Full circle	
	(Rpm)	% CO	ppm HC	% CO	ppm HC	% CO	ppm HC
1	1000	1.84	550	0.95	481	1.19	295
		1.85	552	0.98	480	1.12	298
		1.83	554	1.01	484	1.18	296
		1.84	552	0.98	481.6	1.16	296.3
2	2000	1.56	234	0.92	342	0.75	502
		1.57	235	0.94	341	0.73	505
		1.55	232	0.94	340	0.76	501
		1.56	233.6	0.93	341	0.75	502.6
3	3000	1.4	741	0.62	714	0.73	826
		1.41	743	0.64	716	0.76	821
		1.43	740	0.63	715	0.72	825
		1.41	741.3	0.63	715	0.74	824

From Table 1 it can be seen that the lowest emission of CO is 0.63 percent and the highest is 1.41 percent at 3000 rpm with full-circle adsorbents. The lowest emission of HC is 715 ppm and the highest is 824 ppm. Fig. 3 details the CO results.

It is clear that the emission level is affected by the engine speed. The CO emission increases along with the speed. This is true for both conditions with and without an adsorbent. The use of adsorbent decreases the emission by 55 percent from 1.41 percent. This is caused by the adsorption by activated carbon placed along the exhaust pipe.



a

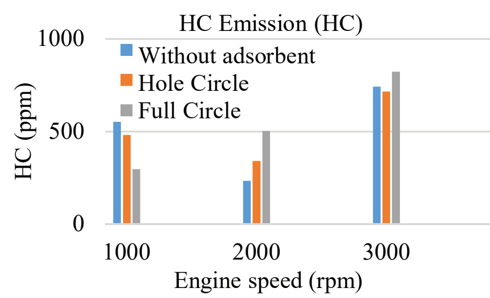


b

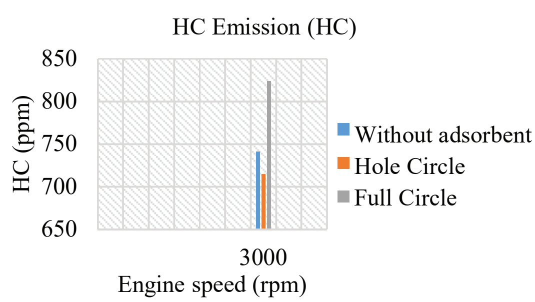
Fig. 3. CO emission for: *a* – 3 variation of filters; *b* – 2 variation of filters

5. 2. Relationship between engine speed on emission of HC

The following will discuss the results of research for HC emissions. Fig. 4 shows results from the HC emission.



a



b

Fig. 4. HC emission for: *a* – 3 variation of filters; *b* – 3 variation of filters just for 3000 rpm

It is also clear that the HC emission is affected by the engine speed. It increases as the speed increases either when an adsorbent is added or not. At 1000 rpm, the use of an adsorbent reduces the emission especially when the shape is a full circle. At 2000 rpm, the addition of an adsorbent increases the emission. The lowest emission at 3000 rpm is given by the use of a holed-circle adsorbent. The hold-circle adsorbent can reduce the HC emission by 3.51 percent. High exhaust gas flow at 3000 rpm blocked by the full circle adsorbent turned out to cause the highest emission and damaged part of the adsorbent.

5. 3. The relationship between engine speed on torque and power

5. 3. 1. Engine performance with holed-circle adsorbent

The engine performance with holed-circle adsorbent is shown in Table 2 and also in Fig. 5.

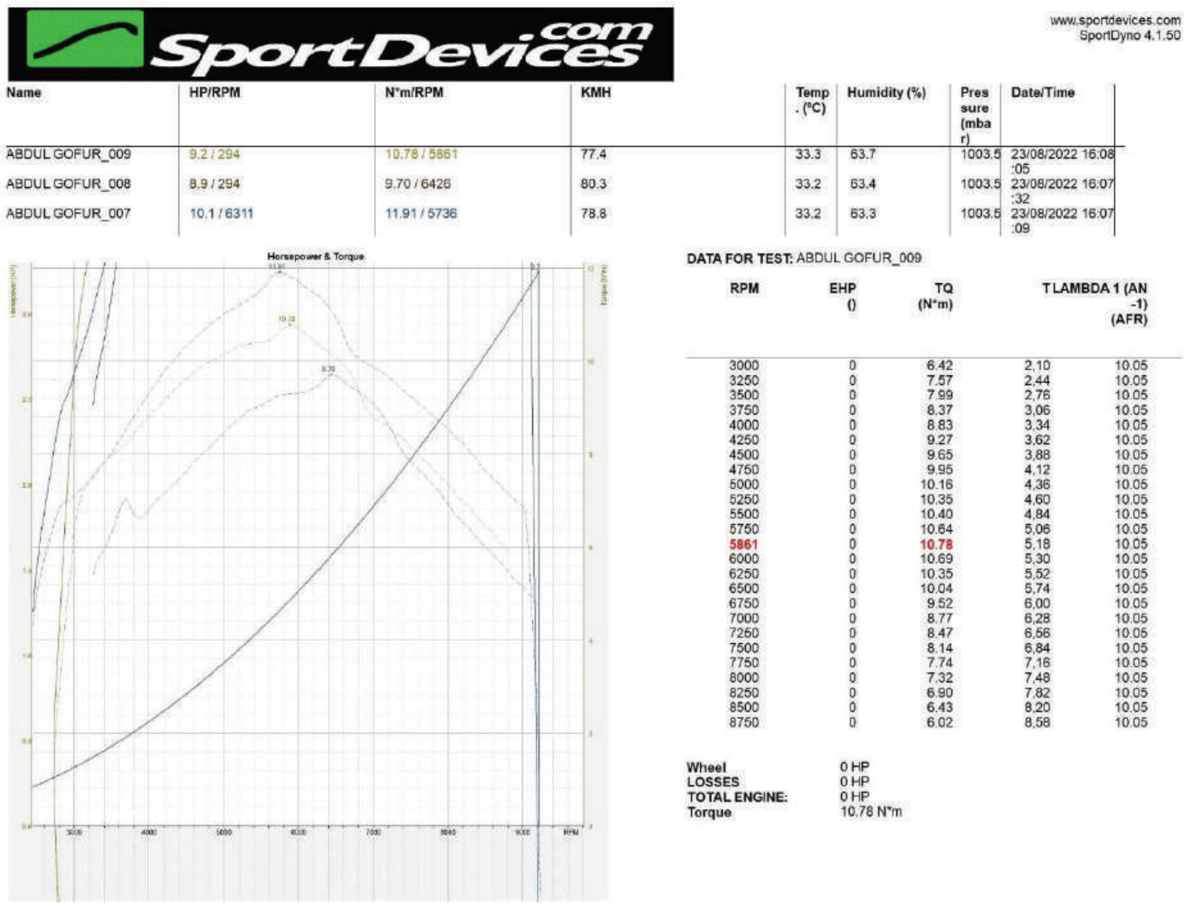


Fig. 5. Engine performance with holed-circle adsorbent

Table 2

Engine performance with holed-circle adsorbent

No.	Rpm	Tq (Nm)
1	2	3
1	3000	6.42
2	3250	7.57
3	3500	7.99
4	3750	8.37
5	4000	8.83
6	4250	9.27
7	4500	9.65
8	4750	9.95
9	5000	10.16
10	5250	10.35
11	5500	10.4
12	5750	10.64
13	5861	10.78
14	6010	10.55
15	6250	10.35
16	6500	10.04
17	6750	9.52
18	7000	8.77

Continuationf of Table 2

1	2	3
19	7250	8.47
20	7500	8.14
21	7750	7.74
22	8000	7.32
23	8250	6.9
24	8500	6.43
25	8750	6.02
25	9000	6.00

The maximum torque of 10.78 Nm is obtained at 5861 rpm, while the maximum horse power of 10.1 hp is at 6311 rpm.

5. 3. 2. Engine performance with full-circle adsorbent

The engine performance with holed-circle adsorbent is shown in Table 3 and also in Fig. 6.

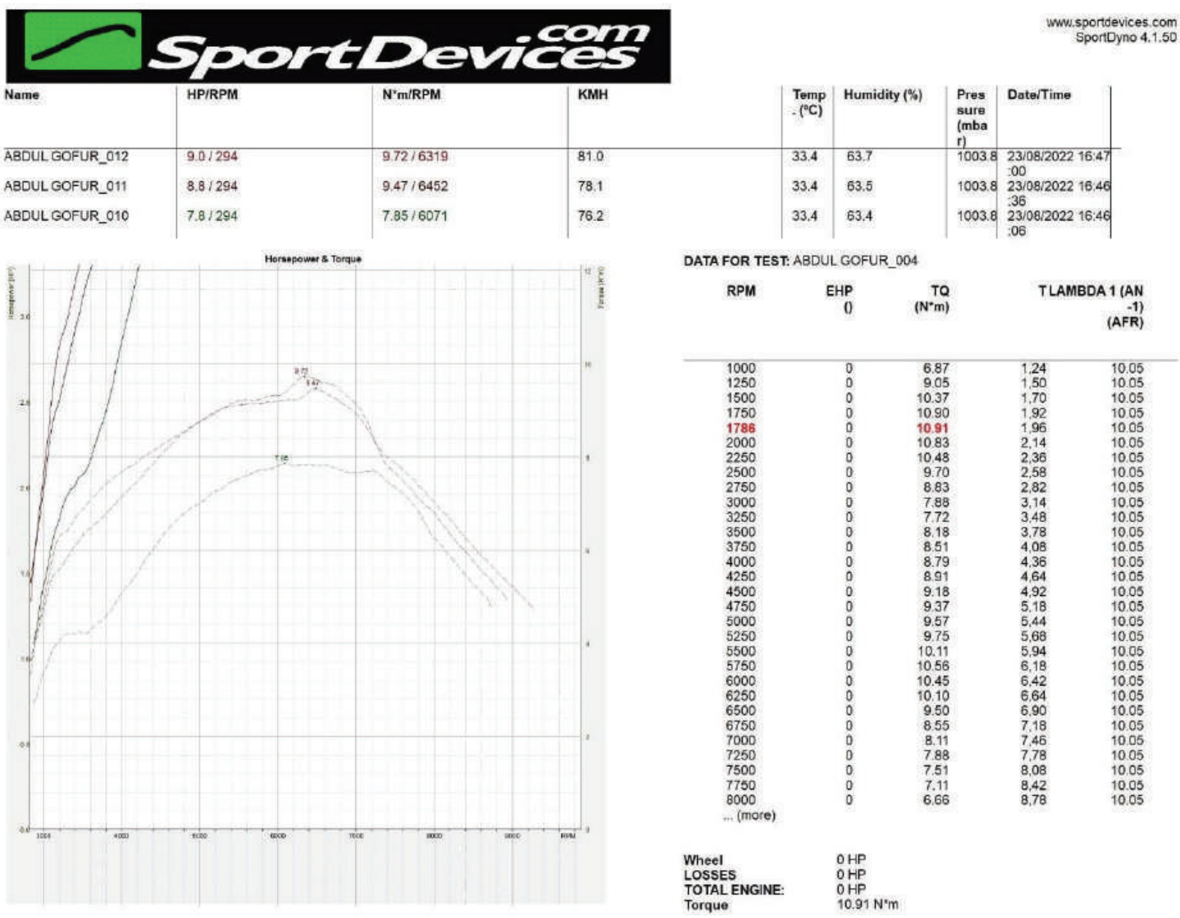


Fig. 6. Engine performance with full-circle adsorbent

Table 3

Engine performance with full-circle adsorbent

No	Rpm	Tq (Nm)
1	2	3
1	1000	6.87
2	1250	9.05
3	1500	10.37
4	1750	10.9
5	1786	10.91
6	2000	10.83
7	2250	10.48
8	2500	9.7
9	2750	8.83

Continuationf of Table 3

1	2	3
10	3000	7.88
11	3250	7.72
12	3500	8.18
13	3750	8.51
14	4000	8.79
15	4250	8.91
16	4500	9.18
17	4750	9.37
18	5000	9.57
19	5250	9.75
20	5500	10.11
21	5750	10.56
22	6000	10.45
23	6250	10.1
24	6500	9.5
25	6750	8.55
26	7000	8.11
27	7250	7.88
28	7500	7.51
29	7750	7.11
30	8000	6.66

The maximum torque of 9.72 Nm is obtained at 6319 rpm, while the maximum horse power of 9.0 hp is at 294 rpm.

Overall, from Fig. 5, 6 the performance in terms of torque and power does not change significantly in other words the torque is almost the same between the hole circle and the full circle. Likewise, the results of the power are also almost the same.

5. 4. Validation of research result

Below is a validation of research results in Table 4.

Table 4

Validation result

Researcher	Engine speed(Rpm)	Torque (N m)
Research by [19]	5168	9.627
Current research	5168	9.613

Validation was carried out with previous researchers, namely [20]. The conditions are designed accordingly with the experimental conditions of the previous researchers. The results are presumably in good agreement with previous studies.

6. Discussion of experimental results on determining the effect of peat soil adsorbents and variations in the use of filters on exhaust gas

From the research data Fig. 3, it was obtained that the lowest CO emission was 0.63 which was achieved when the engine speed was 3000 rpm using a peat soil adsorbent with the mold, a circle with a hole in the middle. When compared with the value of carbon monoxide (CO) emissions from the test engine without using an adsorbent, it is 1.41. So that the results of this test showed a reduction of 55.3 % in the value of CO emissions by using an adsorbent with a hollow circular shape. The test results show that the use of peat soil adsorbent with perforated circle molds (outside and inside diameter) is more effective in reducing motorized vehicle CO emissions compared to the use of peat soil adsorbents with solid circle molds. This is due to the hollow circle mold having two surfaces, namely, the first surface is on the outside diameter and the second surface is on the inside diameter. This situation causes the adsorbent to maximize the adsorption of other substances that pass through the adsorbent. The adsorption of a substance (adsorbate) on an adsorbent surface is called adsorption. Exhaust gas adsorption is the ability to adsorb gas in a peat soil briquette. Adsorption occurs due to the molecules on the surface of the substance causing an unbalanced tensile force that tends to be attracted inward (the cohesion force of the adsorbent is greater than the adhesion force), as a result, the substance as an adsorbent tends to attract other substances that come into contact with its surface based on the interaction between the surfaces of the adsorbent and the adsorbate that occurs in the exhaust gas channel. When compared with previous studies by researchers [20] with the same rpm, namely 2000 rpm, CO & HC emission testing on motorbike exhausts with the addition of active carbon peat soil adsorbent, the results are shown in Table 5 below.

Table 5

Comparison of exhaust emissions from previous researchers with current researchers

No	Researcher	Engine rotation (rpm)	Emission	
			CO	HC
1	Research by [19]	2000	2.615	1437
2	Current research	2000	0.93	341

The engine of the motorcycle is different for both types of research. In table 5 above it can be seen that the use of peat soil adsorbent with hole circle filters results in smaller

CO and HC exhaust emissions compared to previous researchers [20]. As explained above, this is due to the greater adsorption of CO and HC with hole circle filters due to adsorption on the 2 surfaces, namely the outer surface and the inner surface of the peat soil adsorbent.

Whereas for Hydro Carbon (HC) in Fig. 4 the lowest emission value is 715. When compared the emission value of Hydro Carbon (HC) without using adsorbents is 741.3. So the reduction is 3.5 %. If to compare the adsorbent with the hollow circle and the adsorbent with the full circle in Fig. 4, *b*, namely at 3000 rpm, it can be seen that the HC hole circle filter is 710 while the HC full circle filter obtained is 815. The use of a filter with this circle hole can reduce HC emissions by 12.8 % compared to the full circle filter. This decrease is due to the more effective adsorption by the peat soil adsorbent with a full-circle filter placed in the middle of the exhaust gas channel. This is because the hole circle filter adsorbs more due to the adsorption that occurs on the two surfaces.

From the performance tests of motorcycles in Tables 3, 4 using full circle adsorbent and holed circle adsorbent. It was found that the presence of these adsorbents did not interfere with the motorcycle performance. The results of the motorcycle performance of the two objects tested are almost the same, which means that with the presence of this adsorbent the engine does not make abnormal sounds, or in other words the engine does not turn off. It can be concluded that the use of peat soil adsorbents and filters for both hole circles and full circles does not affect the motorcycle performance. The same results were also obtained by researchers [20] that the motorcycle performance of the peat soil adsorbent with the filter installed in the exhaust gas did not experience a significant increase.

The limitation of this study is that the peat soil adsorbent with a variety of filters is installed on the exhaust of the 125 cc Honda Kharisma motor vehicle, which has gone through processes to produce carbon activation. Because the highest CO emissions produced by gasoline engines occur at idle and deceleration, and lowest during acceleration and at a constant speed. For this reason, the speed of emission testing is in the range of 1000 rpm, 2000 rpm, and 3000 rpm. With low horsepower (hp) so it cannot be used for test drives in open fields. This test equipment needs to be developed on the side of adding other materials to peat soil so that it becomes a better adsorbent. Setting in the carburetor needs to be done. This research is suitable for testing in a gas analyzer only. The activated carbon test needs to be carried out to determine the moisture content, ash content, morphology, and surface area of the activated carbon.

The results of the validation in Table 4 show that there are similarities between this study and previous studies. The error percentage is about 1.4 %. This shows that the procedure that has been carried out is correct. The research conditions have been designed according to the experimental conditions of the previous researchers [19]. Then in this study, engine performance testing uses a chassis dynamometer.

7. Conclusions

1. Emission of CO test result show that the emission of CO from peat soil adsorbent & hole circle filter decrease compare to conventional muffler. For emission of CO, the decrease is approximately 55 %. The results of CO and HC exhaust emissions from this study are still below the threshold.

2. From test result of HC emission show that the emission of HC from peat soil adsorbent & hole circle filter decrease compare to conventional muffler. For emission of HC, the decrease is approximately 3.51 %.

3. The motorcycle performance test from peat soil adsorbent and filter compares to conventional muffler where the difference is not too significant.

The same result was also obtained by previous researchers [19] using a peat soil adsorbent installed in the exhaust of a supra motorbike with variations in the length of the adsorbent pipe. It is established that the length of the tube affects the absorbent ability to reduce emission, but it does not significantly affect the engine's performance.

4. The validation results are in accordance with previous study. The difference from the 2 research results is around 1.4 percentage.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

Manuscript has data included as electronic supplementary material.

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