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The Use of Adsorbents of Lampung Natural eolites/Coal-Fly Ash in Reducing Fuel Consumption and Exhaust Gas Emissions of a 4-Stroke PETROL Motorcycle

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ABSTRACT. Research in utilization of Lampung natural zeolite/coal-fly ash was performed to observe its effect on fuel consumption savings and the reduction of exhaust emissions on a 4-stroke petrol motorcycle. Percentage variations of zeolite/coal-fly ash were abbreviated by 0/100 (Z0-F100), 25/75 (Z25-F75), 50/50 (Z50-F50), 75/25 (Z75-F25), and 100/0 (Z100-F0) (wt.%). Tests of fuel consumption were conducted by stationary tests at engine speed of 1000, 3000, and 5000 rpm and road tests as far as 5 km. Meanwhile, exhaust emissions tests were performed at engine speed of 1500 and 3500 rpm. Filter of zeolite/coal-fly ash was put on the air filter casing, so before entering the combustion chamber, the combustion air was firstly contacted with this filter. The test results showed that the best fuel consumption savings for stationary tests occurred in the use of filter Z25-F75 that is as big as 53.06%, and the best fuel consumption savings in road tests as far as 5 km at a constant speed of 60 kph also occurred in the use of filter of Z25-F75 that is by 33.43%. In addition, the highest reduction of CO and HC concentration also occurred in the use of filter of Z25-F75 that is by 38.47% and 30%, respectively.

INTRODUCTION

In decades, issues in air pollution and fossil fuel energy crisis due to increasing in production of motorcycle, car, and industrial engines is huge problem in global world [1]. In Indonesia, the scarcity of fuel availability in gas stations sometimes occurred at several cities. Increasing in motorcycle and car production every year, caused an increase in fossil fuel consumption and later leads to increase in air pollution. This impact greatly contributes to the high amount of hazardous gases for health and greenhouse effects [2]. In addition, waste of coal-fly ash also provides negative impacts on the environment (accumulating air pollution and surrounding environment) [3]. The largest production of fly ash are resulted from a coal-fired power plants. The use of zeolites and coal-fly ash as air filter in increase of engine motorcycle performance can alternatively solve a problem in the energy crisis and air-environmental pollution.

Many studies have suggested that zeolite has an ability to adsorb nitrogen gas and water vapor in air environment [4,5], whereas coal-fly ash is able to adsorb moisture [6]. Iyer and Stanmore [7] also proved that fly ash has a property to absorp water. Chunfeng et al. [8] confirmed that fly ash containing ratio SiO_2/Al_2O_3 of < 5 is a similar content in natural zeolite. These properties are a reason that zeolite and coal-fly ash can be used as an air filter. Wardono *et al*., [9] had proved the ability of the zeolite pellets as air filter in saving fuel consumption of 31.03%, and reducing CO gas of 13.64%. In another study, Wardono and Mario [10] had proved the ability of coal-fly ash for saving fuel consumption and reducing exhaust gas emissions. They reported that coal-fly ash pellets were able to save a fuel consumption of up to 34.48% in stationary tests, and 22.38% in road tests, respectively. In addition, fly ash pellets also reduced CO emission gas by 15.81% and HC gas by 18.20%, respectively. An increase in motorcycle performance during stationary and road tests was attributed using natural zeolite or coal-fly ash as air filter because the zeolite has a property to adsorb nitrogen gas and water vapor, and coal-fly ash are able to adsorb water vapor.

As mentioned above, it proves that both Lampung natural zeolite and coal-fly ash are able to save a fuel consumption and reduce exhaust emissions gas. Basically, natural air is composed of nitrogen, oxygen, other gases and water vapor. In the combustion process, the gas required is only oxygen. Meanwhile, nitrogen gas and water vapor are not required in combustion process, so that they should be removed in the combustion air. Less

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content of nitrogen gas and water vapor in the combustion air, higher heat accepted by fuel at the end of the compression stroke. Therefore, the experimental research is required to investigate the engine performance of a 4-stroke motorcycle using of air filter made up from pellets containing mixtures of natural zeolite/coal-fly ash. The stationary and road tests of motorcycle performance data are compared to get the best composition of mixtures of zeolite/coal-fly ash. Production of pellets made up from mixture of zeolite/fly ash were very easy and cheap. Filter containing the pellets was very easy to being mounted in a motorcycle, and required no modifications in the engine.

MATERIALS AND METHODS

MATERIALS

Raw materials used in this experiments to produce pellets were Lampung natural zeolite, coal-fly ash, mineral water, and tapioca. Natural zeolite is from Sidomulyo-South Lampung. Coal-fly ash is obtained from Steam Power Plant in Tarahan-South Lampung.

Pellet Preparation

After the tools and materials were prepared, zeolite, coal-fly ash, mineral water, and the tapioca flour were firstly weighed using a digital balance (unit in gram), respectively. Compositions of pellets were varied with zeolite/fly ash ratio of 0/100, 25/75, 50/50, 75/25, and 100/0 (wt.%). Furthermore, all raw materials were mixed and stirred until form a pasta, and cool in room temperature. Thereafter, pasta was inserted into pellet moulding and formed tablet with diameter of 10 mm and thickness of 3 mm. The pellets containing of zeolite/fly ash ratio of 0/100, 25/75, 50/50, 75/25, and 100/0 (wt.%) are abbreviated with Z0-F100, Z25-F75, Z50-F50, Z75-F25, and Z100-F0, respectively. Pellets were then heated in oven at 100 °C for 1 h for removing water content (Fig. 1a). After that, pellets were packaged using 3 variations of weight: 15 g (full filter), 11.15 g (medium filter), and 7.5 g (half filter) and neatly arranged using wire frame as filter (Fig. 1b). After that, the air filter containing pellets was mounted in air filter casing of motorcycle (Figure 2a).

(a) (b)

FIGURE 1. (a) Zeolite/coal-fly ash pellets and (b) the pellet filters.

Motorcycle Performance Tests

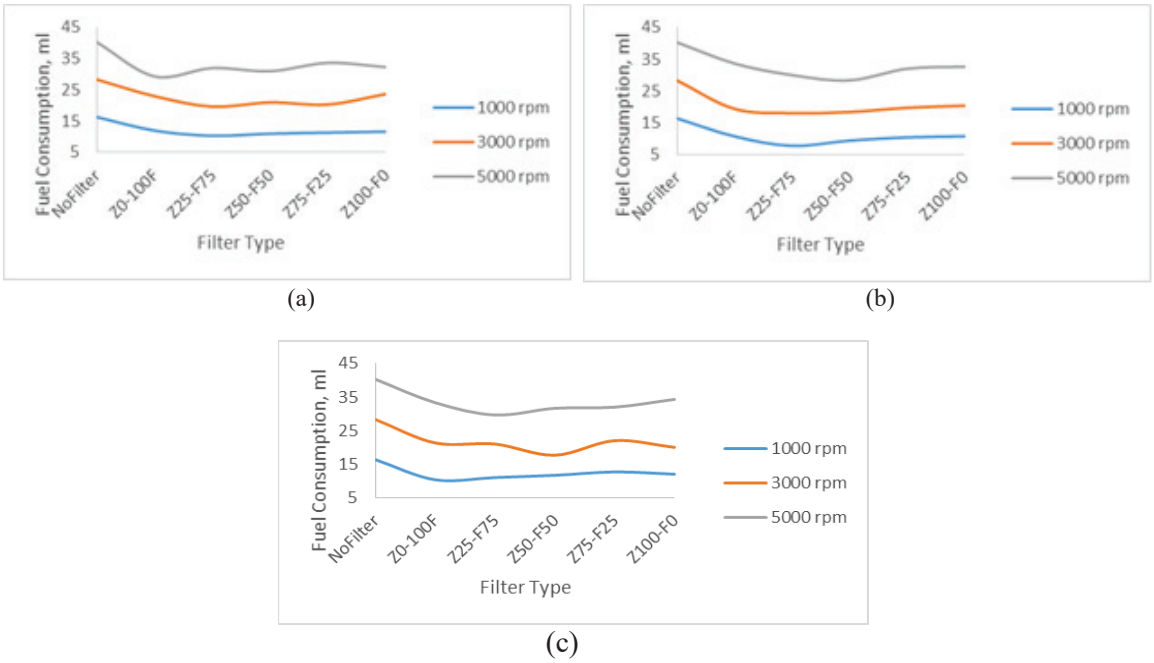
Experiments were started firstly by observing a fuel consumption on motorcycle under two conditions, namely stationary tests and road tests. Stationary tests were performed at idle engine condition. The first is preparation by warming up the engine until the engine reach stable, and the second is setting up an engine rotation (rpm) at 1000, 3000, and 5000 rpm, respectively, and then the engine was turned off. The testing was started by filling gasoline into artificial tank up to 240 ml and the engine was turned on again together with the stopwatch turning on. After 5 minutes, the engine and stopwatch was turned off. The remaining fuel in the tank was measured again for determining the amount of fuel consumption. The engine performance test was continued using air filters containing mixtures of zeolite/fly ash with a different weight for all ratios of zeolite/fly ash compositions. After that, tests were continued with variations in other engine rotations for 3000 and 5000 rpm. Furthermore, the engine tests were performed also using pellets with 11.25 g and 7.5 g. All results were recorded, and compared with the test results using with and without air filter of zeolite/fly ash pellets.

(a) (b)

FIGURE 2. (a) Mounting of pellet filter on motorcycle and (b) gas analyzer.

After stationary tests, fuel consumption tests were also performed for road tests. The experimental procedure performed was the same as stationary tests, the difference was the motorcycle goes as far as 5 km at an average speed of 60 kph. Testing began with no pellet filter, continued with filter Z0-F100, Z25-F75, Z50-F50, Z75-F25, and Z100-F0 mounted in the air filter casing, with a variation of the pellets weight of 15 g, 11.25 g and 7.5 g. All the test results were recorded, then compared with the results of the test without using filter pellets.

From the test results of fuel consumption, it shows that the filter zeolite/fly ash with weight of 11.25 g provides the best fuel consumption savings. Thus, in the exhaust emission tests, weight of pellets used was only 11.25 g for all variations of zeolite/fly ash composition. The test sequence was preceded by no pellet filter mounted on the engine, then followed by filter of Z0-F100, Z25-F75, Z50-F50, Z75-F25, and Z100-F0 with a variation of the engine rotation of 1500 and 3500 rpm. Emission test results required in this research were the concentration of CO and HC gas produced by the combustion gases. The concentration of emission gases were measured by a gas analyzer, as shown in Fig. 2b. The results of concentration of CO and HC gas were recorded, then compared with test results without using filter of zeolite/ fly ash pellets.



(a) (b)

(c)

FIGURE 3. Fuel consumption in stationary tests (a) 15 g, (b) 11.25 g, and (c) 7.5 g.

RESULTS AND DISCUSSIONS

Fuel Consumption at Stationary Tests

Figure 3 shows that the use of the entire filters of zeolite/fly ash pellets are able to save fuel consumption of motorcycle for the weight of 15 g (Fig. 3a), 11.25 g (Fig.3b), and 7.5 g (Fig. 3c). The use of pellet filters with

weight of 15 g was able to save fuel consumption by 26.51% till 36.75% at 1000 rpm, 16.47% till 30.59% at 3000 rpm, and 16.53% till 27.27% at 5000 rpm, as shown in Fig. 3a. The best result was obtained in the use of 11.25 g pellet filter, which was able to save fuel consumption of by 34.70% till 53.06% at 1000 rpm, 28.24% till 36.47% at 3000 rpm, and 16.53% till 29.75% at 5000 rpm, as shown in Fig. 3b. Meanwhile, the use of 7.5 g pellet filter was able to save fuel consumption by 22.45% till 36.74% at 1000 rpm, 22.35% till 37.65% at 3000 rpm, and 14.88% till 21,49% at 5000 rpm, as shown in Fig. 3c. From the above results, the highest fuel consumption saving occurred in the use of filter with weight of 11.25 g pellets, that was 53.06%. It occurred for use of Z25-F75 filter.

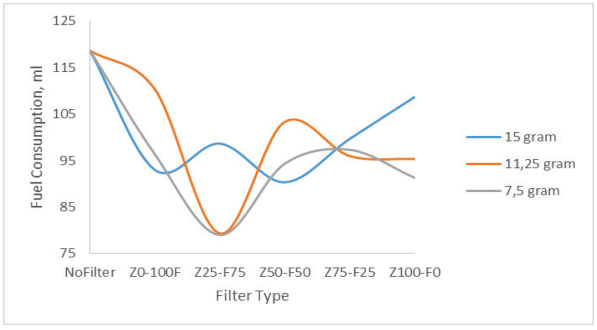
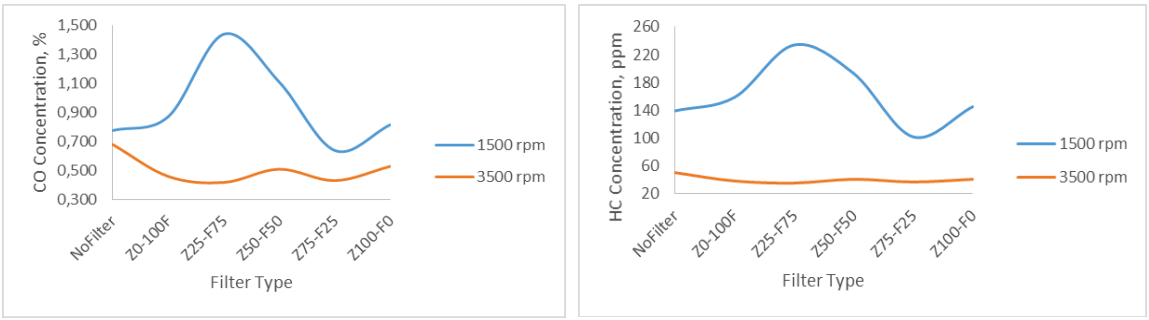


FIGURE 4. Fuel consumption in road tests at 60 kph for 5 km.



(a) (b)

FIGURE 5. Emission gas concentration in exhaust gas (a) CO and (b) HC.

Fuel Consumption at Road Tests

Similar results as stationary tests also occurred in road tests. The fuel consumption savings occurred were quite significant, as shown in Fig. 4. In road tests, the highest fuel savings also occurred in the use of the pellet filter of Z25-F75 with weight 7.5 g and 11.25 g, those were 33.43% and 33.15%, respectively. The fuel consumption savings occurred at 8.43% till 23.88% with weight of 15 g, 7.02% till 33.15% with weight of 11.25 g, and 17.98% till 33.43% with weight of 7.5 g.

Exhaust Gas Emissions at Stationary Tests

Slightly different from the results obtained in the test of fuel consumption, in exhaust emissions test, the exhaust emissions were able to be reduced at test of 3500 rpm, while at the engine rotation of 1500 rpm, it was the opposite result, as shown in Fig. 5a and Fig. 5b. Reduction of exhaust emissions at 3500 rpm was obtained at between 22.10 till 38.47% for CO gas, and 19.0 till 30.0% for HC gas. The highest reduction of exhaust gas emissions occurred in the use of the pellet filter of Z25-F75, namely 38.47% till 30.0% for gas of CO and HC, respectively.

CONCLUSIONS

Air filter made up from mixtures of Lampung natural zeolite with coal-fly ash was proven to be able to save a fuel consumption at the stationary tests and road tests. Exhaust gas emissions were only reduced at the engine

rotation of 3500 rpm. The best performace of a-4 stroke petrol motorcycle are obtained using air filter containing of pellet with composition of Z25-F75, and followed by air filter containing of pellet with composition of Z50-F50.

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