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EFFECTS OF CATALYTIC MUFFLER ON THE PERFORMANCE AND EMISSION OF TWO-STROKE MOTORCYCLE

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In Malaysia, two-stroke motorcycles are favorable due to its higher performance and cheaper maintenance cost compared to four-stroke motorcycles. However, its disadvantages in terms of emission required improvement in existing exhaust system. This paper investigates the potential capability of using porous alumina-zeolite (PAZ) filter in reducing hydrocarbon (HC) and carbon monoxide (CO) from a two-stroke 110 cc carburetted motorcycle engine. The impact on engine performance was also investigated. The filter employed polymeric sponge method to produce porous structure with a composition of 70 vol. % alumina and 30 vol. % of zeolite, coated with stanum (IV) oxide. It was installed in the muffler of the original exhaust system and its performance was tested using Dynomite Chassis Dynamometer and emission analyzer. The testings were conducted from 2000 to 3000 rpm using three different configurations namely non-coated PAZ filter, coated PAZ filter and non-filter system. Results show lower exhaust gas emission which indicates the potential capability of using PAZ filter in the existing system without requiring major modifications on the system.

Keywords: Porous alumina-zeolite (PAZ) filter; polymeric sponge method; two-stroke motorcycle, hydrocarbon (HC); carbon monoxide (CO).

1. INTRODUCTION

Two-stroke motorcycles received particular attention due to its rapid growth in Asia. Compared to its counterpart, four-stroke engine; it has less components, cheaper, higher specific power and easier for maintenance. However, its disadvantage in terms of higher emission of CO, HC, particulate matter and high level of noise affects the overall new model development and finally the production of these engines. Several technique had been introduced but the exhaust after-treatment is considered the most popular and cost-effective method in meeting this regulations [1].

Existing exhaust control technology applied on two-stroke motorcycles is similar with the technology used on automobile. Some commercial catalytic converters employ honeycomb structures, diameter 1~2 mm which results the flow to become laminar. Considerable attention has been given on the structure of the substrate in order to make the flow turbulent [2]. Turbulence is preferred as it improves chemical reaction and thus to enhance turbulence, porous structures have the potential to be employed in design of catalysts. Its open cell structure with interconnected channels offers relatively low-pressure drop, radial mixing and tortuous flow paths to encourage the turbulence [3]. Using the oxidation catalyst such as platinum and palladium deposited on the metallic substrate, it has been incorporated on the system.As for oxidation catalyst, stanum (IV) oxide was tested [4] and has the potential as an alternative materials compared to highly expensive Platinum Group Metals (PGM).

This paper presents the effects of PAZ filters coated with stanum (IV) oxide on the two-stroke motorcycles. Performance and emission testing were conducted on three configurations of the exhaust system. It is shown that the emission level can be reduced up to 22 % for both CO and HC measurement. Further analysis indicates the advantage of PAZ filter in term of engine performance.

2. MATERIALS AND METHODOLOGY

2.1 Preparation of PAZ filters

Polymeric sponge method was used to prepare the PAZ filters. The first stage was the slurry preparation using 70wt% of alumina and 30wt% of natural zeolite (clinoptilolite). 70wt% of ovalbumin and water were added respectively as the carrier and binder for the ceramic slurry. It was stirred until a uniform mixture was obtained. Additional binder was also added into the slurry composition. In the second stage, polyurethane sponge was impregnated with ceramic slurry. The sponge was compressed to remove air, immersed into the slurry and allowed to expand. This process was repeated to achieve the required ceramic loading as the excess slurry was removed from the sponge. The third stage involved the drying and sintering process. The sponge was left in the room temperature for 24 hours before the drying process in a microwave oven. The dried sponge was then sintered in high temperature furnace at 1350°C before it was ready for the next process.

2.2 Coating of PAZ filters with stanum (IV) oxide

Dip-coating process was conducted to deposit the stanum (IV) oxide on the filters. This process generally involved 3 steps: immersion, dwell time and withdrawal. Prior to that, coating mixture was prepared by dissolving stanum (IV) oxide in distilled water inside a dipping tank. This solution was allowed to settle from 2 to 3 hours before the immersion process took place. The filter was immersed in the solution at constant speed and remained for 24 hours. Then, it was gradually withdrawn from the solution before the drying process in the oven for 6 hours. This coating process was expected to form a layer of stanum (IV) oxide on the surface structure of the filter. X-Ray diffraction (XRD) analysis was performed to determine the presence of stanum (IV) oxide on the PAZ filters.

2.3 System configuration

The exhaust system layout was depicted briefly in Figure 1. The PAZ filters was installed inside the existing muffler supported by the cone (at the inlet side) and silencer (at the exhaust outlet). First configuration consisted of non-coated PAZ filter installed in the muffler. In second configuration, PAZ filter coated with stanum (IV) oxide was assembled. Third configuration was used as a reference in which the exhaust gas was not treated before emitted to the environment (non-filter system). This is the original design of the motorcycle. The volume of the PAZ filters was used is identical with the engine capacity of 110 cc.

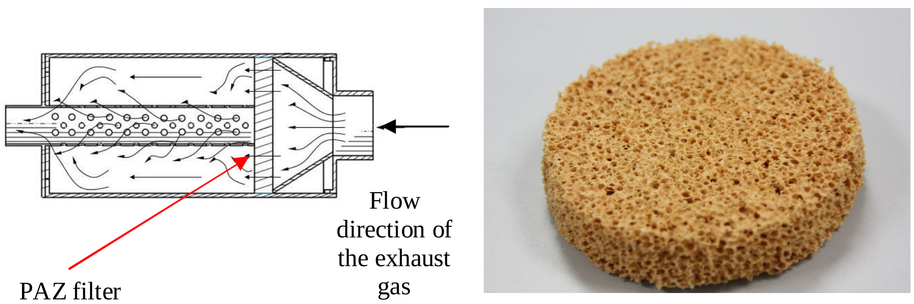


Fig. 1. Location of PAZ filters inside the exhaust muffler and PAZ filter

2.4 Performance and emission testing

The testing was conducted using a 300 hp Dynomite motorcycle chassis dynamometer on a 108 cc, single cylinder, 2-stroke air cooled motorcycle engine (specifications as in Table 1). Gas emission analyzer was used to measure the emission from the engine. The engine was tested at constant load (maximum throttle) at 2000 rpm. Parameters of power and torque; emissions of HC and CO were measured. Then the engine speed was increased by 250 rpm (2000, 2250, 2500, 2750 and 3,000 rpm). The testing parameters were applied on all the configurations as in Figure 2.

Table 1. Technical specification of the engine.

Type of engine	SOHC 2-stroke single cylinder, air cooled
No. of cylinders	1
Capacity	108 cc
Bore x Stroke	53 x 50.6 mm
Maximum power	6.6 kW@ 8500 rpm
Maximum torque	9.3Nm @ 4000 rpm
Compression ratio	9.0:1

Fig. 2. Performance test conducted on motorcycle chassis dynamometer.

3. RESULTS AND DISCUSSION

3.1 XRD analysis on PAZ filters

Effectiveness of dip coating process on the surface of the PAZ filters required further investigation. In Figure 3, XRD analysis from the coated PAZ filter has indicates the presence of stanum (IV) oxide in the filter. High peaks of elements for aluminium oxide and stanum (IV) oxide suggests the effectiveness of dip coating process in embedding stanum (IV) oxide particles onto the surface of PAZ filters.

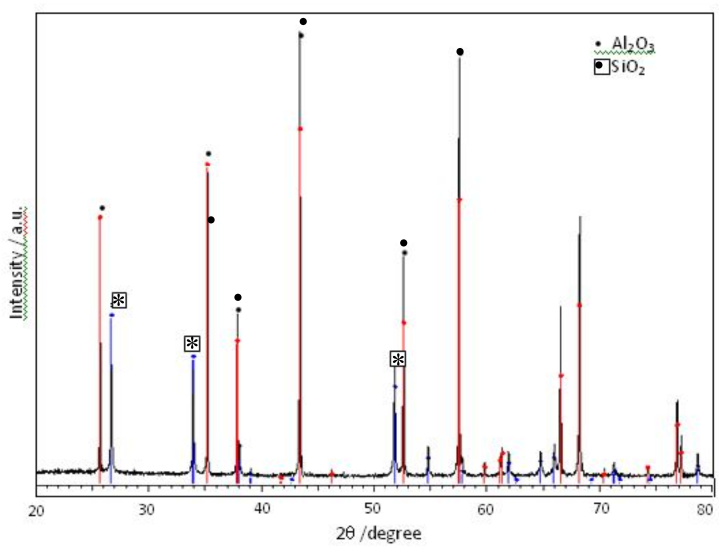
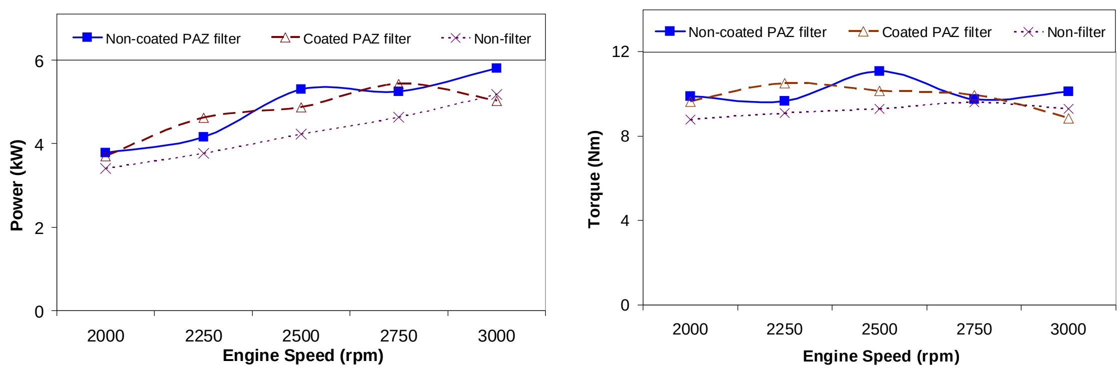


Fig. 3: XRD analysis of PAZ filters coated with stanum (IV) oxide.

3.2 Performance and emission testing

Performance of the engine in terms of power and torque is displayed in Figure 4. There is an increase in power for non-coated filter (average is 12.4 %) and coated filter (average is 11.5 %). The results show the advantage in using PAZ filters as its presence improve engine performance up to 12.4 %. Similar trend is seen for torque measurement. Average increase up to 8.5 % is seen with the application of PAZ filters in the exhaust system.

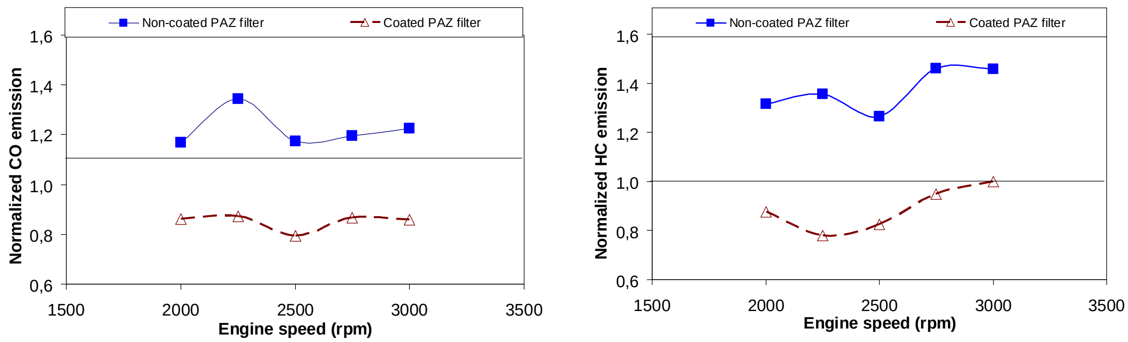


(a) (b)

Fig. 4. Comparison of engine performance (a) and engine torque (b).

Figure 5 represents the normalized form of CO and HC emission. The results are plotted as normalized emission by dividing emission concentration of the tested configuration to the concentration emitted in the non-filter system (if the value is larger than 1.0, then the emission is higher than the emission from non-filter system and vice versa).

Effectiveness of PAZ filters are measured compared to the non-filter system. Figure 5 shows consistent reduction of CO emission with average 14.9 % for coated filters from 2000 to 3000 rpm. Similar trend is also seen in HC emission as the average improvement is up to 11.4 %. However, at higher engine speed (2750 and 3000 rpm), high concentration of HC resulting less effectiveness of the filter. Overall results indicate the presence of stanum (IV) oxide on the PAZ filters has significantly improved the emission level from the engine.



(a) (b)

Fig. 5: Normalized CO emission (a) and HC emission (b).

4. CONCLUSION

The results of performance test here demonstrate coated PAZ filters does not affect two-stroke engine performance. In terms of emission, stanum (IV) oxide presence in the filter has the potential to improve CO and HC emitted by the engine. Overall, coated PAZ filters has shown its capability in emission reduction and highlight its potential application to be adopted in the exhaust system for 2-stroke motorcycles.

Acknowledgment

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