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JILID 1

DEVELOPMENT OF CATALYTIC-CONVERTER SYSTEM FOR MOTORCYCLE ENGINE BY USING COBALT BASED TITATIUM DIOXIDE

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ABSTRACT

Motorcycle emits substantial quantities of hydrocarbons (HC), carbon monoxide (CO), nitrogen oxide (NO_x) and particulate matter. The emission could contribute to a poorer quality of air due to the increasing of motorcycle number. A catalytic exhaust control can be developed as an excellent solution for the problem and it is recognized to be the most cost-effective way to meet stringent emission standards. The three-way catalytic converters (TWC) were developed for 4-stroke engine is to oxidize the unburned HC and CO to form H_2O and CO_2 respectively as well as to reduce NO_x to nitrogen. Two designs of catalytic converter were developed to compare the effectiveness combination of Co-TiO_2 catalyst. The first design is an arrangement of wire mesh to replace the conventional honeycomb structure. While the second design in spiral shaped; purposely to change the linear flow of the exhaust gases to a vortex flow. It was found that the technology developed with cost-effective concept successfully reduce the emission level of the toxic gases.

INTRODUCTION

Worldwide, motorcycle usage is increasing at a rapid pace, especially in the urbanized areas of Asia. Well over 100 million two-wheel vehicles are currently in use and this number is growing at a rate of around 7 million vehicles per year (the net of ~ 20 million vehicle sales less vehicles scrapped). The majority of these vehicles are powered by 2-stroke engines which comparatively produced higher exhaust emissions than 4-stroke engines (1).

The large number of motorcycle accounts for a significant portion of global mobile source hydrocarbon (HC) and carbon monoxide (CO). NO_x emissions from motorcycle are relatively small compared to other mobile sources. Confronted with the need to address deteriorating air quality, a growing number of countries worldwide have implemented, or are in the process of implementing, programs to substantially reduce gaseous emissions from spark-ignition (SI) of these vehicles. In making pollution control decisions, countries in Asia and Europe, where ~20 million motorcycle are sold each year, are considering a number of issues. These issues include the levels of the emission standards to implement, the types of control strategies that will be implemented, and, in some cases, even whether the 2-stroke engine could be abandoned and replaced with the lower-polluting 4-stroke engine.

In controlling emissions from motorcycle, legislative authorities have tended to implement increasingly stringent emission standards in stages. Strict standards normally result in the use of catalytic exhaust technology. As emission standards are tightened even further, a systems approach using more developed engine designs and advanced catalyst technology is needed. The use of improved engines and operating systems in combination with catalytic technology makes possible very significant emission reductions from motorcycle. The staged implementation of increasingly stringent emission standards provides the opportunity to achieve a smooth transition toward low-emission motorcycle.

Catalyst technology is a proven and cost-effective approach for reducing hydrocarbon, carbon monoxide, nitrogen dioxide and particulate emissions from both two and four stroke powered motorcycle while maintaining the desired engine performance characteristics. Worldwide, over 5 million catalyst-equipped motorcycles have been sold. An excellent example of catalyst technology application on motorcycles is in Taiwan where catalyst technology has enabled over 4 million 2-stroke engine powered motor vehicles to meet rigorous emissions requirements since 1992. The result is a proven success of catalyst technology and Taiwan manufacturers have expanded its use to both 2-stroke and 4-stroke vehicles to meet the more stringent emission standards effective for all motorcycle produced after January 1, 1998. (1)

Theoretically the reaction occurred during conversion process are:

a) Oxidation reaction of CO and HC

$4HC + 5O_2 \qquad 2H_2O + 4CO_2$

$2CO + O_2 \qquad 2CO_2$

b) Reduction reaction of NO_2

$2CO + 2NO_2 \qquad N_2 + 2CO_2$

METHODOLOGY

Design cat-co. In this study, two type of catalytic converter chamber were designed. The first design is an arrangement of the wire mesh with a suitable length to replace conventional honeycomb structure in the exhaust chamber. The chamber allows replacement system of the catalytic converter and could reduce the maintenance cost of catalytic converter. The second designed is a spiral structure, where the gases from the engine must pass trough the structure before exit the chamber. The catalysts are closely coupled to the engine in order to increase the reactivity of catalyst.

Catalyst preparation. TiO_2 80 % anatase and 20 % of the rutile forms were used in the cat-co development. The cobalt doped TiO_2 carrier was prepared by the following method:

- An amount of TiO_2 was poured into 10 % HCl and thoroughly mixed. Soak wire mesh with TiO_2 solution for 8 hour. Then dried at 104 °C in oven for 2 hour. Finally heat with furnace around temperature 500 to 550 °C. All steps above were repeated 3 times. The heat treatment purposely to form crystallized structure of TiO_2.

- Catalyst was prepared by impregnation of the support with appropriate amount of aqueous solution of cobalt. Impregnated support was dried at 110 °C for 16 hour. Finally heat the catalyst wire mesh in a furnace at 500 to 600 °C. All the steps above were repeated 2 times.

Test method. The catalytic wire mesh than placed into the catalytic converter chamber that has been designed. The gaseous emission was detected before and after treatment at moderate speed of motorcycle by using combustion analyzer unit.

RESULT AND DISCUSSION

Figures 1,2,3 and 4 show the result obtained by using the first design. Figure 1 shows the percentage emission of the carbon dioxide for three types of catalyst used. The incremental percentage emission of carbon dioxide by using activated carbon, titanium dioxide and cobalt-based titanium dioxide obtained were 103 %, 107 % and 130 % respectively. As a result, high conversion of carbon dioxide can be achieved by using cobalt-based titanium dioxide as a catalyst.

The ability of the catalytic converters to reduce the amount of carbon monoxide also plays a critical factor in determining the effectiveness of catalytic converters. Figure 2, shows the results for carbon monoxide emission percentages associate with the catalyst. Reduction of 74.13 % was obtained by using cobalt based titanium dioxide, compared to 40.10% and 48.75% were obtained by using activated carbon and titanium dioxide respectively. Thus, the higher reduction of carbon monoxide is most effective when we used cobalt-based titanium dioxide as a catalyst.

Reduction performance of nitrogen dioxide is shown by Figure 3. Higher reduction of nitrogen dioxide obtained is 50 % when titanium dioxide used as a catalyst. Meanwhile, 44.82 % reduction of nitrogen dioxide was obtained by using cobalt-based titanium dioxide as a catalyst. Higher reduction of nitrogen dioxide associate with titanium dioxide could be due to the inertness to sulfate formation and its surface properties. Thus, titanium dioxide is a preferred carrier for catalytic reduction of nitrogen compound. The slightly lower of nitrogen dioxide reduction by using cobalt based titanium dioxide as a catalyst might be due to decreasing of the active surface of titanium dioxide by cobalt element.

Theoretically, oxygen content in exhaust gas will be reduced when passing through catalytic converter. Figure 4 show the result of oxygen concentration based on activated carbon, titanium dioxide and cobalt-based titanium dioxide as catalyst. The percentages of oxygen reduction in these designs are about 43.92%, 50.96% and 52.43% respectively. This figure clearly shown that the catalytic converter with cobalt-based titanium dioxide as a catalyst gives the best result of oxygen reduction. This is due to the large oxygen consumption during the carbon dioxide and carbon monoxide conversion process (oxidation).

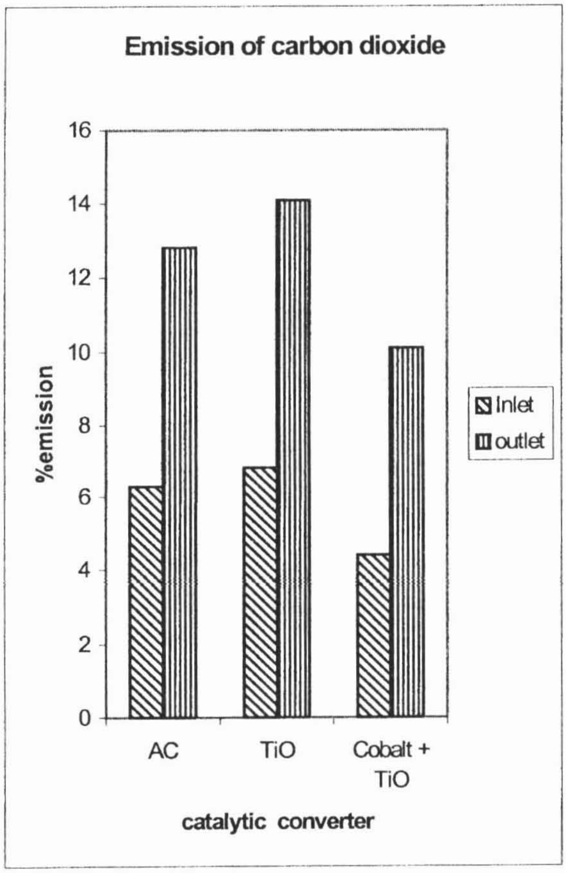

Figure 1: Graf for the emission of the carbon dioxide using the first design

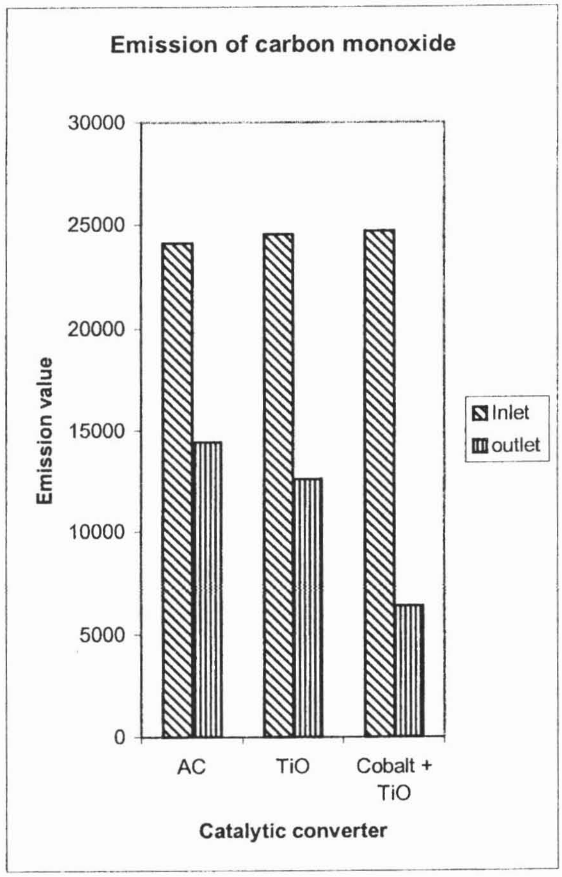

Figure 2: Graf for the emission of the carbon monoxide using the first design

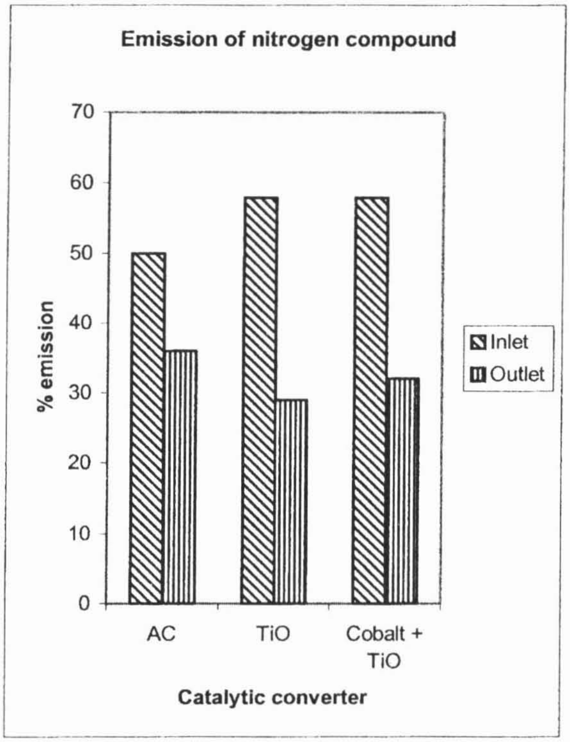

Figure 3: Graf for the emission of the nitrogen dioxide using the first design.

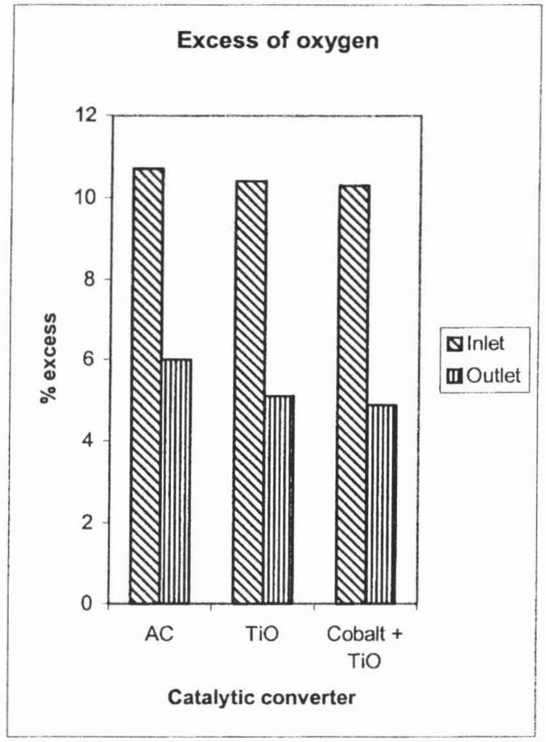

Figure 4: Graf for the excess oxygen using the first design.

Figure 5,6,7 and 8 show the result from the second design, i.e. spiral structure. From Figure 5, the highest conversion of the carbon dioxide obtained from cobalt based titanium dioxide as a catalyst. The increment is about 89.04 % while percentage of increment of carbon dioxide from titanium dioxide and activated carbon catalyst is about 56.96 % and 15.58 % respectively. From Figure 6, the higher reduction of the carbon monoxide is obtained from the cobalt-based titanium dioxide as a catalyst. The oxidation of carbon molecule is also involved during reduction process. The reduction is around 49.47 % compare to catalytic converter that associate with titanium dioxide and activated carbon as catalyst, which is only reduced about 29.50 % and 22.68 % respectively.

Meanwhile, Figure 7 shows the reduction of the nitrogen dioxide (NO_2) to nitrogen gases (N_2). The higher conversion is obtained from the catalytic converter associated with titanium dioxide as a catalyst. The reduction of nitrogen is around 37.9 %. However, the reduction percentage of nitrogen compound achieved by using cobalt and titanium dioxide as the carrier close to the titanium dioxide as catalyst, i.e. 37.93 %. Figure 8 shows the amount of oxygen reduced after the gaseous passed through the catalytic converter. Higher reduction of the oxygen obtained from the catalytic converter using cobalt-titanium dioxide based, i.e. 62.26 % compared to the titanium dioxide and activated carbon, i.e. 57.26 % and 34.48 % respectively.

Figure 9 shows the overall performance of the catalytic converter. Increment of carbon dioxide is better by using the first design (130 %) compare to second design (89.04 %). Beside that, percentages reduction of carbon monoxide and nitrogen dioxides also higher by using the first design (74.13 % and 44.82 %) compared to the second design (49.47 % and 35.57 %). However, percentages of excess oxygen is higher in the second design (62.26 %) compared to the first design (52.43 %). From the figures, it is reasonable to say that the first design of catalytic converter chamber fitted by arrangement of wire mesh is better than spiral design. Better performance of the first design could be due to large external surface area, which increases the contact area between exhaust gases and catalyst.

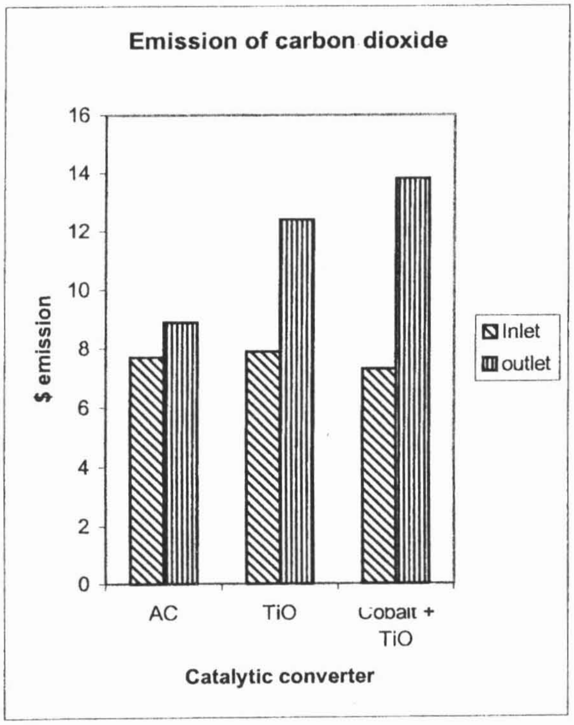

Figure 5: Graf for the emission of the carbon dioxide using the second design.

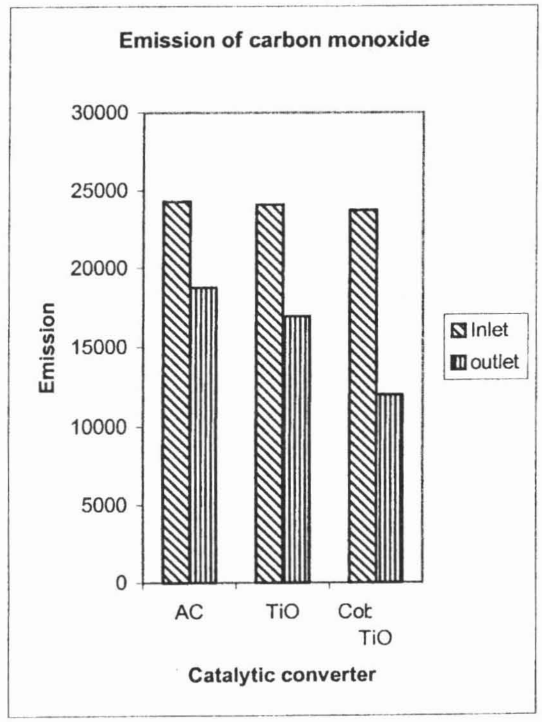

Figure 6: Graf for the emission of the carbon monoxide using the second design.

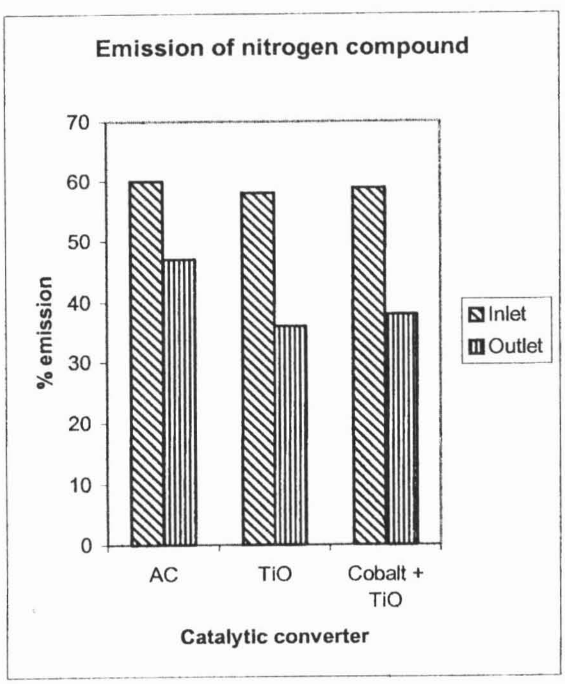

Figure 7: Graf for the emission of the nitrogen dioxide using the second design.

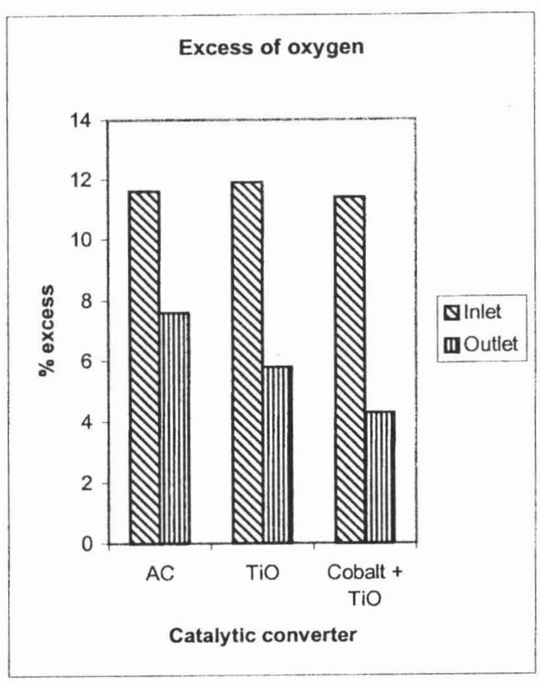

Figure 8: Graf for the excess oxygen using the second design.

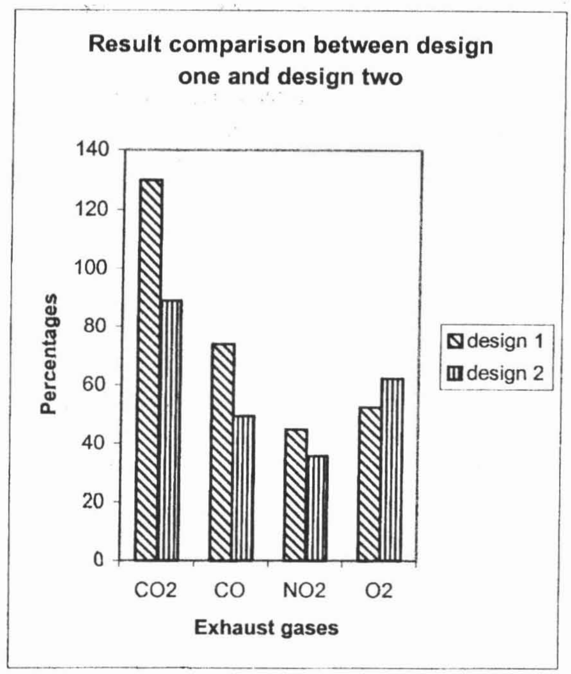

Figure 9: Graph for result comparison between the design one and design two

CONCLUSION

The highest activity of catalyst obtained from cobalt-based titanium dioxide as catalyst. The first design, i.e. linear arrangement wire mesh of catalytic converter is better than the second design, i.e. spiral design.

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