The three way catalyst efficiency increase

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Abstract: - Air pollution has been a problem throughout history. It is made up of many kinds of gases and particles that reduce the quality of air. Among all the pollution sources in a city the road transport emissions are often the most important source. Furthermore, the biggest causes of pollution are the operation of fossil fuel burning power plants and automobiles that combust fuel. Air pollutants, such as ozone, nitrogen oxides and sulphur dioxide have diverse and numerous harmful effects on the human being, plants and animals. In nowadays there is a great increase in car ownership and use. Therefore, it remains to be seen what measurers needs to be adopt, in order to reduce emissions from road traffic and consequently to prevent transport related air pollution problems. It is generally accepted that the process of catalyst deactivation originates from the entrance sections of the converter and gradually progresses towards the exit. The purpose of this paper is to investigate the possibility of a catalyst operating life extension via a mounting inversion, when the catalyst is close to its limits in the normal position. The experimental results indicate that under full load conditions at 3000 rpm improvement of catalyst efficiency can be accomplished reaching approximately 30% for CO and HC. This mounting inversion can be easily accomplished by an appropriate symmetric design of the monolith casing and mounting flanges, so that smooth gas flow conditions can be attained in both flow directions.

KeyWords: - Gas emissions, Catalyst mounting inversion

I. Introduction

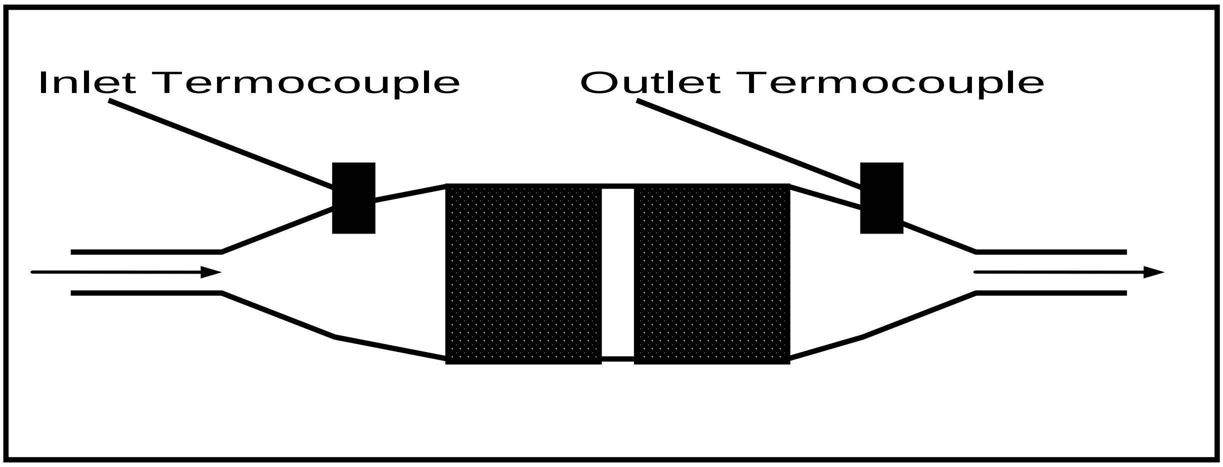
Most of the cities have a large number of automobiles; as a consequence they suffer from problems of air pollution. Concretely, emissions from road, air rail and water transport have been partly responsible for acid deposition, stratospheric ozone depletion and climate change. Air pollution can have serious consequences for the health of human being in the short and long term. Examples of short term effects include irritation to the eyes, nose and throat and upper respiratory infections, such as bronchitis and pneumonia. Examples of long term effects can include chronic respiratory disease, lung cancer, heart disease and even damage to the brain, nerves, liver or kidney. People of all ages can be affected from air pollution and particularly from sources, such as vehicle exhausts and residential heating, but mainly those with existing heart and respiratory problems are in an extra risk. Air pollutants are also responsible for the acidification of forests and water ecosystems and eutrophication of soils and waters and corrode buildings and materials. Considering all the above, it can be concluded that transport has a great impact on the atmospheric environment and therefore it is necessary to reduce emissions from the road traffic. The catalytic efficiency of a three-way converter (TWC) gradually deteriorates due to thermal, chemical and mechanical effects. If we exclude the case of an abrupt destruction due to extreme mechanical or thermal stresses or lead poisoning, it is generally accepted that, under normal operating conditions, the deterioration of catalyst efficiency due to chemical deactivation originates from the entrance sections of the converter and gradually progresses towards the exit. This phenomenon effects also the temperature of catalyst light-off that is around 250^oC for a new catalyst and tends to increase as the converter ages [1,2,3,4,5]. Some of the chemical effects that cause catalyst efficiency reduction are reversible, as HC and CO storage due to temporary ë sensor malfunction or engine misfire [4,5,6,7], whereas other processes as lead, sulfur, zinc poisoning are permanent. Thermal effects as Pt/Ph, Pd/Rh sintering are also permanent. Higher temperatures are normally measured near the exit of the converter, whereas the chemical deactivation of the catalyst surface is greater at the inlet section and gradually progresses to the interior as the catalyst ages [2,5,6,8,9]. Therefore, it is quite natural to investigate the possibility of a catalyst operating life extension via a mounting inversion, when the catalyst is close to its limits in the normal position. In this way the later sections of the catalyst that are normally more chemically active will form the new inlet section and could cause a catalyst regeneration. This simple procedure is physically possible because the catalytic performance is strongly effected by the temperature of the exhaust gases. Therefore, as the converter ages and the chemically active region retreats to the exit sections, the temperature of the exhaust gases that reach this region becomes progressively lower due to the heat convection losses in the previous inactive region[10,11,12,13,14]. This effect reduces the overall efficiency, the heat production and the gas temperature rise even further. On the other hand the proposed mounting inversion places the more active sections at the catalyst inlet where the exhaust gases are hotter, thus increasing the rate of catalysis, the heat production and the overall temperature level[15,16,17,18]. The mounting inversion can be easily accomplished if a symmetric design of the monolith casing and mounting flanges is adopted, so that smooth gas flow conditions can be attained in both flow directions, a feature that is essential for high catalytic efficiency.

II. Instrumentation And Experimental Results

The tests were carried out on a HONDA CRX 1590 cm3 engine type D16Z5 with 130 PS at 6800 rpm. This is a 4 cylinder engine with a multipoint injection. The experimental procedure included tests with normal and inverse catalyst mounting with constant engine speed under full load conditions.

The catalyst which was used had exceeded exhaust limits (>150.000km).The test duration was 2500s. The engine speed was 3000 rpm. During the test the CO, HC emissions were monitored and the catalyst inlet Ti and outlet To temperatures. For this purpose the HP 3497 Data Acquisition Unit was used interfaced to an IBM-486.

For the exhaust gas high temperature measurements K type thermocouples with a range 0-1100 ^oC were installed. Their response time was 0.2 s and their accuracy +/- 3 ^oC for 0-400 ^oC and +/- 0.75 % for 400- 1100 ^oC. The positions of the thermocouples are shown on picture 1.



Picture. 1. The positions of the thermocouples

For the CO, HC measurements the HORIBA MEXA-574E with an accuracy of 0 - 10% vol. for CO and 0 - 10000 ppm for HC NMOG. This unit uses for calibration a special gas mixture (n-hexane). With respect to the catalyst inverse mounting a suitable adapter was machined, however, the monolith operated in its original stainless steel casing. We will return to this point in a later section.

A. Experimental results

The results obtained for the CO emissions and normal and inverse converter mounting are illustrated in Fig. 1.

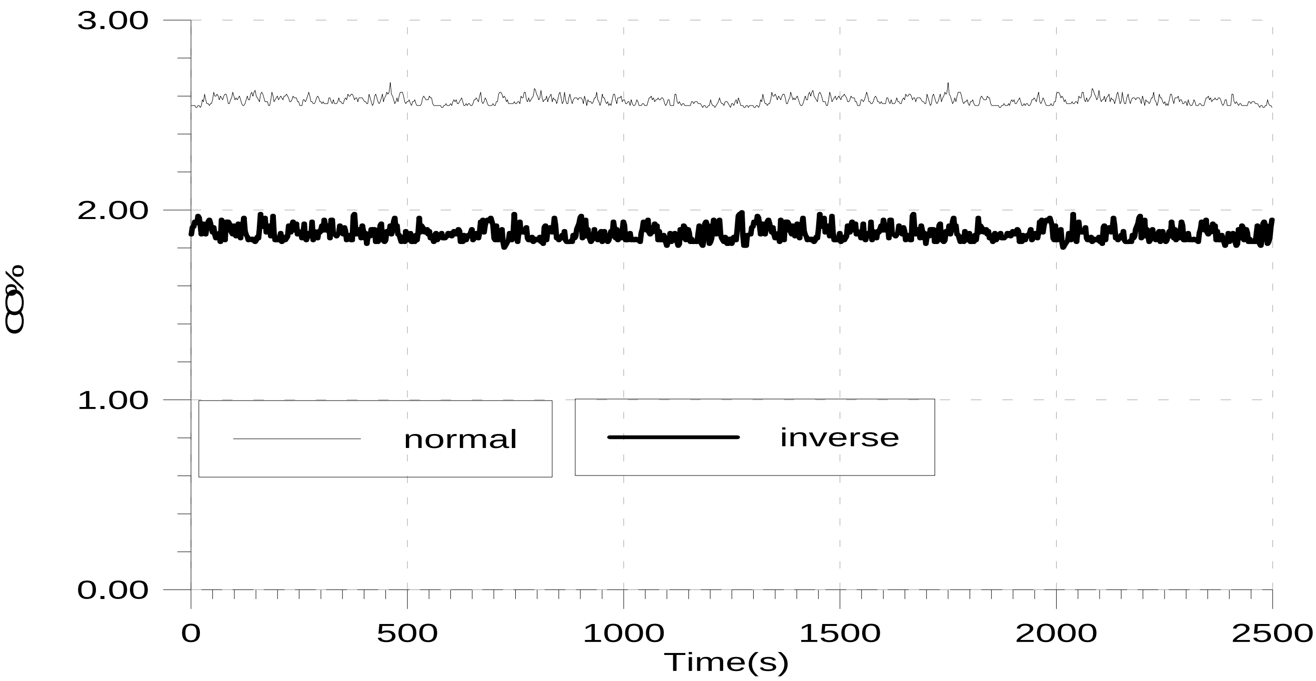


Figure 1. CO emissions for normal and inverse converter mounting at 3000rpm under full load conditions

Figure 1 shows the CO average value is 2,57% in the case of normal converter and 1,86% in the case of inverse converter, which means a 28% decrease.

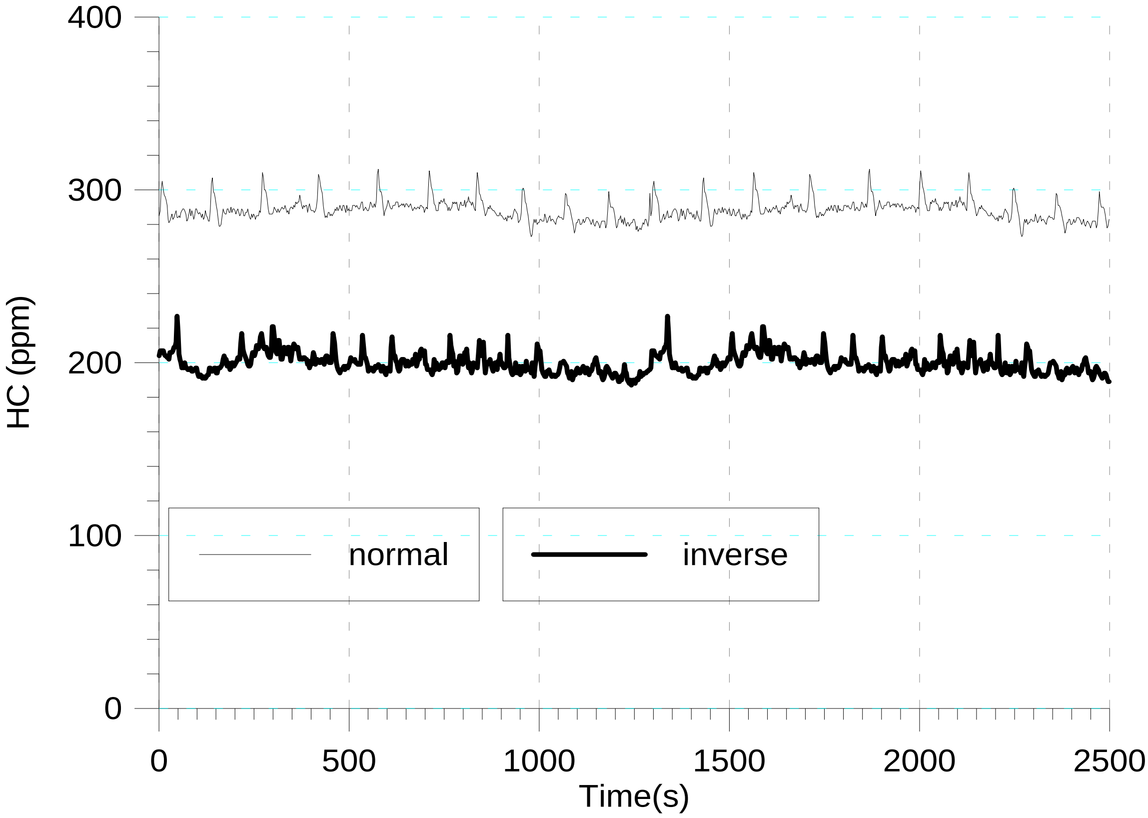


Figure 2. HC emissions for normal and inverse converter mounting at 3000 rpm under full load conditions.

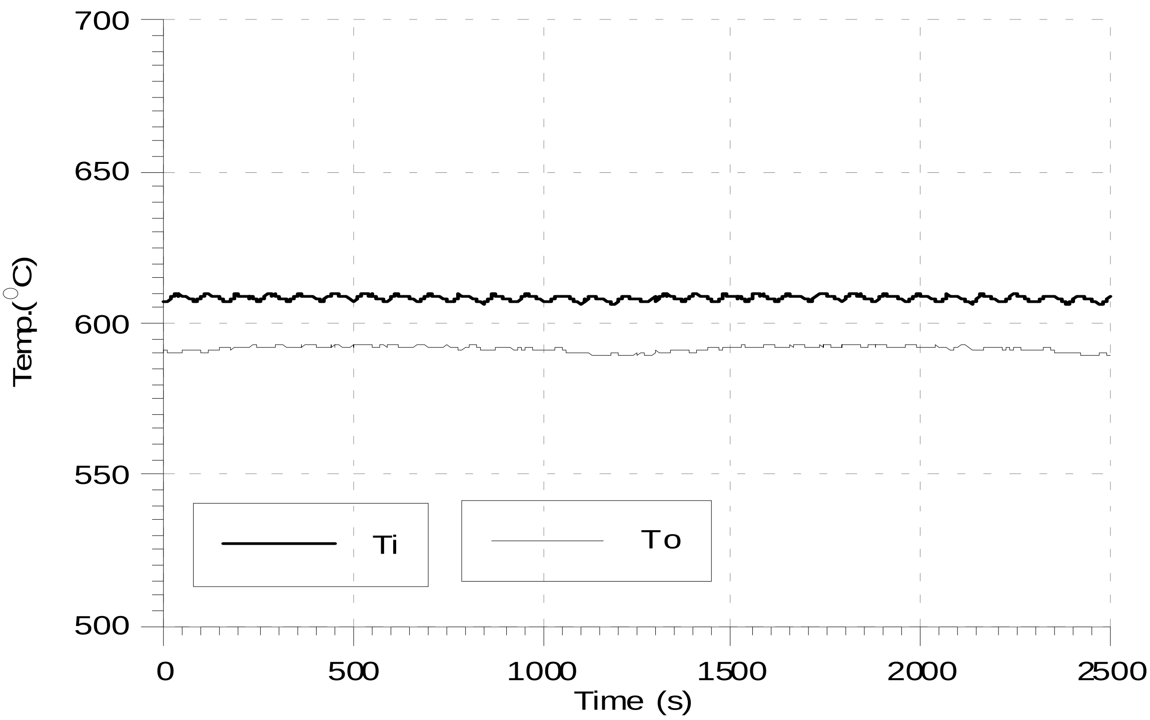


Figure. 3. Catalyst outlet, inlet temperatures for normal converter mounting at 3000 rpm under full load conditions

In Fig. 2 the corresponding HC emissions measurements are presented. The HC average value is 285 ppm in the case of normal converter and 197 ppm in the case of inverse converter.
In this case we also notice that by inverse position a 31% decrease.
In Fig. 3, it is noticed that the average of inlet temperature is 607^{o}C while of the outlet temperature is about 590^{o}C .

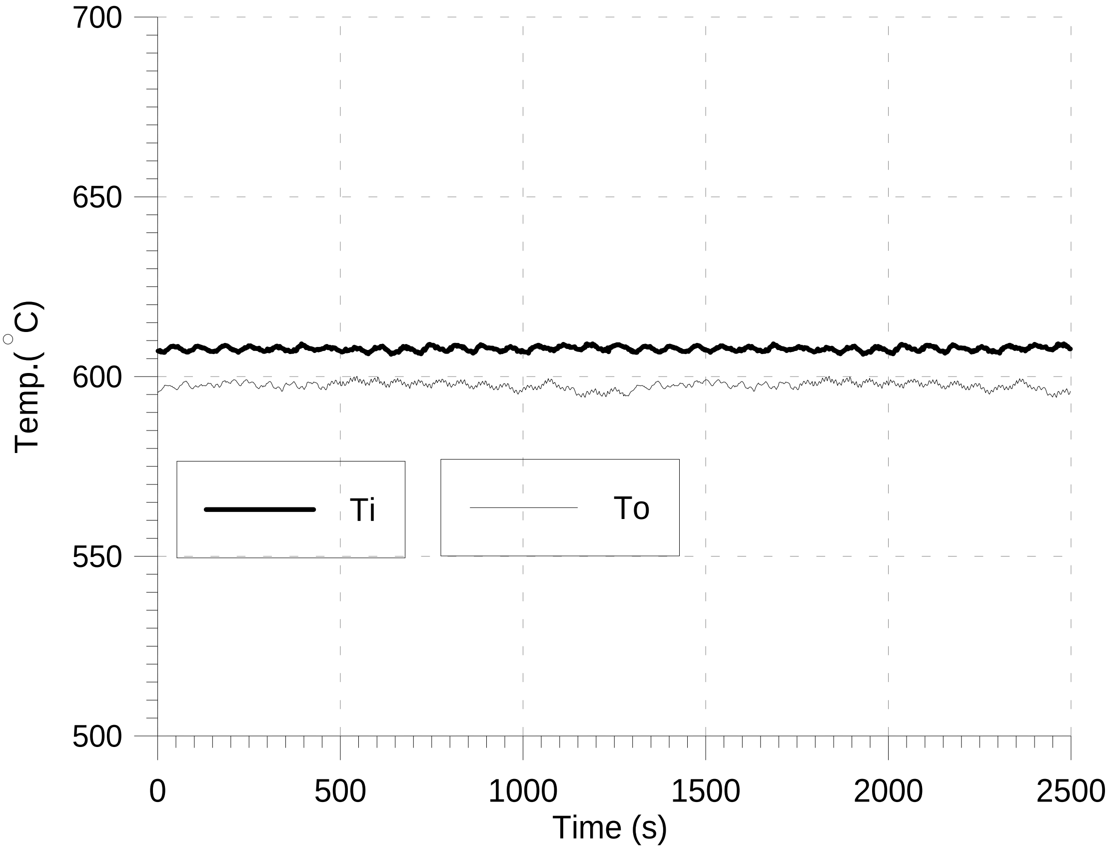


Figure. 4. Catalyst outlet, inlet temperatures for inverse converter mounting at 3000 rpm under full load conditions.

In fig. 4 the temperatures, between the catalyst outlet and inlet sections is illustrated for inverse mounting at 3000 rpm under full load conditions. The temperature average value at the inlet is 607^{o}C, while at the outlet is 597^{o}C.

In figures 4,5 it is noticed that the inlet exhaust temperatures of the catalyst are the same in both cases, whereas the outlet temperatures differ. In the case of inverse catalyst, the outlet temperature is 7^{o}C higher than the outlet normal catalyst temperature. This fact indicates that the catalyst factions better as the outlet temperature increase is the result of the biggest heat emitted from the catalyst converter. This temperature difference (Ti-To) appears in fig. 5 in detail.

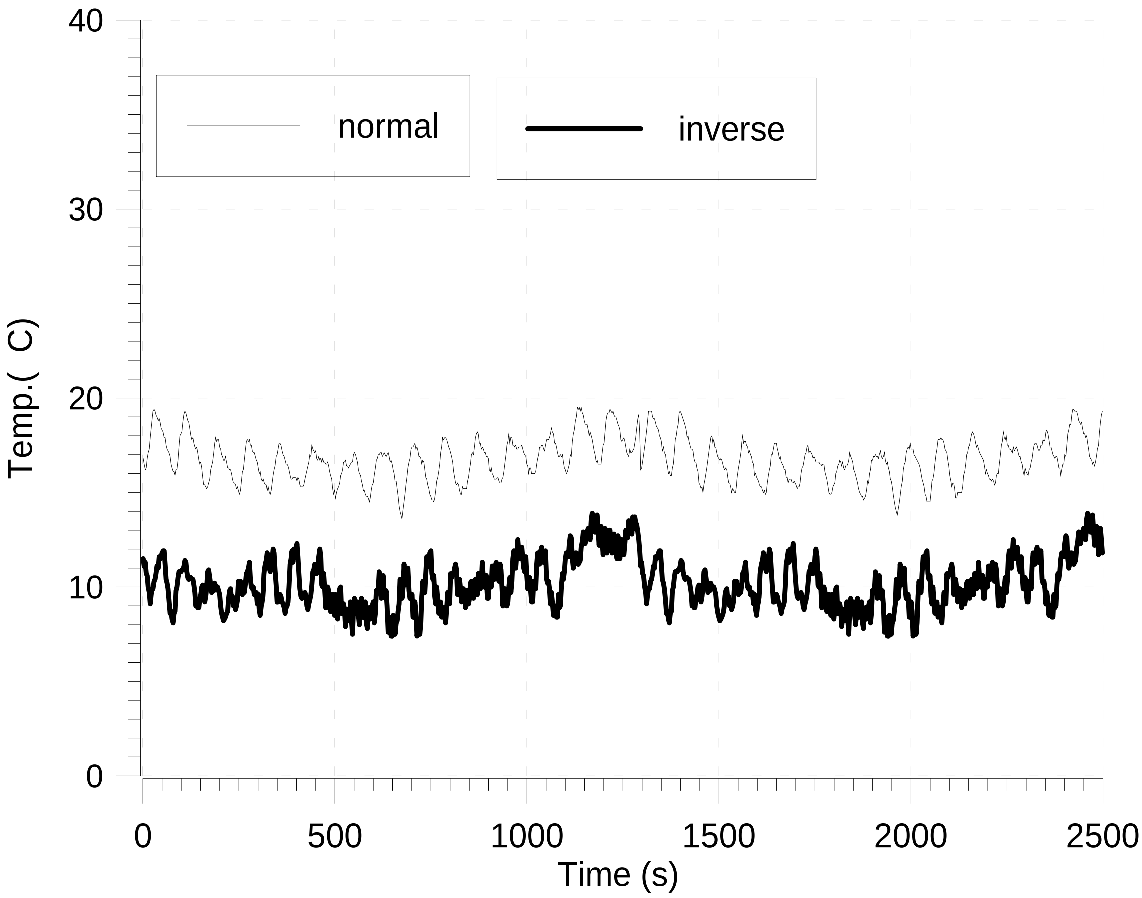


Figure. 5. Catalyst outlet-inlet temperature difference for normal and inverse mounting under full load conditions.

In figure 5 a decrease of the temperature difference (Ti - To), is noticed in the case of inverse boundary, a fact which indicates a catalytic efficiency increase during the inverse position of the catalyst converter. In Table shows the mean values of temperatures differences (Ti - To), HC and CO content.

Mounting	**(Ti-To)°C**	**HC(ppm)**	**CO(%vol)**
Normal	17	285	2.57
Inverse	10	197	1.86

Table 1. Experimental results for the normal and inverse mounting with respect to the mean values of (Ti - To), HC and CO.

Table 1 it is noticed that the (Ti - To) reduction linked to a corresponding the HC, CO reduction

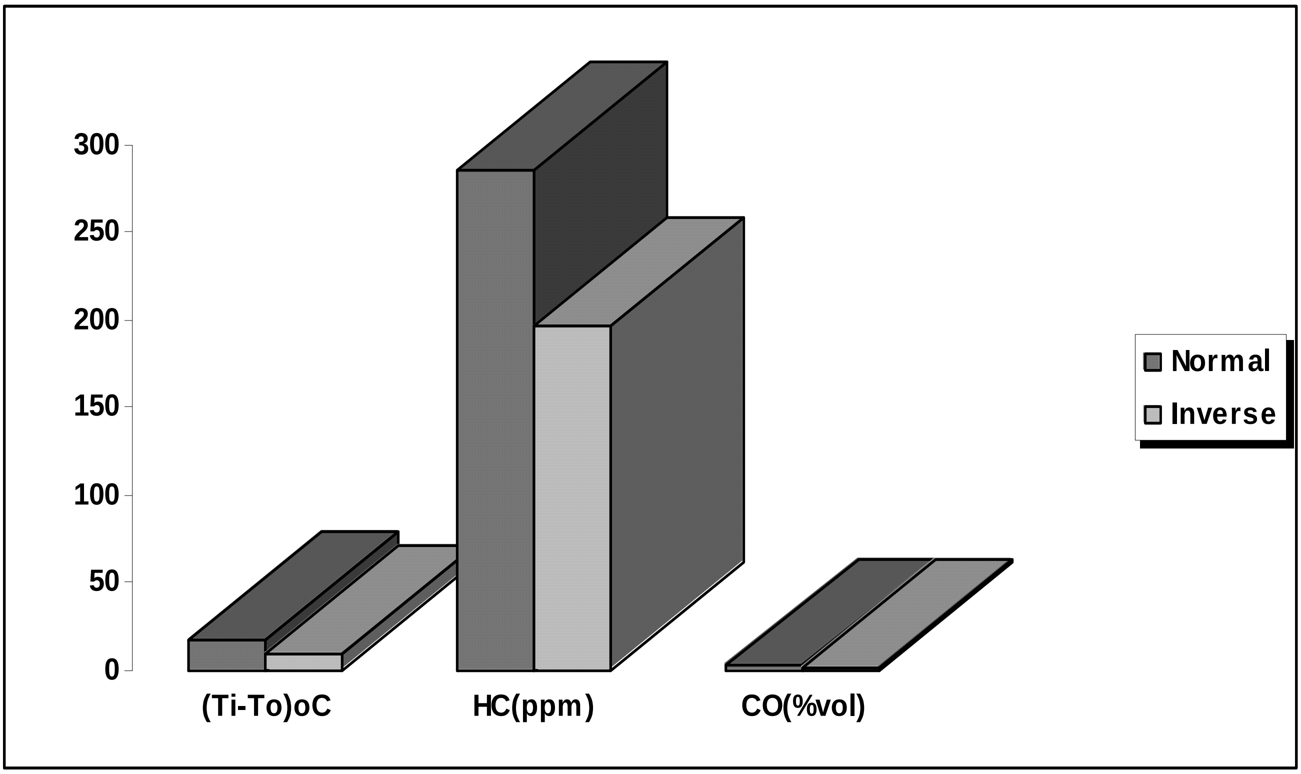


Figure 6. The graphic representation of table 1

The % rate of reduction of (Ti - To), CO, HC, by mounting inversion is given below (figure 7):

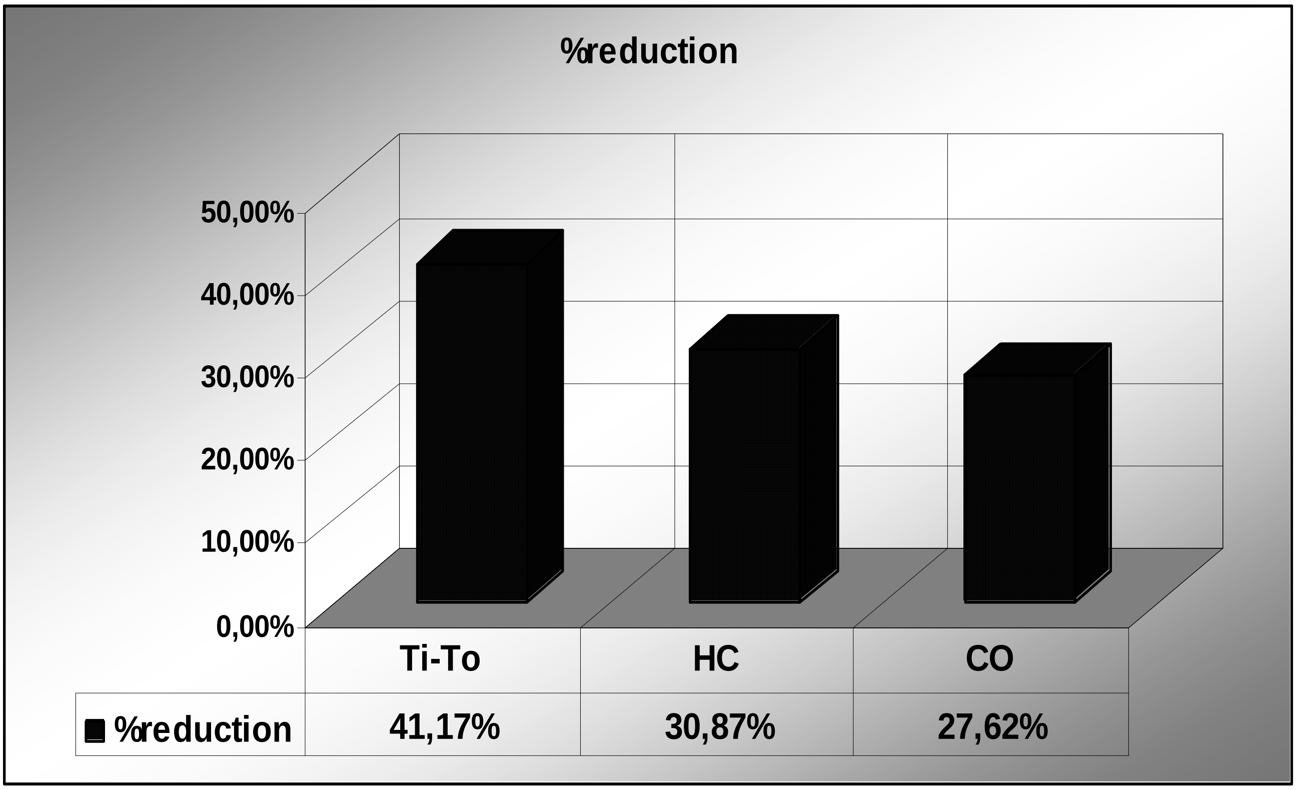


Figure 7. The % rate of (Ti - To), CO, HC reduction.

III. CONCLUSION

The present paper is an investigation of a possible catalyst life extension via inverse mounting. The tests were carried out using a converter with asymmetric design at the inlet and outlet sections. The experimental results indicate that during tests at full load at 3000 rpm conditions there is a noticeable catalytic efficiency improvement for CO, HC.

It should be clear that the proper answers to these questions must be given through a series of future engine tests.

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