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Development and testing of a catalytic converter on single cylinder CNG engine.

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ABSTRACT

The rapid increase in the consumption of fossil fuels is resulting into climate change which is considered as the most important environmental problem of the present century and the recent studies hence indicates that the emission of green house gases to the atmosphere have contributed to the increase in the global mean temperature by approximately 0.8 °C during the past century.

Numbers of alternative technologies like improvement in engine design, fuel pretreatment, use of alternative fuels, fuel additives, exhaust treatment or better tuning of the combustion process etc. are being considered to reduce the emission levels of the engine.

Use of catalytic converters based on platinum (noble) group metal is the best way to control automotive exhaust emissions

Catalytic converter oxidizes harmful CO and HC emission to CO2 andH2O in the exhaust system and thus the emission is controlled. The exhaust contains principally three primary pollutants, unburned or partially burned hydrocarbons (HCs), carbon monoxide (CO) and nitrogen oxides (NOx), mostly NO, in addition to other compounds such as water, hydrogen, nitrogen, oxygen, etc.

The main focus of the work is development and testing of catalytic converter with various loading and at various location in the vehicle to achieve BSIV emission norms.

Major Steps include: i)Selection of the suitable catalytic converter ii)Engine testing without and with catalytic converter, iii)Testing and validation of engine with the various loading, iv)Comparison of results viz. raw emissions, and emission with the various loading of catalytic converter.

Keywords— Catalytic Convertor, Conversion Efficiency, and Emissions.

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I. INTRODUCTION

In the last 60 years the world vehicle fleet has increased from about 40million vehicles to over 700 million; this figure is projected to increase to 920 million by the year 2014.Exhaust emissions of much concern are Hydrocarbon (HC), Carbon Monoxide (CO) and Nitrogen Oxide (NOx) from the automotive vehicles.

Catalytic converter oxidizes harmful CO and HC emission to CO2 andH2O in the exhaust system and thus the emission is controlled. The exhaust contains principally three primary pollutants, unburned or partially burned hydrocarbons (HCs), carbon monoxide (CO)and nitrogen oxides (NOx), mostly NO, in addition to other compounds such as water, hydrogen, nitrogen, oxygen, etc. Sulphur oxides, though polluting, are normally not removed by the post-combustion treatments.

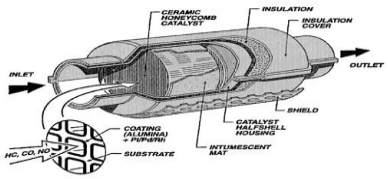

Figure 1. Catalytic converter

Out of various technologies available for automobile exhaust emission control a catalytic converter is found to best option to control CO, HC and NOx emissions from petrol driven vehicles while diesel particulate filter and oxidation catalysts converter or diesel oxidation catalyst have so far been the most potential option to control particulates emissions from diesel driven vehicle.

A catalytic converter (CC) is placed inside the tailpipe through which deadly exhaust gases containing unburnt fuel, CO, NOx are emitted [17]. The function of the catalytic convertor is to convert these gases into CO2, water, N2 and O2 and currently, it is compulsory for all automobiles plying on roads.

Figure 2. Function of catalytic converter

1) The oxidization catalytic converter :-

An oxidation catalyst is a device placed on the tailpipe of a car. The oxidation catalyst is the second stage of the catalytic converter. It reduces the unburned hydrocarbons and carbon monoxide by burning (oxidizing) them over a platinum and palladium catalyst. This catalyst aids the reaction of the CO and hydrocarbons with the remaining oxygen in the exhaust gas .

$$HC + O_2 \longrightarrow CO_2 + H_2O \quad (1)$$

$$2CO + O_2 \longrightarrow CO_2 \quad (2)$$

2) The reduction catalytic converter

A reduction catalyst to control NOx can be used as a separate system in addition to the oxidation catalytic converter. The reduction catalyst is fitted upstream of the oxidation system. The reduction catalyst is the first stage of the catalytic converter. It uses platinum and rhodium to reduce the nitrogen oxide emissions. When such molecules come in contact with the catalyst, the catalyst rips the nitrogen atom out of the molecule and holds on to it, freeing the oxygen in the form of O2. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst forming N2.

$$2NO \longrightarrow N_2 + O_2 \quad (3)$$

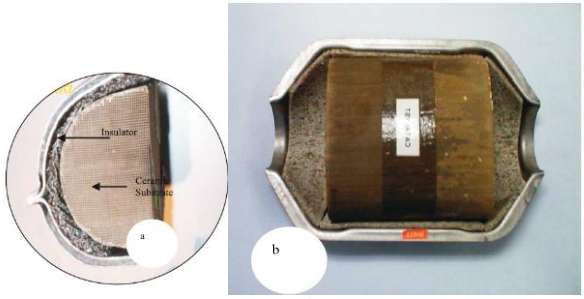

Figure 3. Core of catalytic converter

The catalyst core, or substrate. For automotive catalytic converters, the core is usually a ceramic monolith with a honeycomb structure. Metallic foil monoliths made of FeCrAl are used in some applications. This is partially a cost issue. Ceramic cores are inexpensive when manufactured in large quantities. Metallic cores are less expensive to build in small production runs, and are used in sportscars where low back pressure and reliability under continuous high load is required. Either material is designed to provide a high surface area to support the catalyst washcoat, and therefore is often called a “catalyst support”. Gas flows through the passages and reacts with catalyst within the porous washcoat.

The washcoat is a carrier for the catalytic materials and is used to disperse the materials over a high surface area. Aluminum oxide, titanium dioxide, silicon dioxide, or a mixture of silica and alumina can be used.

Catalyst:-

In three way catalytic converter-

Platinum and palladium – oxidising catalyst for HC and CO

Rhodium – reducing the Nox percentage.

Cerium- promotes the oxidation to improve oxidation efficiency

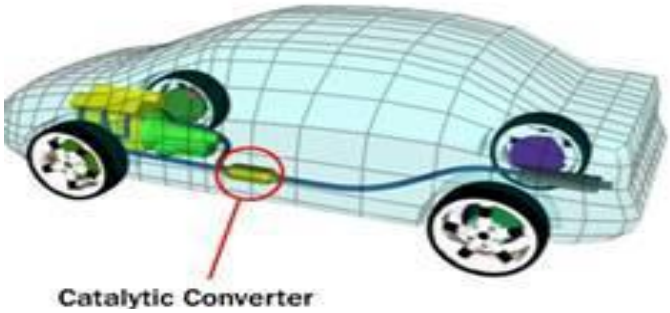

Figure 4. Installation of catalytic converter

II. EXPERIMENTAL WORK

I. a Literature Survey

SAE Paper No. 2009-26-037- Development of BS-III Open Loop CNG Engine for a mini truck - Shinde, B. J and Adsure, S. S., Force Motors Ltd., India.

Optimization of Catalytic Converter Loading : Five types of 3 way catalytic converts were used to study the effects of precious metal loading on exhaust emission. Effects of individual cat-con and cat-con in series were also studied. Exercises included study of exhaust emission of vehicle for CR (11:1) with/ without 3 way catalytic converters. Effect

of different precious metal loading on exhaust emission was also studied.

Project supported by the European Commission Under RTD contract : 019795,Biogasmax / Exhaust gas aftertreatment and emissions of natural gas and biomethane driven vehicles.Written by: Christian Bach, Robert Alvarez and Dr. Alexander Winkle Empa

This report presents results about the impact of methane based fuels (natural gas and biomethane) on the emission profile and catalytic converter aging of passenger vehicles. Analysis of an aged catalytic converter from a biomethane driven passenger vehicle after a mileage of 100'000 km. For comparison, a new catalytic converter of the same type was also analyzed.

Research of efficiency of catalytic converters in automobiles with an otto enginesaugirdas Pukalskas1, Rytis Zautra2, Saulius Nagurnas3, Jonas Matijošius4, Virginijus Švelnia5, Ricardas V_gneris6The 8th International Conference May 9–10, 2013, Vilnius, Lithuania Selected papers

The main attention in this work is paid to the method of temperature measuring. The experimental research is carried out measuring temperatures of exhaust pipe before the catalyzer and after it. The methodology of efficiency evaluation of a catalyst is prepared for enterprises which perform technical examination of road motor vehicles.

CATALYTIC CONVERTER THEORY, OPERATION AND TESTINGKevin S. McCartney 1993, 1997, 2003 crashh@prodigy.net 209-873-1155

- An air/fuel mixture of 14.64:1 is the best compromise but it does not provide perfect combustion.
- A 14.64:1 mixture gives the lowest CO and HC levels but it also produces very high NOxlevels.
- A 14.64:1 mixture also results in low oxygen levels.
- A catalyst can not clean up CO and HC unless there is enough oxygen in the exhaust.
- A catalyst can not clean up NOx unless the level of oxygen in the exhaust is very low.

Review paper on Catalytic Converter for Automotive Exhaust Emission Julie M Pardiwala, Femina Patel, Sanjay PatelINSTITUTE OF TECHNOLOGY, NIRMA UNIVERSITY, AHMEDABAD – 382 481, 08-10 DECEMBER, 2011

This review paper discusses automotive exhaust emissions and its impact, automotive exhaust emission control by platinum (noble) group metal based catalyst in catalytic converter, history of catalytic convertor, types of catalytic convertor, limitation of catalytic convertor and also achievements of catalytic convertor.

Development and test of a new catalytic converter for natural gas fuelled engine.M A KALAM, H H MASJUKI, M REDZUAN,MS received 18 October 2007; revised 25 January 2009

This paper presents characteristics of a new catalytic converter (catco) to be used for natural gas fuelled engine. The catco were developed based on catalyst materials consisting of metal oxides such as titanium dioxide (TiO2) and cobalt oxide (CoO) with wire mesh substrate. Both of the catalyst materials (such as TiO2 and CoO) are inexpensive in comparison with conventional catalysts such as palladium or platinum.

- The NOx conversion efficiency of OEM and wire mesh catalytic converters are 69% and
- 93% respectively. Wire mesh reduces 24% higher than OEM catalytic converter.
- The CO conversion efficiency of OEM and wire mesh catalytic converters are 48% and
- 89% respectively. Wire mesh reduces 41% higher than OEM catalytic converter.
- The HC conversion efficiency of OEM and wire mesh catalytic converters are 42% and
- 82% respectively. Wire mesh reduces 40% higher than OEM catalytic converter.

Automotive catalytic converters: current status and some perspectivesJan Kašpar, Paolo Fornasiero, Neal HickeyCatalysis Today 77 (2003) 419–449

The aim of this paper is to illustrate the technology for abatement of exhaust emissions by analyzing the current understanding of TWCs, the specific role of the various components, the achievements and the limitations. The challenges in the development of new automotive catalysts, which can meet future highly demanding pollution abatement requirements

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3. Exhaust gas after treatment and emission of the natural gas and bio methen vehicles. Written

by:Christian Bach, Robert Alvarezand Dr. Alexander Winkler.

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5. Development and test of a new catalytic converter for natural gas fuelled engine.M A KALAM, H H MASJUKI, M REDZUAN, T M I MAHLIA, M A FUAD,Department of Mechanical Engineering, University of Malaya, 50603 KualaLumpur, Malaysia
6. RESEARCH OF EFFICIENCY OF CATALYTIC CONVERTERS IN AUTOMOBILES WITH AN OTTO ENGINESaugirdas Pukalskas1, Rytis Zautra2, Saulius Nagurnas3, Jonas Matijošius4, Virginijus Švelnia5, Ricardas V_gneris6
   The 8th International Conference May 9–10, 2013,
7. Review paper on Catalytic Converter for Automotive Exhaust Emission Julie M Pardiwala, Femina Patel, Sanjay PatelINSTITUTE OF TECHNOLOGY, NIRMA UNIVERSITY, AHMEDABAD – 382 481, 08-10 DECEMBER, 2011

