Indian J. Innovations Dev., Vol. 1, No. 5 (May 2012) ISSN 2277 - 5390

Design and manufacturing of *Nano* catalytic converter for pollution control in automobiles for green environment

Durairajan A[1,*], Kavitha T[2], Rajendran A[3], Kumaraswamidhas LA[4]

[1,*]*Department of Mechanical Engineering, K.S.R. College of Engineering, Tiruchengode, Namakkal (DT), Tamil Nadu, India, E-mail: durai_rajan@rocketmail.com*
[2]*Department of Physics, Nehru Memorial College, Puthanampatti, Tamil Nadu, India, E-mail: kavithaphysics@gmail.com*
[3]*Department of Physics, Nehru Memorial College, Puthanampatti, Tamil Nadu, India, E-mail: rajendran20@gmail.com*
[4]*Department of Mechanical Engineering, National Institute of Technology, Trichy, Tamil Nadu, India*

***Corresponding author**: Department of Mechanical Engineering, K.S.R. College of Engineering, Tiruchengode, Namakkal (DT), Tamil Nadu, India, E-mail: durai_rajan@rocketmail.com, Tel: (+91) 8015655878, 9442385688, 9003847527.

Abstract

Automobile plays an important role in contribution to the pollution. Air pollution is predominately emitted through the exhaust of motor vehicles and the combustion of fossil fuels. Pollution control is the very important role for future generation to control toxic emissions like CO, NO_X and HC. The objective of the work is to reduce the emissions from the automobiles through design and manufacturing of nano catalytic converter by replacing the existing expensive metals such as platinum, cerium oxide. Nano materials like nano rhodium and nano palladium were obtained by using chemical vapour deposition (CVD) technique. The obtained nano powder was deposited in the honey comb structure by using spin coating method. Further the characterization of nano palladium and nano rhodium powder is made through scanning electron microscope, X-ray diffraction, transmission electron microscope. By using the nano catalytic converter the pollution is reduced.

Key words: Nano catalytic converter; Nano materials; Automobile pollution; Transmission electron microscope.

Abbreviations: CVD-chemical vapour deposition; HC - Hydrocarbon; NOx - Nitrogen-di-oxide; CO - Carbon- monoxide; SI - Spark ignition; CI - Compression ignition.

Introduction

Nanotechnology is a science of controlling individual atoms and molecules which has great future and is considered to be the manufacturing technology of 21st century. One of the serious problems facing the world is the drastic increase in environmental pollution by internal combustion engines. All transport vehicles; both SI (Spark ignition) and CI (Compression ignition) are equally responsible for emitting different kind of pollutants (Genslak, 1972; Hizbullah *et al*. 2004). Two stroke SI engines have certain advantages such as compactness, lightweight, simple construction and low cost and low nitric oxide emissions, but they suffer from problems of high specific fuel consumption, high hydrocarbon and high carbon monoxide emissions. Some of the primary kinds having direct hazardous effects such as, carbon mono oxide, hydrocarbons, nitrogen oxides, etc. other the secondary pollutants which undergo a series of reactions in the atmosphere and become hazardous to health (Latusek and Burrrahm, 1993). The emissions exhausted into the surroundings to pollute the atmosphere and cause global warming, acid rain, smog, odors respiratory and other health hazards. A pollutant is a phenomenon which changes the balance of the environment and nature under normal condition (Joseph *et al*., 2005; Ketteler *et al*., 2002). Carbon-di-oxide is not considered as a pollutant in nature recycles. If carbon-di-oxide exceeds 5000ppm, then it becomes a health hazard (Klimstra and Nederlandse Gasunie, 1989; Kureti, 2003; Seldlitz, 1974). In the proposed study, using nano-catalytic converter, pollution is controlled by means of catalytic reaction.

Methods

Synthesis of nanoparticles

Indian J. Innovations Dev., Vol. 1, No. 5 (May 2012) ISSN 2277 - 5390

Synthesis of nano palladium & nano rhodium based on following methods

- Laser ablation
- Arc discharge
- Chemical vapor deposition (CVD), (Fig.1)

Here we used CVD method to synthesis the nano palladium (Fig.2) & nano rhodium which is an

- Easy method
- Gas phase deposition
- Large scale possible
- Relatively cheap

Automobile pollution

Generally, automobile plays an important role in contribution to the pollution. It is defined as the introduction of chemicals, particulate matter, or biological materials to the atmosphere that cause harm or discomfort to the living organisms. Due to the advancement in science and technology there is a drastic improvement in automobile production which results in more amount of harmful gas is let into the atmosphere. These gases react with the atmosphere and pollute it.

Catalysis

Catalysis is the process in which the rate of a chemical reaction is increased by means of a chemical substance known as a catalyst. Unlike other reagents, a catalyst is not consumed during the chemical reaction. Thus, the catalyst may participate in multiple chemical transformations, although in practice catalysts are secondary processes.

Catalytic converter

A catalytic converter is a device used to reduce the toxicity of emissions from an internal combustion engine (Fig.3). A catalytic converter converts the harmful toxic combustion products and its byproducts into less-toxic substances (Apostolescu *et al*. 2005).

1. It is the most effective after treatment process for reducing engine emission.
2. Catalytic converter is generally called as three way catalytic converter because it promotes in reduction of HC, CO and NOx.
3. It consists of steel container of honeycomb structure inside which contains porous ceramic structure through which the gas flows.
4. It consists of small embedded partials of catalytic materials that promote oxidation reaction in exhaust gas.
5. Catalytic converter uses alumina as base material because it can withstand high temperature.

Catalytic materials

Many types of material often used as catalyst in the recent years. Proton acids are probably the most widely used catalysts, especially for the many reactions involving water, including hydrolyses and its reverse. Multifunctional solids often are catalytically active, e.g. zeolites, alumina, certain forms of graphitic carbon etc. Transition metals such as platinum, paladium, rhodium, iron, silver are often used to catalyses redox reactions (Fig.4).

Types of catalyst

Generally catalyst can be classified into two types

1. Homogeneous catalyst
2. Heterogeneous catalyst
3. Electrocatalyst

Homogeneous catalyst

Homogeneous catalysts are those in which reactant and product are of same phase. One example of homogeneous catalysis involves the influence of H+ on the etherification of esters, e.g. methyl acetate from acetic acid and methanol.

Heterogeneous catalyst

Heterogeneous catalysts are those in which reactants and product are of different phase. For example, in the Haber process, finely divided iron serves as a catalyst for the synthesis of ammonia from nitrogen and hydrogen.

Indian J. Innovations Dev., Vol. 1, No. 5 (May 2012) ISSN 2277 - 5390

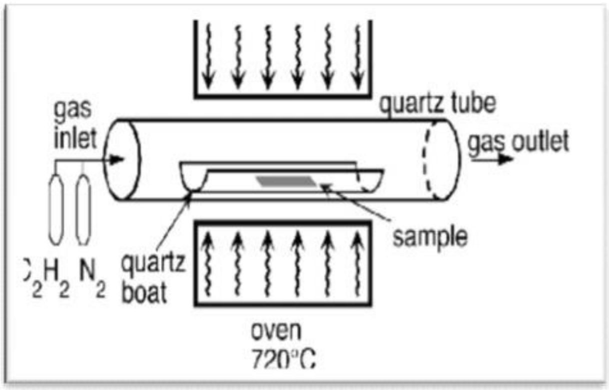

Fig 1. Schematic representation of CVD

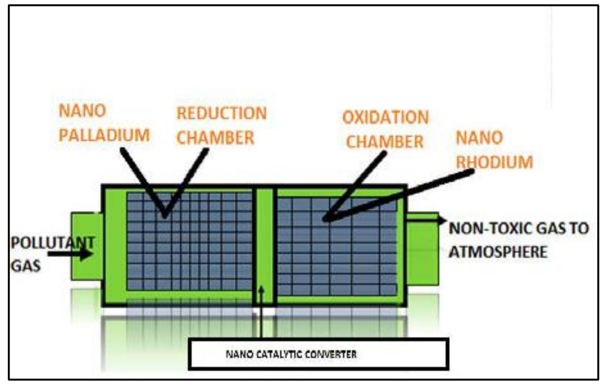

Fig 5. Three way catalytic converter

Fig.2. Chemical vapor deposition set

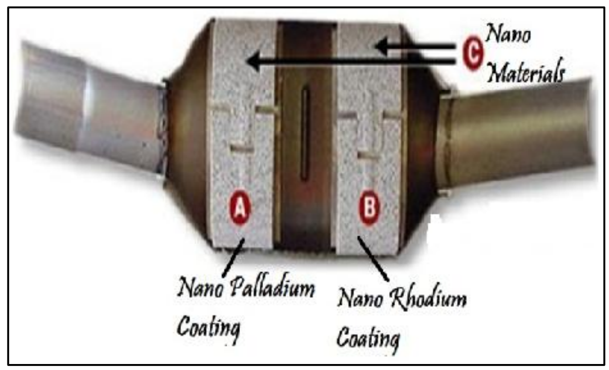

Fig. 6. Cut section of 3 way converter

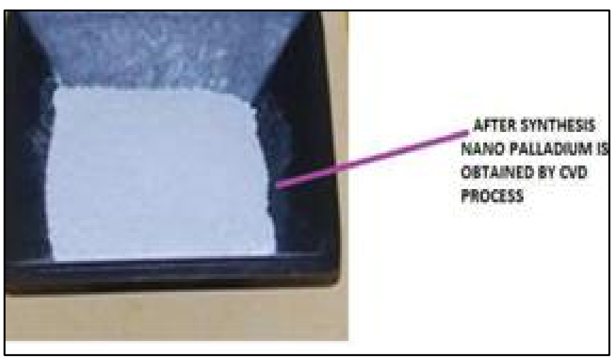

Fig.3. Nano palladium powder

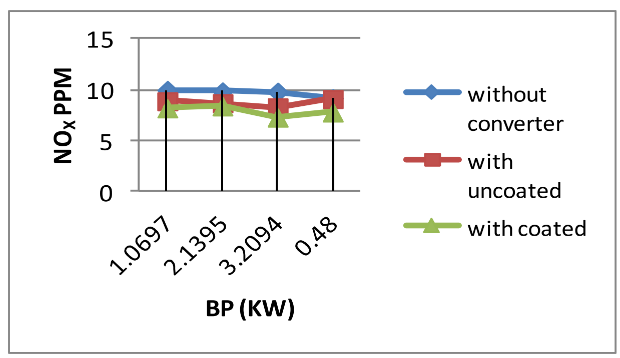

Fig.7. NOx reduction

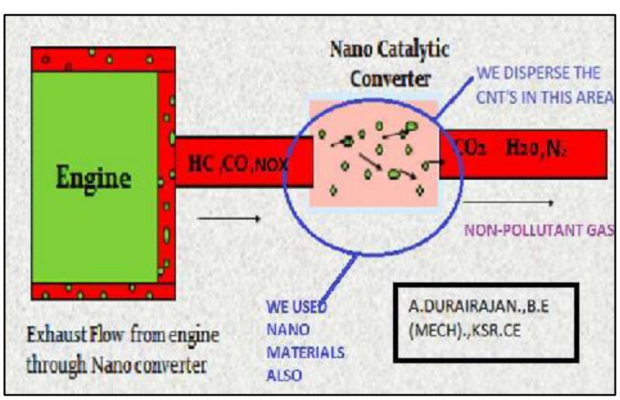

Fig 4. Nano implementation

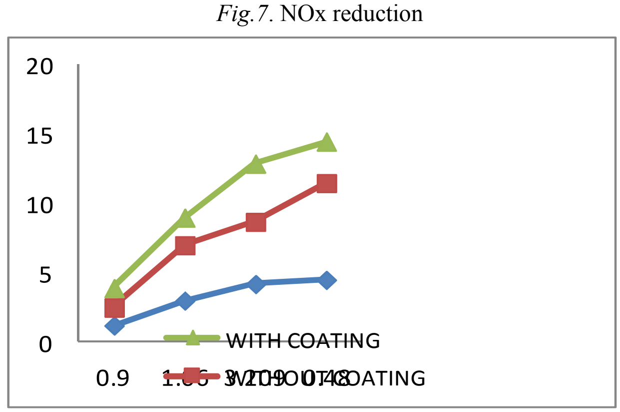

Fig.8. HC reduction

Electrocatalyst

In the context of electrochemistry, specifically in fuel cell engineering, various metal-containing catalysts are used to enhance the rates of half reactions that comprise the fuel cell. One common type of fuel cell electrocatalyst is based upon nanoparticles of platinum that are supported on slightly larger carbon particles when this platinum electrocatalyst is in contact with one of the electrodes in a fuel cell.

Types of catalytic converter

1. Monolithic Converter
2. Two way converter
3. Three way converter
4. Dual bed converter

Three-way catalytic converter

Three-way catalytic converter is widely used in the automobile industries. The three-way catalytic converter is scheduled to perform three simultaneous tasks (Fig.5 and Fig.6).

- Reduction of nitrogen oxides to nitrogen and oxygen

  $2NO_x \rightarrow xO_2 + N_2$

- Oxidation of carbon monoxide to carbon dioxide

  $2CO + O_2 \rightarrow 2CO_2$

- Oxidation of unburnthydrocarbons (HC) to carbon dioxide and water

  $C_xH_{2x} + 2xO_2 \rightarrow xCO_2 + 2xH_2O$

Applications of catalytic converter

1. Petrol engine emission control
2. Diesel engine emission control
3. Food processing industries.
4. Chemical manufacturing industries
5. Gas turbines

Steps for dispersion of particles on to the catalytic converter

1. Capillary Impregnation
2. Drying
3. Calcinations

Results and discussions

NOx reduction

The variations of NOx value with brake power value and at different conditions are shown in the Fig.7. The NOx value keeps on decreasing on the introduction of catalytic converter and finally reaches the minimum value on using coated catalytic converter. Thus at no load condition there is about 33.33% decrease in NOx value and at peak load condition there is about 84.3 % decrease in NOx value. This is due to the fact that NOx undergoes catalytic reaction with catalytic particles such as nano palladium and rhodium composites results in the production of nitrogen and oxygen as the end product. Thus there is steady for decrease in NOx value with the introduction of the coated catalytic converter.

HC reduction

The variations of HC value with brake power value and at different conditions are shown in the Fig.8. The HC value keeps on decreasing on the introduction of catalytic converter and finally reaches the minimum value on using coated catalytic converter. Thus at no load condition there is about 72.1% decrease in HC value and at peak load condition there is about 78 % decrease in HC value. This is due to the fact that HC undergoes catalytic reaction with catalytic particles such as nano palladium, rhodium, composites results in the production of water and oxygen as the end product. Thus there is steady decrease in HC value with the introduction of the coated catalytic converter.

CO reduction

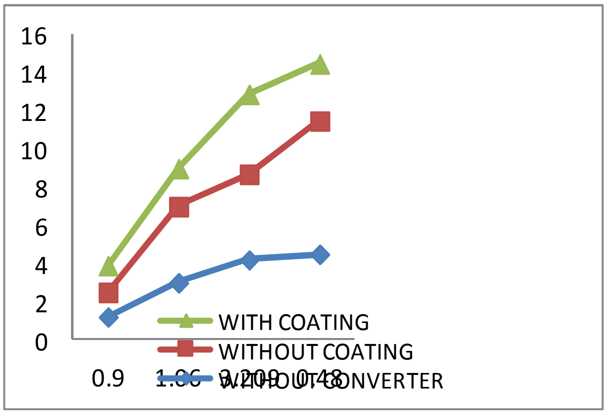

Fig.9. CO reduction

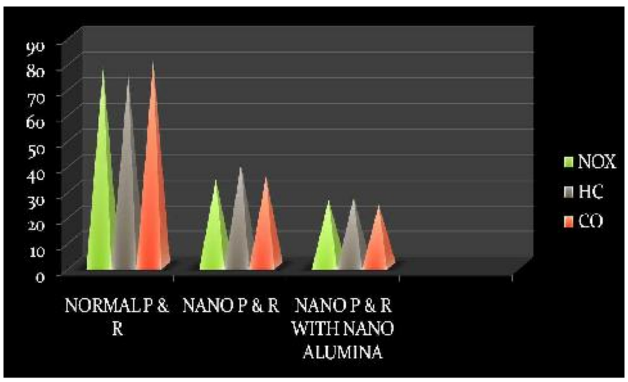

Fig.10. Compare the normal materials with nano materials

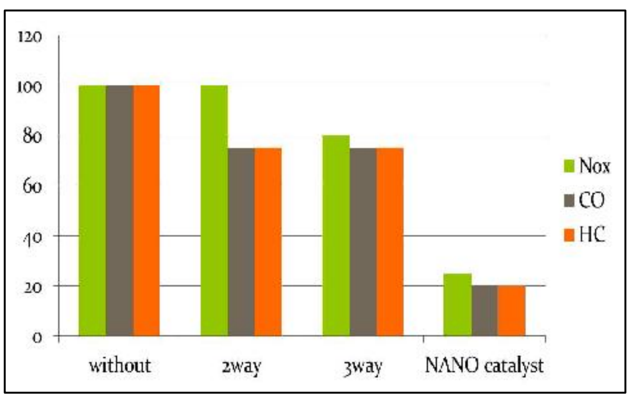

Fig. 11. Comparison of NOx. Co and HC values

The variations of CO value with brake power value and at different conditions are shown in the Fig.9. The CO value keeps on decreasing on the introduction of catalytic converter and finally reaches the minimum value on using coated catalytic converter. Thus at no load condition there is about 60% decrease in CO value and at peak load condition there is about 69 % decrease in CO value. This is due to the fact that CO undergoes catalytic reaction with catalytic particles such as platinum, palladium, rhodium, nano ferric oxide composites results in the production carbon-di-oxide and oxygen as the end product. Thus there is a steady decrease in CO value with the introduction of the coated catalytic converter**.**

The Nano catalytic converter has shown 33.33% decrease in NOx value at no load condition and about 84.3 % decrease in NOx value at peak load condition. Also HC value is decreasing 72.1% at no load condition and 78% at peak load condition. At no load condition 60% decrease in CO value and at peak load condition 69% decrease in CO value (Fig.10 and Fig.11).

Conclusion

The engine exhaust test has been carried out. The usage of nano catalytic converter has shown 33.33% decrease in NOx value at no load condition and about 84.3 % decrease in NOx value at peak load condition. Also HC value is decreasing 72.1% at no load condition and 78% at peak load condition. At no load condition 60% decrease in CO value and at peak load condition 69% decrease in CO value. Using nano catalytic converter, the pollution level was reduced.

Acknowledgments

We thanks to principal, professors and lecturers, technical and non-technical staff those who are all supported for the proposed research in the Department of Mechanical Engineering, K.S.R. College of Engineering.

References

1. Apostolescu N, Geiger B, Hizbullahb K, Jan MT, Kureti S, Reichert D, Schott F, Weisweiler W (2005) Selective catalytic reduction of nitrogen oxides by ammonia on iron oxide catalysts. *Appl. Catal., B*, 62(1-2), 104-114.
2. Genslak SL (1972) Evaluation of Gaseous Fuels for Automobiles. *SAE paper*, No.720125.
3. Hizbullah K, Kureti S and Weisweiler W (2004) Potassium promoted iron oxide catalysts for simultaneous catalytic removal of nitrogen oxides and soot from diesel exhaust gas. *Catal. Today*, 93-95, 839-843.

4. Joseph Y, Ketteler G, kuhrs C, Ranke W, Weiss W and Schlo R (2005) On the preparation and composition of potassium promoted iron oxide model catalyst films. *Phys. Chem. Chem. Phys.*, 2001, 3, 4141-4153.
5. Ketteler G, Ranke W and Schl R (2002) Potassium-Promoted Iron Oxide Model Catalyst Filmsfor the Dehydrogenation of ethylbenzene: An Example for Complex Model Systems. *J. Catal.*, 212(1), 104-111.
6. Klimstra J and Nederlandse Gasunie NV (1989) Carburetors for Gaseous Fuels-On Air-to-Fuel Ratio, Homogeneity and Flow Restriction, *SAE paper*, No.892141.
7. Kureti S, Weisweiler W, Hizbullah K (2003) Simultaneous conversion of nitrogen oxides and
8. Latusek JP and Burrrahm RW (1993) Conversion of Two Small Utility Engines to LPG Fuel. *SAE paper*, No.932447.
9. Seldlitz S (1974) Converting A Gasoline Air-Cooled Engine to Propane. *SAE paper*, No.740746.

Authors' Biographical Notes

Durairajan A is a Mechanical Engineering student from KSR College of Engineering, Tiruchengode, Namakkal (DT), Tamil Nadu, India. He is membership in professional bodies like SAE INDIA, ISTE. He has more than 45 papers in the proceedings of the national conferences and several papers in the proceedings of the international conferences and prestigious journals in the field of nanotechnology, alternative fuels, automobile pollution control, IC Engines.

Kavitha T is working as an assistant professor. She obtained her M.S.C (physics) from Nehru Memorial College and she has published a paper in various prestigious journals. She has presented several papers in the proceedings of the national and international conferences in the field of materials science, solar cell and bio-physics.

Rajendran A is working as a professor in Nehru memorial college Trichy, Tamil Nadu, India. He obtained his M.S.C (physics) from Nehru Memorial College and Ph.D. from poondi pushpam arts & science college, Thanjavur. He published various national & international conferences in the field of bio-physics, metal oxides and solar cells.

Kumaraswamidhas LA is working as a assistant professor in National institute of technology, Trichy, Tamil Nadu, India. He obtained his M.E (Engineering Design) from Bharathiyar University Coimbatore and Obtained Ph.D in vibaration from Anna University, Chennai. He awarded as an International Gold Star Award and Mother Teresa Excellence Award. He published and presented more than 25 papers in national and international conferences in the field of vibration, vehicle dynamics, modeling and simulation.