DESIGN AND ANALYSIS OF DYE SENSITIZED SOLAR CELL USING ETHANOL

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Abstract: Renewable energy is rapidly gaining importance as an energy resource to help aid the national energy depletion crisis of fossil fuel and coal. The search for low-cost, high efficient and flexible devices has led to a remarkable increase in the research and development of solar cell. The Dye-Sensitized Solar Cell (DSSC) is a new type of solar cell which converts the visible light into electricity by using the photo electrochemical system. It is based on the sensitization of the wide band gap semiconductors which is made up of a sandwich-liked structure that consists of a Semiconductor formed between a photo-sensitized anode and an electrolyte. Nano coated Fluorine doped tin oxide glass is used as the photoelectrode.TiO2 and ethanol paste applied on the conducting side of FTO glass which acts as a semiconductor oxide.Co-Sensitization is an appropriate technique to enhance the absorption range of dye molecules and to increase the efficiency of solar cell. Moreover hole transport materials, there are the efficient tool to replace redox couple based liquid electrolyte and it produce stable solid state DSSC. Pomegranate extract is an organic dye which is used as a photosensitizer to absorb energy from the sunlight. Lugol's iodine acts as an electrolyte which is in liquid form for the regeneration of dye. Another FTO glass made as counter electrode which is coated with the carbon soot. The DSSC has 5-7% more efficiency than conventional solar cell at low cost.

Key Words: Sensitization, Renewable energy, Nano coated, Fluorine doped.

1. INTRODUCTION

A catalytic converter is a equipment utilized as a part of vehicle to control emissions by changing over toxic gases from ignition to less harmful pollutants by redox reactions. The catalyst used in the converter is mostly precious metals such as platinum, palladium and rhodium. The monoliths are made by ceramic core like magnesium aluminium silicate or silicon carbide. The wash coat is made by layer of mesh by combination of silica and alumina or titanium dioxide or aluminum oxide or silicon oxide. Moreover studies reveal that the converters reduce the hydrocarbon emission by 87%, carbon monoxide by 85% and nitrous oxide by 62%.The amount of emission of carbon monoxide (CO), Unburned hydrocarbons (HC), Nitrogen oxide (NOx) and particulate matters (PM) are specially concerned due to HC, CO occurrence of the combustion efficiency < 100%. The NOx is formed during the very high temperatures (>1500 C) of the combustion process resulting in thermal fixation of nitrogen in the air which forms NOx.

1.1 CATALYTIC CONVERTER AS A POLLUTION CONTROL DEVICE

The catalytic converter does a great job at reducing the pollution, but it can still be improved substantially. One of its biggest shortcomings is that it only works at a fairly high temperature. When you start your car cold, the catalytic converter does almost nothing to reduce the pollution in your exhaust.

1.2 CATALYTIC CONVERTER

As the name suggests, it basically converts harmful gases into harmless gases, which are environment friendly, with the help of a catalyst. Engine exhausts having harmful gases like CO, NOx & HC which are converted into harmless gases like CO2, N2 & H2O respectively with the use of catalytic converter. It is an emissions control device that converts Toxic gases and Pollutants in exhaust gases to less Toxic pollutants by catalyzing a Redox reaction (an oxidation and a reduction reaction).

Catalytic converters are used with Internal Combustion Engine fueled by either petrol (Gasoline) or Diesel- including lean burn engines.

Figure 1.1: Catalytic Converter

1.3 HISTORY

In 1973, General Motors faced new air pollution regulations and needed a way to make its cars conform to the stricter standards. Robert C. Stempel, who at the time was a special assistant to the GM president, was assigned to oversee development of a technology capable of addressing the problem. Under Stempel's guidance, GM built on existing research to produce the first catalytic converter for use in an automobile.

Catalytic converters were first installed in vehicles made in 1975 in response to EPA regulations passed two years earlier tightening auto emissions and requiring a gradual decrease in the lead content of all gasoline.

In a study released on Nov. 28, 1973, the EPA determined "that lead from automobile exhaust was posing a direct threat to public health." Although catalytic converters were developed in the 1950s, the device couldn't be used in vehicles because the lead in gasoline would render them useless.

Since the introduction of stringent emission regulations in the US in the 1970s, car manufacturers have modified their exhaust systems to incorporate catalytic converters for the removal of NOx, CO and hydro carbons. All new cars registered throughout the European Union from 1st January 1993 have to be fitted with catalytic converters. Platinum, palladium and rhodium are the main active components.

A potential problem appears with the release of platinum group metals (PGMs) from the converters into the environment. There is now convincing evidence for the release of platinum group metals (PGMs) into the environment, possibly by abrasion of the auto catalyst. As a result, PGMs are found to have increased in the environment. In recent study, we found that PGMs have increased in road dust since 1984 and particularly 1991.

1.4 POSITION OF CATALYTIC CONVERTER

First of all catalytic converter was installed in under floor. This design needed further improvement. So additional starter catalyst is installed in closed coupled position The catalytic converter usually looks like a muffler and is located underneath the vehicle in the proximity of the passenger seat in most cars although some cars have multiple converters. The purpose of a catalytic converter is to convert harmful hydrocarbons, carbon monoxide, and nitrogen oxides into harmless compounds. The catalysts inside the catalytic converter convert carbon monoxide and hydrocarbons into carbon dioxide and water, and nitrogen oxides back into nitrogen and oxygen.

1.5 AIR FUEL RATIO

Conversion efficiency of NO, CO and HC as a function of the air-fuel in a three way catalytic converter. The conversion efficiency of NO, CO and HC as function of the air - fuel ratio. There is a narrow range of air- fuel ratio near stoichimetry in which high conversion efficiencies for all three pollutants are achieved. The width of this window is narrow about 0.1 air-fuel ratio for catalyst with high mileage use and depend on catalyst formulation and engine operating conditions.

2. COATING PROCESS

Catalytic converters are used in automobile and industries for pollution abatement. They usually consist of cordierite ceramic extruded to form a structure of honeycomb-like cells that extend as channels along the catalytic converter length. A paint-like liquid containing the precious metal catalyst is coated on the channel walls. During operation, exhaust gases are conveyed with low pressure drop through the catalytic converter. The pollutant gases are removed by catalytic activity in the catalyst coating. Usually, the monoliths are sprayed with a non-viscous solution containing dissolved catalyst. Sometimes the monoliths are coated by dipping into catalyst enriched slurry and then blowing out the slurry with air. The air clears the channels leaving a layer of deposited slurry solids on the channel walls. A solid coat of catalyst, called the wash coat, is left after the liquid components dries out. A third method is to suck the slurry through the monoliths by lowering one end of the monolith into catalyst slurry and applying a vacuum at the other end of the monolith. This vacuum coating method has been the focus of our research and is illustrated below.

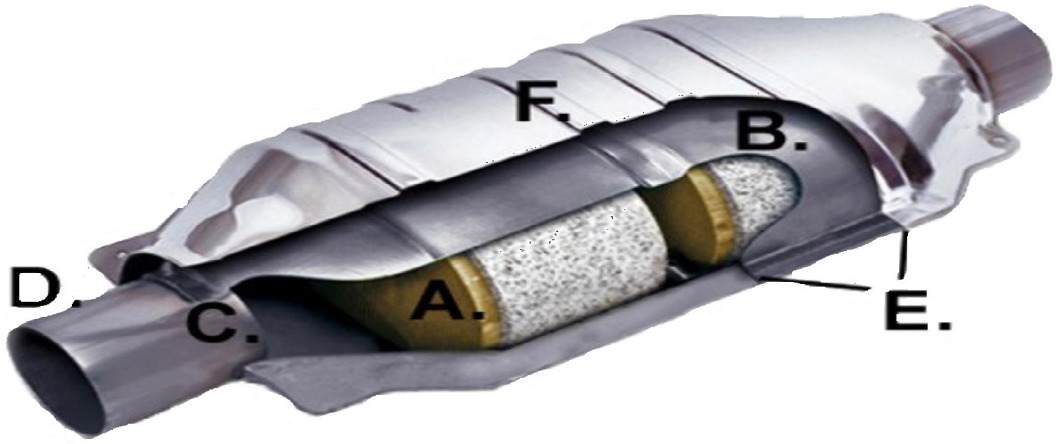

Figure 2.1 : Coating of Catalytic Converter

A. Magna Flow engineers its converters with maximum airflow in mind. The large surface area of the honeycomb ceramic catalyst combines with a detailed coating process to allow the most exhaust to flow through the converter. Innovative technology allows each catalyst to both oxidize and reduce harmful emissions.

B. A ribbed body encases the ceramic to reduce expansion and distortion when the converter reaches its high operating temperature. The ribs form channels that hold the ceramic in proper alignment and protect the cushioning mat from direct exposure to exhaust gases.

C. Magna Flow converters have a smooth –flowing, ½ lap joint where the neck and body connect. This joint prevents the neck from extending into the body, where it could impede exhaust flow.

D. Magna Flow maintains separate dies for several converter body sizes and corresponding neck sizes. This process eliminates the need to adapt neck sizes to make them fit on a single converter body size, which would increase back pressure and decrease airflow and horsepower.

E. The ceramic catalysts are seam welded to a heavy-gauge, stainless steel converter body. Furthermore, a stainless steel heat shield is seam welded to the inner converter body. This style of welding forms a strong bond between the converter's components and prevents the ceramics from shifting.

F. Ribbing on the shield offers a final layer of protection against heat damage while reinforcing the structural stability of the entire converter.

Figure 2.2 : Gases in Catalytic Converter

2.1 FLOW THROUGH CATALYTIC CONVERTER

The nature of the flow in a catalytic converter is very important, and CFD can play a key role in the design of these devices by allowing the engineer to visualize and analyze the exhaust system flow. Key design criteria, such as uniform flow distribution across the substrate, can be easily quantified by CFD, and design performance can be judged via special parameters defined by the automotive manufacturers. To facilitate the extraction of these key design parameters, a special utility has been developed for fluent through user-defined functions (UDFs).

Heated exhaust gas enters through the four inlets of an exhaust manifold, passes through the runners, and enters the substrate inside the catalytic converter. The substrate is modeled as a porous media in FLUENT, where viscous and inertial losses are specified in both the stream wise and transverse directions. By using the porous media model, the number of cells in the computational mesh can be reduced significantly, since the small geometric details of the substrate do not need to be resolved. After passing through the catalytic converter, the gas exits through the tail pipe. The standard k-e model is used for turbulence, along with the standard wall function treatment. The fluid is assumed to be incompressible air.

2.2 CATALYST MATERIALS

A catalytic is a substance that causes chemical reaction without being changed by the reaction. Noble metals are used as catalysts.

Oxidation converters: 70% platinum & 30% palladium and rhodium is not as efficient as platinum but it is used to reduce overall cost of the unit.

Reduction converters: It consists of platinum & rhodium.

Substrate: The monoliths are made by ceramic core like magnesium aluminium silicate or silicon carbide.

Wash Coat: The wash coat is made by layer of mesh by combination of silica and alumina or titanium dioxide or aluminium oxide or silicon oxide.

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3.1 CONVERSION PROCESS

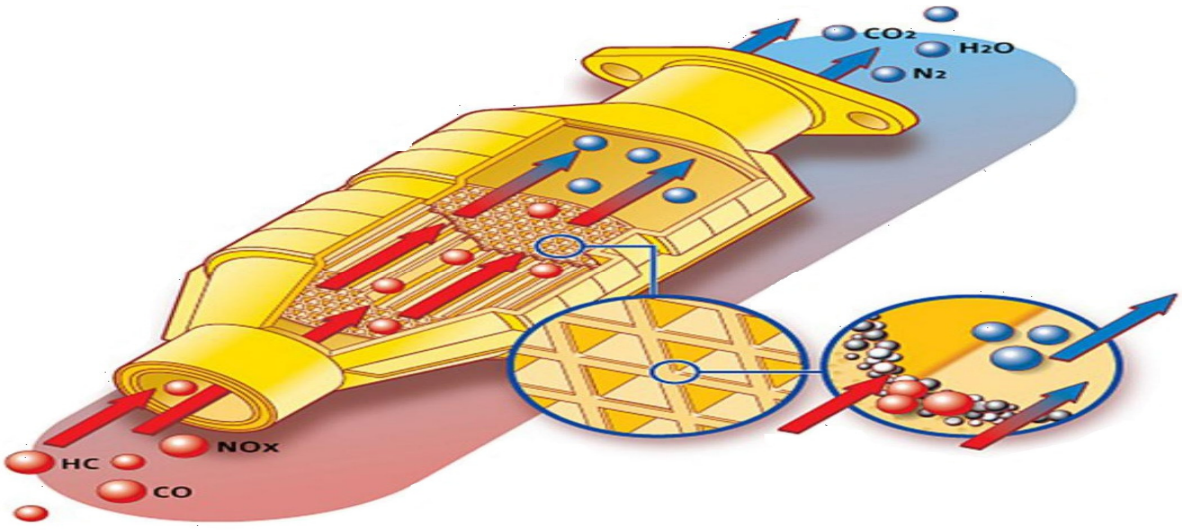


Figure 3.1 : Conversion Process

Most modern cars are equipped with three-way catalytic converters. "Three-way" refers to the three regulated emission it helps to reduce carbon monoxide, VOCs and Nox molecules. The converter uses two different types of catalyst, a reduction catalyst and an oxidization catalyst. Both types consist of a ceramic structure coated with a metal catalyst, usually platinum, rhodium and palladium. The idea is to create a structure that exposes the maximum surface area of catalyst to the exhaust stream, while also minimizing the amount of catalyst required (they are very expensive).

3.2 POLLUTANTS PRODUCED BY A CAR ENGINE

In order to reduce emissions, modern car engines carefully control the amount of fuel they burn. They try to keep the air-to-fuel ratio very close to the stoichiometric point, which is the calculated ideal ratio of fuel. Theoretically, ratio the fuel will be burned using all of the oxygen in the air. For gasoline, the stoichiometric ratio is about 14:7:1, meaning that for each pound of gasoline, 14.7 pounds of air will be burned. Sometimes the mixture can be lean (an air-to-fuel ratio higher than 14.7), and other times the mixture can be rich (an air-to-fuel ratio lower than 14.7).

3.2.1 The main emissions of a car engine are:

Nitrogen gas (N_2): Air is 78%, nitrogen gas and most of this passes right through the car engine.

Carbon dioxide (CO_2) : This is one product of combustion. The carbon in the fuel bonds with the oxygen in the air.

Water vapor (H_2O): This is another product of combustion. The hydrogen in the fuel bonds with the oxygen in the air.

These emissions are mostly begin (although carbon dioxide emissions are believed to contribute to global warming). But because the combustion process is never perfect, some smaller amounts of more harmful emissions are also produced in car engines.

3.2.2 The other main emissions of a car engine are:

Carbon monoxide (CO): A poisonous gas that is colorless and odorless

Hydrocarbons or volatile organic compounds (VOCs): Produced mostly from unburned fuel that evaporates.

Sunlight: Breaks these down to form oxidants, which react with oxides of nitrogen to cause ground level ozone (O3), a major component of smog.

Nitrogen oxides (Nox): Contributes to smog and acid rain, and causes irritation to human mucus membranes.

These are the main regulated emissions, and also the ones that catalytic Converters are designed to reduce.

3.3 WAYS OF CONVERSION

3.3.1 2-WAY PELLETS (BEAD) TYPE:

This type of converter either oxides or reduces but not both at one time, so most often not used now a days.

3.3.2 3-WAY PELLETS (HYBRID) TYPE:

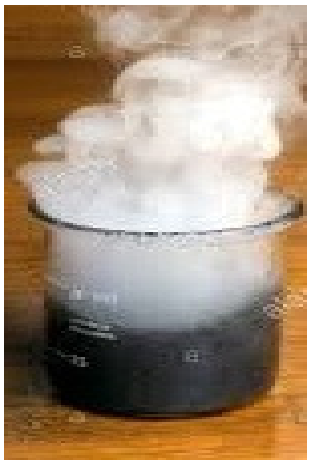
First of all exhaust gases passes through TWC where it reduces Nox & partly oxidizes HC/CO. then pump provides sufficient air form oxidation Purpose. Then it passes through layer, where final oxidation of HC/CO. then Pump provides sufficient air from oxidation purpose. Then it passes through layer, where final oxidation of HC/Co takes place.

3.4 CHEMICAL PREPARATION

In the glass bowl, the solution (1) is prepared by mixing of 200 grams of copper oxide with the dilute nitric acid.

As the same way, the solution (2) is prepared by mixing of combination of 200 grams of manganese oxide and hydrogen peroxide with the dilute nitric acid.

Then the (1, 2) solutions are mixed with magnetic stirrer to attain the bonding property with the acid.



COATING OVER HONYCOMB SUBSTRATE

3.4.1 MANUAL DISPERSION METHOD:

- Manual Dispersion coating process is that the coating is done at a necessary thickness.
- This process is followed by manual dipping of the honeycomb structure into the solution of copper oxide (CuO) and the dilute nitric acid solution (HNO_3) and then air jet sprayed over the honeycomb.
- This process is followed by manual dipping of the honeycomb structure into the solution of Magnesium Oxide and Hydrogen Peroxide ($Mno_2+H_2O_2$) and the dilute nitric acid solution (HNO_3) and then air jet sprayed over the honeycomb.

Figure 3.4 : Coated Catalyst

3.5 METHODOLOGY

- The ceramic core is removed from the catalytic converter.

- The solution (1) is made by mixing of Copper Oxide of 200 grams with the dilute nitric acid solution.
- The solution (2) is made by mixing of Magnesium Oxide and Hydrogen Peroxide 200 grams with the dilute nitric acid solution.
- The coating is done by manual dispersion technique, where the honeycomb is manually dipped and is subjected to air jet spraying so the pores of the honeycomb structure are clear to allow the passage of smoke.
- The coated honeycomb replaced in catalytic converter.
- The catalytic converter is fixed in the vehicle and performance analysis is noted for newly fixed catalyst coated converter.

4.CONCLUSION

After studying all literature review it can be seen that the noble metals Platinum, Palladium and Rhodium, used widely are active catalysts but are expensive. The solution to this is use of materials such as copper oxide, manganese oxide and hydrogen peroxide in place of the conventional noble metals as catalysts. The results of the exhaust emissions obtained were nearly similar when compared to existing catalyst. The use of these materials gave better results of the engine emissions. Also the fact can be ignored that these materials are way too cheaper than the noble metals. Thus, the reduction in environment pollution can be achieved at optimum cost by using effective catalytic convertor.

5.REFERENCE

- Bartholomew, and R. Farrauto, Fundamentals of industrial catalytic processes, 2nd edition, John Wiley & Sons, Inc., New York, 2006, Chapter 10, pp. 706, 733- 735.
- Dorit Adams, Elyse Dumas. Improving the effectiveness of catalytic converters via reduction of cold start emissions. University of Pittsburgh, Swanson School of Engineering, 2013.
- Faghihi, E. M., & Shamekhi, A. H. (2010). Development of a neural network model for selective catalytic reduction (SCR) catalytic converter and ammonia dosing optimization using multi objective genetic algorithm. Chemical Engineering Journal, 165(2), 508-516.
- Ferrando R. and Jellinek J., Nano-particles as a catalysts in catalytic converters, R.L. Johnston, Chem Rev, 108 845 (2009).
- Gilmour P.S., Ziesenis A., Morrison E.R., Vickers M.A., Drost E.M. and Ford .I, Pulmonary and systemic effects of short term inhalation exposure to ultrafine carbon black particles, Toxicological Applications Pharmacology, 195, 35–44 (2004).
- Harrison, Pollution causes, effects & control, 2nd edition, The Royal Society of Chemistry, pp. 221.
- Heck, and R. Farrauto, ″Automobile exhaust catalysts″, Applied Catalysis A: General, vol. 221, pp.443-457, 2001.

- Kaspar, P. Fornasiero, and N. Hickey, ″Automotive catalytic converters: current status and some perspectives″, Catalysis Today, vol. 7, pp. 419 - 449, 2003.

- Kisku, ″Nature and type of pollution from automobiles and strategies for its control″, Industrial Toxicology Research Centre, Environmental Monitoring Division,Lucknow,pp.1-1 http://www.cleanairnet.org/baq2004/1527/articles-59196_Kisku.doc

- Pundir, Engine emissions pollutant Formation and Advances in Control Technology, Narosa Publishing house, New Delhi, Chapter 1, pp. 1-10.