ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Design and Fabrication of Rechargeable Catalytic Converter for IC Engine

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Abstract:

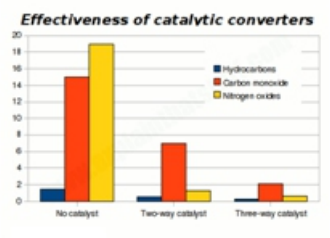
Air and Noise pollution are the biggest causes of environmental degradation in the world. These pollutants also causes health detoriation. The major source for these pollutants are Industries, Automobiles etc. These pollutants can be reduced by using a Catalytic Converter. It is a device which converts the toxic gases into non-toxic gases. Mostly Catalytic Converters are used in Automobiles. Present day Catalytic Converters used in Automobiles are non-rechargeable, so to overcome this problem we have proposed to fabricate an alternative Catalytic Converter which is rechargeable. This Rechargeable Catalytic Converter can be recharged after certain time period. This can be used on all types of IC engines and Diesel Generators which will reduce both noise and air pollution.

I. INTRODUCTION:

Catalytic Converter is a vehicle emissions control device that converts toxic pollutants in exhaust gas to less toxic pollutants by catalyzing a redox reaction (oxidation or reduction). Catalytic converters are used in internal combustion engines fuelled by either petrol (gasoline) or diesel—including lean burn engines. The catalytic converter was invented by Eugene Houdry, a French mechanical engineer and expert in catalytic oil refining who lived in the U.S. around 1950. When the results of early studies of smog in Los Angeles were published, Houdry became concerned about the role of smoke stack exhaust and automobile exhaust in air pollution and founded a company, Oxy-Catalyst. Houdry first developed catalytic converters for smoke stacks called cats for short. Then he developed catalytic converters for warehouse fork lifts that used low grade non-leaded gasoline.

A catalytic converter is a simple device that uses basic redox reactions to reduce the pollutants released by an engine. It converts around 98% of the harmful fumes produced by a car engine into less harmful gases. It is composed of a metal housing with a ceramic honeycomb-like interior with insulating layers. This honeycomb interior has thin wall channels that are coated with a wash coat of aluminum oxide. This coating is porous and increases the surface area, allowing more reactions to take place and containing precious metals such as platinum, rhodium, and palladium. No more than 4-9 grams of these precious metals are used in a single converter.The converter uses simple oxidation and reduction reactions to convert the unwanted fumes. Recall that oxidation is the loss of electrons and that reduction is the gaining of electrons. The precious metals mentioned earlier promote the

transfer of electrons and, in turn, the conversion of toxic fumesthe last section of the converter controls the fuel-injection system. This control system is aided by an oxygen sensor that monitors how much oxygen is in the exhaust stream, and in turn tells the engine computer to adjust the air-to-fuel ratio, keeping the catalytic converter running at the stoichiometric point and near 100% efficiency.



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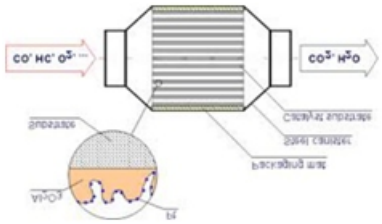
Two way Catalytic Converter:

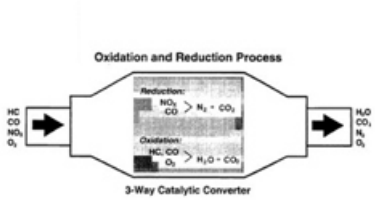


A two-way (or "oxidation") catalytic converter has two simultaneous tasks:

1.Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 \rightarrow 2CO_2$
2.Oxidation of hydrocarbons (unburnt and partially burnt fuel) to carbon dioxide and water:
$C_xH_{2x+2} + [(3x+1)/2]\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$ (a combustion reaction)

This type of catalytic converter is widely used on diesel engines to reduce hydrocarbon and carbon monoxide emissions. They were also used on gasoline engines in American- and Canadian-market automobiles until 1981. Because of their inability to control oxides of nitrogen, they were superseded by three-way converters.

Three way Catalytic Converter



Three-way catalytic converters (TWC) have the additional advantage of controlling the emission of nitrogen oxides (NOx), in particular nitrous oxide, a greenhouse gas over three hundred times more potent than carbon dioxide, a precursor to acid rain and currently the most ozone-depleting substance. Since 1981, "three-way" (oxidation-reduction) catalytic converters have been used in vehicle emission control systems in the United States and Canada; many other countries have also adopted stringent vehicle emission regulations that in effect require three-way converters on gasoline-powered vehicles. The reduction and oxidation catalysts are typically contained in a common housing, however in some instances they may be housed separately. A three-way catalytic converter has three simultaneous tasks:

1.Reduction of nitrogen oxides to nitrogen and oxygen: $2NO_x \rightarrow x O_2 + N_2$
2.Oxidation of carbon monoxide to carbon dioxide: $2CO + O_2 \rightarrow 2CO_2$
3.Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water:
$C_xH_{2x+2} + [(3x+1)/2]\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$.

These three reactions occur most efficiently when the catalytic converter receives exhaust from an engine running slightly above the stoichiometric point. This point is between 14.6 and 14.8 parts air to 1 part fuel, by weight, for gasoline. The ratio for Autogas (or liquefied petroleum gas (LPG)), natural gas and ethanol fuels is each slightly different, requiring modified fuel system settings when using those fuels.In general, engines fitted with 3-way catalytic converters are equipped with a computerized closed-loop feed-back fuel injection system using one or more oxygen sensors, though early in the deployment of three-way converters, carburettors equipped for feedback mixture control were used.

Three-way catalysts are effective when the engine is operated within a narrow band of air-fuel ratios near stoichiometry, such that the exhaust gas oscillates between rich (excess fuel) and lean (excess oxygen) conditions. However, conversion efficiency falls very rapidly when the engine is operated outside of that band of air-fuel ratios. Under lean engine operation, there is excess oxygen and the reduction of NOx is not favoured. Under rich conditions, the excess fuel consumes all of the available oxygen prior to the catalyst, thus only stored oxygen is available for the oxidation function. Closed-loop control systems are necessary because of the conflicting requirements for effective NOx reduction and HC oxidation.

The control system must prevent the NOx reduction catalyst from becoming fully oxidized, yet replenish the oxygen storage material to maintain its function as an oxidation catalyst.Three-way catalytic converters can store oxygen from the exhaust gas stream, usually when the air–fuel ratio goes lean. When sufficient oxygen is not available from the exhaust stream, the stored oxygen is released and consumed (see cerium (IV) oxide). A lack of sufficient oxygen occurs either when oxygen derived from NOx reduction is unavailable or when certain manoeuvres such as hard acceleration enrich the mixture beyond the ability of the converter to supply oxygen.

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II. LITERATURE REVIEW:

V.Veeraragavan [1], in his paper discussed about an attempt has been made to study the performance of various metal oxide catalyst a combustion of carbon monoxide and tri metal oxide catalyst in reducing the pollutant from four stroke C.I engine it has been found that a stable catalyst have been found through experimental that can act as a promising technology in future.J SojiAdeyinka [2], in his paper designed a reactor for the conversion of exhaust pollutants from an internal combustion engine using gasoline as fuel. A bed height of 420 mm was used with an internal diameter of 40mm; a space-time of 23.6s and a fractional conversion of 0.99 at a space velocity of 0.042 m/s was achieved. And also it was shown performance evaluation of the pollutant conversion at 375 degree C showed 98% conversion of CO, 99% of HC and NO, 98% with 100% nitrogen utilisation.

Rajesh B Biniwale [3], in his study showed that National Environmental Engineering Research Institute (NEERI) has developed a non-noble metal based catalytic converter considering the present and future emission standards. These non-metal based converters can also be fitted to old, on-road vehicles, which shares major part of total vehicular emissions, and thus a large market is readily available. Financial analysis reveals that the technology is cost- effective and has wide commercial application.Narendrasinh R. Makwana [4], in his work developed a cost effective Nickel based oxidation catalytic converter to be used with four stroke diesel engine. Inexpensive CAT development, performance evolution and engine test results have been presented with discussion.

Ch. Indira Priyadarsini [5], in her paper presented that The pressure, velocity, mass flow and temperature fields in the converter with respect to inlet conditions are studied. In CFD analysis, fluid properties are specified with suitable assumptions. Parameters are taken from an experiment on a four stroke single cylinder spark ignition engine running at a speed of 3000rpm. Catalytic converter plays an important role in reducing harmful gases without changing the design of an engine, but the presence of catalytic converter increases the exhaust back pressure which results in the volumetric efficiency decrease and higher fuel consumption. Therefore studies on simulation of flow through the catalytic converter are very important.

B.Balakrishna [6], in his paper discussed that the rare earth metals now used as catalyst to reduce NOX are costly and rarely available. The scarcity and high demand of present catalyst materials necessitate the need for finding out the alternatives. Among all other particulate filter materials, knitted steel wire mesh material is selected as filter materials in this paper. Through Computational Fluid Dynamics (CFD) analysis, various models with different wire mesh grid size combinations were simulated using the appropriate boundary conditions. The comparison of back pressure of different catalytic converter models is made in this paper.

P.Karuppusamy [7], in his paper deals with the catalytic converter designed and through CFD (Star CCM+ software) analysis, a compromise between two parameters namely, more filtration efficiency with limited back pressure was aimed at. In CFD analysis, various models with different wire mesh grid size combinations were simulated using the appropriate boundary conditions and fluid properties specified to the system with suitable assumptions. The back pressure variations in various models and the flow of the gas in the substrate were discussed in. Finally, the model with limited backpressure was fabricated and Experiments were carried out on computerized kirloskar single cylinder four stroke diesel engine test rig with an eddy current dynamometer. The performance of the engine and the catalytic converter were discussed.

Krunal P. Shah [8], in his study made a research to study of different paper related to zirconium dioxide coating in catalytic converter and the wire mesh structure effect in the catalytic converter instead of honeycomb structure also find their effect on the performance of the I.C. engine. Catalytic converter with different catalyst for compression ignition engine to reduce pollute gases is chosen for present work. The emphasis is given on hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen. The wire mesh is developed as catalyst .The wire mesh is coated with zirconium dioxide (ZrO_2). The catalyst materials are inexpensive in comparison with conventional catalysts (noble metals) such as palladium or platinum. Catalytic converter oxidizes harmful CO and HC emission to CO_2 and H_2O in the exhaust system and thus the emission is controlled.

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P.K.V.S.Subramanyeswararao [9], in his paper discussed that The analysis involved in determining reduction of pollutant emissions across the converter in three different modules i.e. different lengths of substrates, different diameters of Substrate and using the supply of external air. The converter performance is simulated by considering chemical reactions as the exhaust gases flow through the catalyst. The results show that increasing the length or cross-sectional area of the catalyst increases the conversion efficiency. Pollutant emissions are lower in case of catalytic converter with supply of external air.

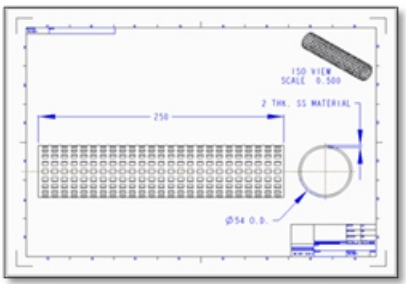
M AKalam [10], in his paper is to develop a low-cost three way catalytic converter to be used with the newly developed CNG-DI engine. Detailed review on catalytic converter, low-cost catalytic converter development characteristics and CNG-DI engine test results have been presented with discussions.

Jan Kaspar [11], in his paper illustrated that the technology for abatement of exhaust emissions by analysing 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, are also discussed.

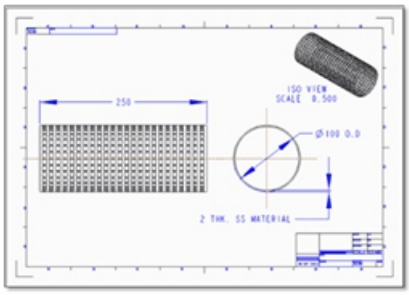
III. DESIGN OF CATALYTIC CONVERTER:

We propose to fabricate a catalytic convertor which can be recharged after its initial life validity is over. So we cannot only decrease the pollution but also increase the life period of the equipment.Creo Parametric-Creo Parametric is a computer graphics system for modeling various mechanical designs and for performing related design and manufacturing operations. The system uses a 3D solid modeling system as the core, and applies the feature-based, parametric modeling method. In short, Creo Parametric is a feature-based, parametric solid modeling system with many extended design and manufacturing applications.Creo Parametric is the first commercial CAD system entirely based upon the feature-based design and parametric modeling philosophy. Today many software producers have recognized the advantage of this approach and started to shift their product onto this platform.The differences between a feature-based, parametric solid modeling CAD system, such as Creo Parametric, and a conventional CAD system include:

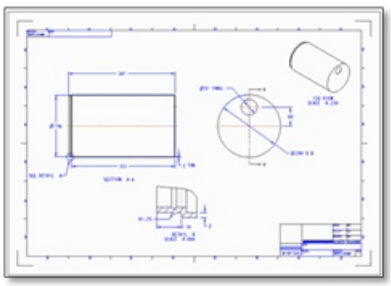
Creo Parametric Conventional CAD SystemsSolid Model Wireframe and Solid ModelParametric Model Fixed-dimension ModelFeature-based Modeling Primitive-based ModelingA Single Data Structure and Full Function-Oriented Data StructuresAssociativity with Format InterpretersSubject-oriented Sub-modeling Systems A Single Geometry-Based SystemManufacturing Information Texts Attached to Geometry Entities-Associated with FeaturesGeneration of an Assembly by Generation of an Assembly byAssembling Components Positioning Components



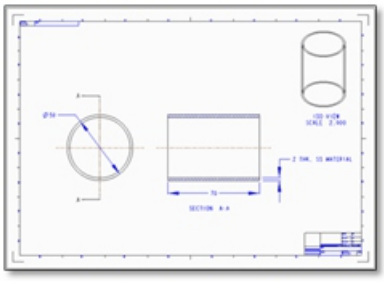
Modelling of Inside Filter



Modelling of Outside Filter



Modelling of Body Cover



Modelling of Outlet Tube

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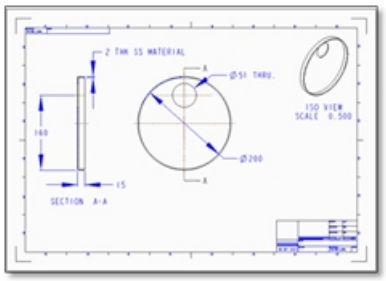
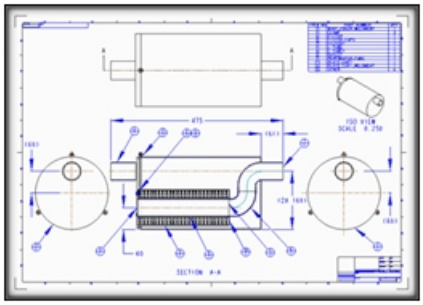


Modelling of Body Cap



Final Assembly

IV. FABRICATION OF CATALYTIC CONVERTER:

Fabrication of catalytic converter involves operations like roller bending, fillet welding, drilling, grinding and seam welding operations

Fabricated Catalytic Converter
Cartridge Recharged with Coal
Stainless steel Filter
Body Cap

Top View of Catalytic Converter
Outlet Tube
Filter cap for screwing

V. RESULTS AND DISCUSSIONS:

Testing-The Catalytic converter is made to test in a real time condition for a four wheeler vehicle. The readings are as shown in the below two certificates under Fig. 5.1 and Fig. 5.2 respectively.

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Pollution Under Control Certificate Without Catalytic Converter

Pollution Under Control Certificate With

Catalytic Converter

	Without Catalytic converter	With Catalytic converter
H.S.U	49.88	28.65

Conclusion:

H. S. U is defined as the Hartridge Smoke Unit. A value of 0 indicates perfect transmission, or zero opacity. A value of 100 indicates total absorption, or complete opacity. Hence we can see that the H.S.U is reducing up to 42.5% than earlier. Hence in this way we can say that the smoke from the exhaust is reduced.

of Catalytic Converter-The catalytic converter's sole purpose is to reduce the amount of harmful pollution produced by the combustion of hydrocarbon-based fossil fuels in cars.Catalytic converters decrease hydrocarbon emissions by about 87 percent, carbon monoxide by 85 percent and nitrous oxide by 62 percent during the expected life of a vehicle.

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