

Possibility to Use Catalytic Converter to Reduce Exhaust Emission from Automobile- A Review Paper

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ABSTRACT: The motivation behind this paper is to present Air contamination created from versatile sources is an issue of general interest. Vehicle populace is anticipated to develop near 1300 million by the year 2030. Because of deficient ignition in the motor, there are various fragmented burning items CO, HC, NO_x, particulate matters and so forth. These contaminations have negative effect on air quality, environment and human wellbeing that leads in stringent standards of poison outflow. Quantities of option advances like change in motor outline, fuel pre-treatment, utilization of option powers, fuel added substances, debilitate treatment or better tuning of the ignition procedure and so on are being considered to decrease the outflow levels of the motor. Among every one of the sorts of advancements grew in this way, utilization of exhaust systems in light of platinum (honorable) bunch metal is the most ideal approach to control car fumes emanations. This survey paper examines car fumes discharges and its effect, car fumes emanation control by platinum (honorable) bunch metal based impetus in exhaust system, history of synergist convertor, sorts of reactant convertor, impediment of reactant convertor furthermore accomplishments of synergist convertor.

KEYWORDS: Catalytic converter, Exhaust emission, Conversion

I. INTRODUCTION

Issue always been bantered among the tree huggers throughout the decades and late years is air contamination. As the innovation continue advancing and developing, it conveys along undesirable impacts separated from its expansive application and use. One of the fundamental supporters is said to be the outflow of destructive gasses created by vehicle debilitate lines. The quantity of vehicles miles flies out every year keeps on expanding as an aftereffect of higher request and needs. Subsequently, an expansion in the number prompted the expansion of the substance of toxins in air. The need to control motor outflows was perceived as right on time as 1909. Because of the more stringent principles and discharge guidelines, car producers started to build up a treatment gadget for fumes gasses known as exhaust system for their vehicle models. contamination produced from portable sources, for example, cars contributes significant air quality issues in provincial and also urban and industrialized territories in both created and creating nations. Around 50 million autos are delivered each year and more than 700 million autos are utilized around the world. Vehicle populace is anticipated to develop near 1300 million by the year 2030. Most vehicular transportation depends on burning of gas, diesel and plane fills with expansive measure of discharge of carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NO_x) and particulates matter (PM) are particularly concern. HC and CO happen in light of the fact that the ignition proficiency is under 100%. The NO_x is shaped amid the high temperatures (>1500 °C) of the ignition procedure bringing about warm obsession of the nitrogen noticeable all around which frames NO_x.

Run of the mill fumes gas piece at the ordinary motor working conditions are: carbon monoxide (CO, 0.5 vol.%), unburned hydrocarbons (HC, 350 vppm), nitrogen oxides (NO_x, 900 ppm) hydrogen (H₂, 0.17 vol.%), water (H₂O, 10 vol.%), carbon dioxide (CO₂, 10 vol.%), oxygen (O₂, 0.5 vol.%). Carbon monoxide is a prominent toxic substance that has a liking for hemoglobin in the blood 210 times more noteworthy than the As the emanation guidelines were fixed, more propelled control techniques were connected that included adjustments in motor outline and fuel framework, control of motor parameters and utilization of refined fumes after treatment gadgets. Lessening of dangerous substances outflow from ignition motors can be accomplished by essential (inside motor) measure and auxiliary (outside motor) measures. As essential measures various conceivable outcomes and specialized techniques for diminishing fumes gas discharge are utilized e.g. ignition of incline air fuel blend, multistage infusion fuel, fumes gas distribution, fuel gas subsequent to smoldering, stacking of extra water into barrel volume. Nowadays optional measures, in car fumes after treatment forms a scope of cutting edge innovation is connected in view of oxidation and three-way impetus adsorption stockpiling and filtration process. This empowers diminishment of the carbon monoxide (CO), hydrocarbons (HC), nitrogen oxide (NO_x) and particulate discharges from a gas or diesel motor to meet the requests of present and future fumes outflow controls. This audit paper talks about car fumes discharges and its effect, car fumes outflow control by Platinum (respectable) bunch metal based impetus in exhaust system, history of synergist

convertor, sorts of reactant convertor, confinement of synergist convertor furthermore accomplishments of synergist convertor.

II. CATALYTIC CONVERTER

The toxins have negative effect on air quality, environment and human wellbeing that leads in stringent standards of contamination emanation. Quantities of option innovations like change in motor outline, fuel pre-treatment, utilization of option fills, fuel added substances, debilitate treatment or better tuning of the burning procedure and so forth are being considered to diminish the discharge levels of the motor. Out of different advancements accessible for car fumes discharge control an exhaust system is found to best alternative to control CO, HC and NO_x emanations from petrol driven vehicles while diesel particulate channel and oxidation impetuses converter ordiesel oxidation impetus have so far been the most potential choice to control particulates outflows from diesel driven vehicle. An exhaust system (CC) is put inside the tailpipe through which destructive fumes gasses containing unburnt fuel, CO, NO_x are radiated. The capacity of the reactant convertor is to change over these gasses into CO₂, water, N₂ and O₂ and right now, it is obligatory for all autos employing on streets in US and Japan to have exhaust systems as they utilize unleaded petrol. In India the administration has made exhaust systems obligatory for enrollment of new autos.

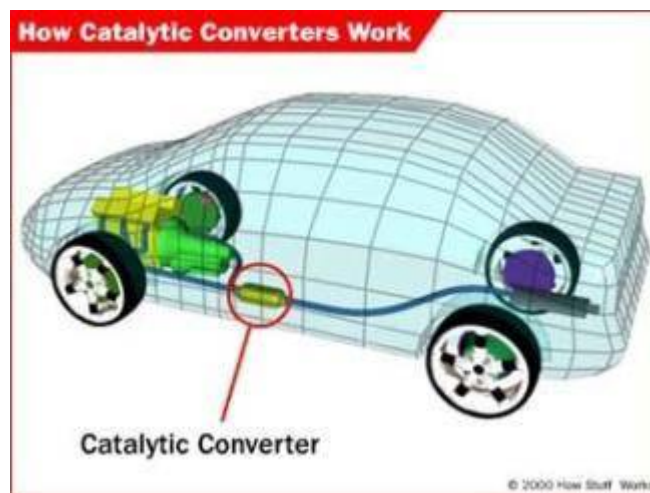


Fig. 1. Catalytic Converter Position in a Vehicle

History

The exhaust system was designed by Eugene Houdry, a French mechanical specialist who lived in the United States. In 1950, when the aftereffects of early investigations of brown haze in Los Angeles were distributed, Houdry got to be worried about the part of car fumes in air contamination and established a unique organization, Oxy-Catalyst, to create exhaust systems for gas motors - a thought comparatively radical for which he accomplished a patent (US2742437). Be that as it may, until the greatly powerful against thump operator tetra-ethyl lead was dispensed with from most gas over natural concerns, it would "harm" the converter by framing a covering on the impetus' surface, successfully debilitating it. The exhaust system was later on further created by John J. Mooney and Carl D. Keith at the Engelhard Corporation making the main creation exhaust system in 1973. Starting in 1979, an ordered lessening in NO_x required the improvement and utilization of a three route impetus for CO, HC and NO_x decrease.

Exhaust system has experienced numerous procedures and amazing development for as far back as 30 years. It is said to be a standout amongst the best apparatus to battle against the staggering contamination substance in our surroundings, as it lessens just about 80% of the unsafe gasses coming about because of the fragmented ignition of the motor. Exhaust system is a stainless steel compartment mounted some place along the fumes channel of the motor and inside the holder is a permeable earthenware structure through which the fumes gas streams (V.GANESAN). In many converters, the earthenware is a solitary honeycomb structure with numerous stream entries. The entries involve numerous shapes, including square, triangular, hexagonal and sinusoidal. Early converters utilized free granular clay with the gas going between the stuffed circles. Since it is hard to keep the circles set up, numerous converter designers picked earthenware stone monument which offers different preferences. Among these focal points are littler volumes, lower mass and more noteworthy simplicity of bundling.

III. TYPES OF CATALYTIC CONVERTER

1) The oxidization catalytic converter

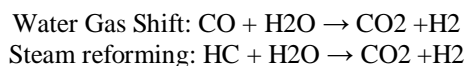
An oxidation impetus is a gadget put on the tailpipe of an auto. The oxidation impetus is the second phase of the exhaust system. It decreases the unburned hydrocarbons and carbon monoxide by blazing (oxidizing) them over a platinum and palladium impetus. This impetus helps the response of the CO and hydrocarbons with the rest of the oxygen in the fumes gas.

2) The reduction catalytic converter

A lessening impetus to control NO_x can be utilized as a different framework as a part of expansion to the oxidation exhaust system. The decrease impetus is fitted upstream of the oxidation framework. The lessening impetus is the main phase of the exhaust system. It utilizes platinum and rhodium to diminish the nitrogen oxide outflows. At the point when such particles interact with the impetus, the impetus tears the nitrogen iota out of the atom and clutches it, liberating the oxygen as O₂. The nitrogen atoms bond with other nitrogen atoms that are also stuck to the catalyst forming N₂. $2NO = N_2 + O_2$ (1)

3) The three-way catalytic converter (TWC)

TWCs have the advantage of performing the oxidation of carbon monoxide (CO), hydrocarbons (HC) and the reduction of nitrogen oxides (NO_x) simultaneously. Noble metals are usually used as the active phase in TWCs. Pd catalysts are especially attractive since Pd is by far the cheapest noble metal in the market and has better selectivity and activity for hydrocarbons. Rhodium the other essential constituent of three-way catalysts is widely recognized as the most efficient catalyst for promoting the reduction of NO to N₂. The TWCs performance in the emission control can be affected by operating the catalyst at elevated temperatures (> 600°C). Reactions occurring on the automotive exhaust catalysts are very complex as listed below. The major reactions are the oxidation of CO and HC and the reduction of NO_x. Concept is based on incorporation of a Also, water gas shift and steam reforming reaction occur. Intermediate products such as N₂O and NO₂ are also found. The NO_x storage storage component into the three-way catalyst (TWCs) to store NO_x during lean conditions for a time period of minutes. Reactions in Catalytic Converter:- Oxidation : $2CO + O_2 \rightarrow 2CO_2$
 $HC + O_2 \rightarrow CO_2 + H_2O$ Reduction/3-way: $2CO + 2NO \rightarrow 2CO_2 + N_2 + HC + NO \rightarrow CO_2 + H_2O + N_2$
 $2H_2 + 2NO \rightarrow 2H_2O + N_2$



Modern Three way catalytic converter

A run of the mill outline of a cutting edge three-way exhaust system is a stainless steel holder that joins a honeycomb stone monument made of artistic or metal. The stone monument goes about as the inactive substrate covering with washcoat and dynamic impetuses. Washcoat is a layer of blend (for the most part aluminum) which gives a further unpredictable and bigger surface region additionally contains oxygen stockpiling promoters and stabilizers. To plan the active stone monument, a layer of washcoat is initially saved on the substrate and the impetuses are then stored on the washcoat or dunking the stone monument into a slurry containing washcoat parts and platinum bunch metals. The overabundance of the saved material (washcoat) is evacuated utilizing high-weight air or by applying a vacuum. At that point the stone monument is calcined to get the completed impetus. The monolith's geometrical qualities assume a key part in affecting the dispersions of temperature and species all through the gadget and afterward deciding the productivity of the converter. It joins the prerequisites of smallness, high volumetric stream rates and low back weight.

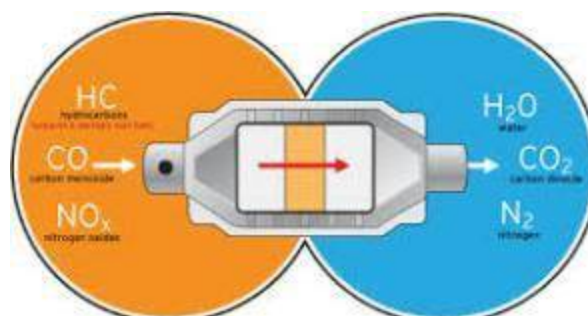


Fig 2. Catalytic Converter

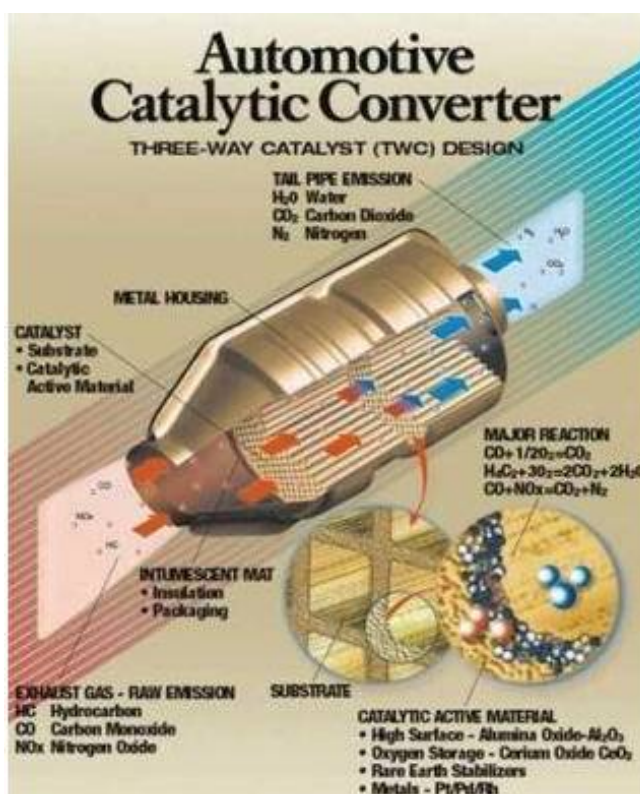


Fig.3. Schematic diagram of Catalytic Converter Catalyst

IV. CATALYST

These incorporate oxides of base metals e.g. copper, chromium, nickel, cobalt and so on and the honorable metals platinum (Pt), palladium (Pd) and rhodium (Rh). Base metal oxides albeit observed to be viable at higher temperature yet they sinter and deactivate when subjected to top of the line fumes gas temperature of routine SI (Spark-Ignition) motor operation. Likewise, their transformation proficiency is extremely restrained by sulfur dioxide coming about because of sulfur in fuel. The base metal impetuses are required in a moderately vast volume and thusly because of high warm dormancy they took more time to warm up to working temperature. Along these lines by and by just the honorable metals are utilized as they have high particular action high imperviousness to warm debasement, Superior frosty begin execution and low deactivation brought about by fuel sulfur. The respectable metal are more costly yet the sum required for a car exhaust system is little around 1 to 2 gm as it were. The honorable metal stacking regularly fluctuates from around 1.0 to 1.8 g/l (30 to 50 g/ft³) of exhaust system volume.

A blend of platinum and palladium in 2:1 mass proportion is normally utilized as oxidation impetus. Palladium has higher particular action than Pt for oxidation of CO, olefins and methane. For the oxidation of aromatics, Pd and Pt have comparable movement while for the oxidation of paraffin hydrocarbon (higher than propane) Pt is more dynamic than Pd. Palladium has a lower sintering inclination than platinum at high temperatures of around 980 °C in the oxidizing environment. Rhodium is principally a NO lessening impetus. The NO diminishment action of honorable metals is in the request Rh>Pd>Pt. at the point when synchronous transformation of CO, HC and NO_x is fancied in the 3-way exhaust systems, blend of Pt + Pd is utilized with Rh as a part of a proportion of 5:1 to 10:1. The dynamic metal in the car impetuses Pt, Pd and/or Rh is little (0.1 to 0.15 % by weight of stone monument) and it is exceedingly scattered on the surface of the impetus support. The molecule size of the honorable metal particles when crisp is around 50 nm or littler. At high temperature the respectable metals sinter and particles may develop to a size of around 100 nm.

Substrate/Support Pellets:

The primary exhaust systems of traveler autos in mid 1970s utilized a bed of round earthenware pellets. These are otherwise called pressed bed exhaust system. The round pellets made of γ -alumina (γ -Al₂O₃) of 3-6 mm width were utilized. The material of pellets is chosen to have a high mechanical quality against squash and scraped spot even after introduction to high temperature of around 1000°C on the permeable surface of pellets that gives a substantial surface

range, the respectable metal salts are impregnated to a profundity of around 250 μm. The pellets are then dried at about 120°C and claimed to a temperature of about 500°C. The pellets catalysts were loaded with approximately 0.05 % by weight of noble metals composed of Pt : Pd in 2.5 : 1

Monoliths

A stone monument is an earthenware square comprising of countless straight and parallel channels. The stone monuments are made by expulsion. An extraordinary blend of dirt covers and added substances is pushed through an advanced color to make the stone monument structure. The material is dried sliced to the required length and let go at high temperatures. The solid structure has a distance across of around 15 cm and can have distinctive shapes. The measurement of the channels ranges from 0.5 to 10 mm and the length of the stone monument can be up to 1 meter long. On the dividers of the channels a synergist dynamic layer can be connected in which concoction responses can happen. Due to the huge number of channels the contact territory between the reactant layer and the liquid that goes inside the channels is huge. Further the channels are straight and parallel so that the stream is not hindered.

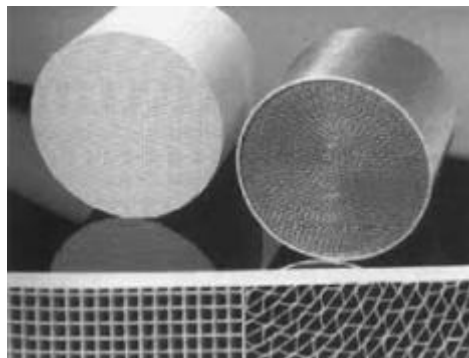


Figure 4: ceramic and metallic exhaust monolith

The fired and metallic solid permits high transformation efficiencies at high vaporous throughput, gives a high geometric surface region with lower weight drop, brilliant high temperature and warm stun resistance and can be helpfully situated in the fumes train in any number of bearings. The solid impetus is mounted in a stainless-steel holder with a tangling material wrapped around it to guarantee imperviousness to vibration.

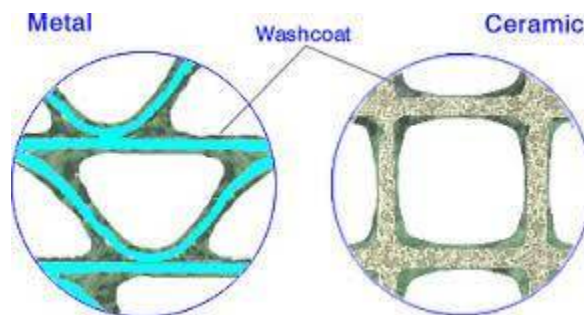


Fig.5. Internal structure of Ceramic and Metallic monolith.

The size and shape of the final catalyst configuration varies with each automobile company but typically, they are about 10-12 cm in diameter and 7-10 cm in long with multiple honeycomb catalysts.

Air to fuel ratio

There is a narrow range of air- fuel ratio near stoichiometry 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 depends on catalyst formulation and engine operating conditions. Conversion efficiency of NO, CO and HC as a function of the air-fuel in a three way catalytic converter. Fig.5 shows the conversion efficiency of NO, CO and HC as function of the air - fuel ratio.

1) When the A/F ratio is leaner than stoichiometry

The oxygen content of the exhaust stream rises and the carbon monoxide content falls. This provides a high efficiency operating environment for the oxidizing catalysts (platinum and palladium). During this lean cycle the catalyst (by using cerium) also stores excess oxygen which will be released to promote better oxidation during the rich cycle.

2) When the A/F ratio is richer than stoichiometry

The carbon monoxide substance of the fumes rises and the oxygen content falls. This gave a high proficiency working environment for the lessening impetus (rhodium). The oxidizing impetus keeps up its effectiveness as put away oxygen is discharged [27], [28]. A shut circle criticism fuel administration framework with an oxygen sensor in the fumes is utilized for exact control of air-fuel proportion. To acquire a proficient control of the A/F proportion the measure of air is measured and the fuel infusion is controlled by a mechanized framework which utilizes an oxygen (λ) sensor situated at the bay of the exhaust system. The sign from this λ sensor is utilized as a criticism for the fuel and air infusion control circle. A second λ sensor is mounted at the outlet of the exhaust system (Fig. 4). This setup constitutes the premise of the supposed motor locally available diagnostics (OBD). By contrasting the oxygen fixation prior and then afterward the impetus, A/F vacillations are identified. Broad changes of A/F at the outlet signal framework disappointment. Impact of A/F proportion on the change productivity of three-way impetuses tight A/F window at the stoichiometric point is the unique mark of a successful TWC framework. A basic shut circle criticism motor fuel administration framework is demonstrated schematically in fig. 5.

V. LIMITATION

In the fumes stream with temperatures up to 1000 °C the metal in the impetus is inclined to deactivation by sintering, prompting a decrease in surface zone and thus synergist action. The traditional intends to meet fixing administrative outflows control targets is just to expand the measure of PGM in the auto impetus. The need to ensure impetus execution over the run of the mill vehicle lifetime of 80,000 km likewise implies that abundance metal must be included, following the execution of the impetus drops off after some time. Moreover rising PGM request and expenses are impetuses towards accomplishing lower metal loadings and higher action. The exhaust systems in the fumes framework get to be decayed by a few components e.g. warm crumbling and harming. Warm crumbling happens as an aftereffect of introduction of the impetus to high temperature conditions. This cause sintering of the PGM, loss of bolster surface range and stage change. Harm likewise cause loss of action primarily by obstructing the pores prompting dynamic destinations or even by direct blockage of the dynamic locales themselves.

VI. CONCLUSION

Today's automobiles are meeting emission standards that require reductions of up to 99 percent for HC, CO and NO_x compared to the uncontrolled levels of automobiles sold in the 1960s. Environmental, ecological and health concern result in increasingly stringent emissions regulations of pollutant emissions from vehicle engines. Among all the types of technologies developed so far, use of Metal Monolith type catalytic converters is the best way to control auto exhaust emission. Three-way catalyst with stoichiometric engine control systems remain the state of art method for simultaneously controlling hydrocarbon, CO and NO_x emissions from vehicle. The economical reasons, limited resources of platinum group (noble) metal and some operating limitations of platinum group metal based catalytic converters have motivated the investigation of alternative catalyst materials. This type of Catalytic converters have also been developed for use on trucks, buses and motorcycles as well as on construction equipment lawn and garden equipment marine engines and other non-road engines. Catalytic converters are also used to reduce emissions from alternative fuel vehicles powered by natural gas, methanol, ethanol and propane. To date more than 500 million vehicles equipped with catalytic converters have been sold worldwide. In 2005, 100 percent of new cars sold in the U.S. were equipped with a catalytic converter, and worldwide over 90 percent of new cars sold had a of metal monolith type catalyst.

Acronyms

CO Carbon monoxide

HC Hydrocarbons

NO_x Nitrogen oxides

PM Particulates matter

A/F Air to fuel ratio

TWC Three way catalytic convertor

Rh Rhodium

Pt Platinum

Pd Palladium

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