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The Role of Catalytic Converter in Vehicles

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ABSTRACT

Liquefied petroleum gas (LPG), diesel, and petrol are utilized in large numbers as energy sources for various vehicles in Afghanistan. Vehicles running on LPG are increasingly the primary source of ambient volatile organic compounds. Long-term observations revealed that the catalytic converter was quite effective in reducing the levels of nitric oxide (NO), NO_x, and volatile organic compounds (VOCs) linked to LPG in the air. Catalytic materials are used in car silencers to stop dangerous compounds from burning fuels in engines that cause air pollution, which poses a threat to human health. The role of car silencers is very important to the cleanliness of the environment because these silencers can protect the environment from harmful gases or change more harmful gases into less harmful gases. Those silencers that do not have a catalytic converter in them cause air pollution. Afghanistan's influence is spreading globally, releasing harmful gases into the atmosphere. To reduce these, transport equipment silencers are needed. Carbon monoxide, nitrogen oxides, and partially burned hydrocarbon components can be converted into less harmful substances. Catalysts aim to reduce toxic gases, such as volatile organic hydrocarbons, carbon monoxide, and nitrogen oxides that are created when fossil fuels are not burned completely.

Keywords: Catalytic Converter, Oxidation, Reduction, Pollutants

INTRODUCTION

In recent years, the world's need for energy has increased dramatically. The rate of economic expansion, population growth, and the quick development of the transportation and industrial sectors all contribute to an increase in the need for energy. From now on, the primary source of energy for the world's energy demand is still non-renewable fossil fuels. The expansion of the national and international economies is accompanied by growth in the transportation industry. Because diesel engines are more efficient, they are increasingly used in the transportation sector, particularly for heavy vehicles. Diesel engines run on hydrocarbon fuel, which comes from petroleum, a potentially non-renewable resource. Diesel engines are more efficient than petrol engines in terms of performance. Most applications for hydrocarbon fuel are in transportation. Hydrocarbon fuels' primary source, petroleum, may someday run out of resources. Diesel engines, on the other hand, produce more greenhouse gas emissions, including carbon dioxide, carbon monoxide, nitrogen oxides, particulates, hydrocarbons, and other unstable substances that worsen global warming (Ayhan et al., 2011).

Installing catalytic converters on engines to lower the emission of CO, NO_x, and hydrocarbons is one such corrective action. The most popular catalyst is made up of a honeycomb skeleton ($5SiO_2.2Al_2O_3.2MgO$), we can to enhance the catalyst's performance by the alkaline-earth metals, oxides such as Ce, Zr, La, Ni, Fe and Platinum Group Elements (Pd, Pt, and Rh) (Lim et al., 2006), and Cerium oxide (Bleiwas) and V_2O_5–WO_3–TiO_2 (Tronconi et al., 2005). A catalytic converter is an emission control device that transforms toxic gases and pollutants in the exhaust gases of an internal combustion engine into less toxic pollutants by catalyzing a redox reaction. Catalytic converters are commonly used in internal combustion engines that run on gasoline or diesel fuel, including lean internal combustion engines, and sometimes in kerosene heaters and furnaces (Nice, 2003).

Internal combustion engine emissions pose significant threats to air quality, human health, and global warming. These emissions include unburned hydrocarbons, carbon monoxide, nitrogen oxides, and particulate matter. Governments are working to control these emissions through fuel quality, emission control systems, engine design, and vehicle operating conditions. The EPA identifies four main pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. These pollutants come from point sources,

mobile sources, biogenic sources, and area sources. Hydrocarbon fuels, such as gasoline and diesel, contain hydrogen and carbon atoms that react with oxygen in the air (Sharaf, 2013).

In this article, various sources have been used, such as the Google Scholar database using the search terms “catalytic converter," “effect of nitrogen oxides and carbon monoxides," and “use ceramic in cars." The literature search included 11 articles.

Nitrogen oxides (nox)

Nitrogen and oxygen atoms in the air combine to generate different nitrogen oxides, or NOx, under the high pressure and temperature conditions found in an engine. Similar to hydrocarbons, nitrogen oxides are building blocks for the ozone layer (Sharaf)(Amatayakul & Ramnäs, 2001). They also play a part in the development of acid rain (Nice, 2003).

For around 114 years, nitrogen oxide is present in the atmosphere. When airborne nitrogen and oxygen combine during high-temperature burning, nitrogen oxides are created. Nitrogen oxide emissions are particularly high from diesel engines. Owing to the way this kind of engine burns, NO_X emissions contribute significantly to smog production, which results in the brown dust that is frequently visible in cities. About 300 times as much heat is released into the atmosphere in 100 years by one pound of N_2O as by one pound of CO_2. N_2O is a potent and long-lived greenhouse gas that poses a threat to global warming. Nitrogen oxides have an impact on people in addition to changing the climate. They can lead to lung issues, throat infections, nasal congestion, and mucous membrane irritation.

Carbon Monoxide

When fuel's carbon is only partially converted from carbon to carbon monoxide (CO), incomplete combustion results in the production of carbon monoxide (CO). Carbon monoxide is especially harmful to those who have heart problems because it decreases the amount of oxygen in the blood (Sharaf, 2013).

Carbon Dioxide

Carbon dioxide is a byproduct of "perfect" combustion, and the U.S. Environmental Protection Agency (EPA) has begun to see it as a pollution problem in recent years. While carbon dioxide is a "greenhouse gas" that traps heat from the planet and raises the possibility of global warming, it does not immediately harm human health (Sharaf, 2013).

Catalytic Converter

A catalytic converter is an exhaust emission control device that converts toxic gases and pollutants in exhaust gas from an internal combustion engine into less-toxic pollutants by catalyzing a redox reaction. Catalytic converters are usually used with internal combustion engines fueled by gasoline or diesel, including lean-burn engines, and sometimes on kerosene heaters and stoves (*Reduction of Emission In SI-Engine By Using Fuel Cell and Aqua Silencer*, 2021).

Placement of catalytic converters

For catalytic converters to function properly, the temperature must be 400 °C (752 °F). They are therefore positioned as near to the engine as feasible, or immediately after the exhaust manifold, one or more smaller catalytic converters referred to as "pre-cats" are positioned.

A 2-way (also known as "oxidation" or "oxi-cat") catalytic converter performs two simultaneous tasks:

1. Carbon monoxide is oxidized to produce carbon dioxide ($2CO + O_2 \rightarrow 2CO_2$).
2. Hydrocarbons (partially and unburned fuel) oxidize to produce carbon dioxide and water using the following process. $C_xH_{2x+2} + (3x+1)/2\ O_2 \rightarrow xCO_2 + (x+1)\ H_2O$

A combustion reaction Three-ways. An extra benefit of three-way catalytic converters is their ability to regulate the release of nitrogen dioxide (NO_2) and nitric oxide (NO), which are sometimes referred to as NO_x and should not be confused with nitrous oxide (N_2O). The antecedents of smog and acid rain are NO_x species (Bolaji & Onipede, 2005).

The United States and Canada have been using "three-way" (oxidation-reduction) catalytic converters in their vehicle emission control systems since 1981. Many other nations have also enacted strict vehicle emission regulations that, in practice, mandate the use of three-way converters on gasoline-powered vehicles. Usually, the

catalysts for oxidation and reduction are housed together, but occasionally, they could be placed apart. Three things are happening at once in a three-way catalytic converter. Reduction reaction of nitrogen oxides to nitrogen.

$C + 2NO_2 \rightarrow CO_2 + 2NO$

$CO + NO \rightarrow CO + ½ N_2$

$2CO + NO_2 \rightarrow 2CO_{2+} ½ NO_2$

$H_2 + NO \rightarrow H_2O + ½ N_2$

Oxidation of carbon, hydrocarbons, and carbon monoxide to carbon dioxide.

$C + O_2 \rightarrow CO_2$

$CO + ½ O_2 \rightarrow CO_2$

When the catalytic converter is exposed to exhaust from an engine operating just above the stoichiometric point, these three reactions happen most effectively. This ratio, measured in weight, for gasoline combustion is 14.6–14.8 parts air to one component fuel. The proportions of ethanol, natural gas, and auto gas (also known as liquefied petroleum gas, or LPG) can vary greatly. This is especially true for oxygenated or alcohol-based fuels, such as e85, which requires around 34% more fuel and different fuel system components when used. A computerized closed-loop feedback fuel injection system employing one or more oxygen sensors is often installed in engines that have three-way catalytic converters; nevertheless, carburetors with feedback mixture control were utilized in the early stages of the three-way converter's adoption.

When the engine is run in a small range of air-fuel ratios close to the stoichiometric point, three-way converters work well. (Jalava et al., 2010) When the engine is run outside of this range, the total conversion efficiency rapidly decreases. The engine produces more NOx, the exhaust gases are somewhat lean of stoichiometric, the catalyst's efficacy in reducing NOx decreases quickly, and the engine produces surplus oxygen. However, because there is oxygen available for oxidation to produce H_2O and CO_2, the conversion of hydrocarbon (HC) and CO is extremely efficient. Slightly rich of stoichiometric, the engine begins to produce a large amount of CO and unburned HC, available oxygen drops, and the catalyst's effectiveness in oxidizing CO and HC drops drastically, especially when stored oxygen is exhausted. That being said, the catalyst reduces NOx with high efficiency, and the engine produces less NOx overall. The air-fuel ratio must to be near to stoichiometric and not stay rich or lean for an extended period of time in order to preserve catalyst efficiency (Brandt et al., 1999).

DISCUSSION

This study highlights the significant impact of vehicle emissions, especially LPG, on air quality and human health in Afghanistan. The use of catalytic converters in car silencers has been proven to reduce harmful gases like nitric oxide, nitrogen oxides, and volatile organic compounds. The study also emphasizes the global impact of Afghanistan's vehicle emissions, emphasizing the need for effective measures to reduce harmful emissions and protect the environment and public health. Prioritizing the implementation of catalytic converters is crucial for reducing air pollution and improving public health.

CONCLUSION

Afghanistan's influence is spreading among the countries every day. As a result of these weapons' use of therma l machinery, more gases are being released into the atmosphere. Once in the atmosphere, these gases are very danger for human life. It is necessary to use the transport equipment's silencers in order to reduce the amount of some gases. Carbon monoxide nitrogen oxides, and any unburned or partially burned hydrocarbon components can be converted into alternative substances that are less harmful, such as nitrogen and carbon dioxide. Carbon deioxide’s significance in climate change primarily stems from its long lasting presence in atmosphere made up of nitrogen, carbon, dioside, and water. (Climate Change greatly relies on carbon dioxide. To lower the nitrogen levels in the atmosphere, it is essential to avoid deforestation and replace the felled trees with other plantations, while opting for public transportation over private vehicles. Similarly, it is important to ensure effective cleaning of the oil present in the factories of oil exporting nations and eliminate any pollutants present in it).

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