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DESIGN AND DEVELOPMENT OF 3 WAY CATALYTIC CONERTER

Ketan Bhabad, Sumedh Aher, Sahil Mhaiske, Samartha nagapurkar

Student

Sarswati College of Engineering, Kharghar

ABSTRACT

The issue of reduction of harmful pollutants emitted from an internal combustion engine has gained large prominence as a part of climate change and global warming. Automobile and power generation systems are identified to be one of the largest contributors to atmospheric pollution.Some of the major pollutant emitted from anengine are Oxides of Nitrogen (NOx), Carbonmonoxide(CO),UnburntHydrocarbon(UBHC)andsootparticles.Thispaperpresents a catalytic converter with emission reduction catalysts to be used for compressed ignition engine. The catalytic converters developed based on the catalyst materials consisting of metal oxides such as aluminum oxide and titanium dioxide coated with wire mesh filter. Both the catalyst materials – aluminum oxide and titanium dioxid eare inexpensive in comparison with conventional catalysts such as palladium or platinum. The objective of this research work is to control the NOx emission and to develop a low-cost three-way catalytic converter. This catalytic converters assembled in the exhaust manifold region of a single cylinder four stroke diesel engine. The emissions from the engine are measured using a five-gas analyzer and the results are tabulated.

1. INTRODUCTION

The urban air pollution is a very complicated problem. The exhaust emissions from internal-combustion engines account for a major portion of this problem. It is realized that the content and concentrations of the exhaust emissions depend on various parameters. These parameters include engine design parameters, operational parameters; exhaust gas after treatment, fuel types, fuel additives and lubricants. The present review project will discusses the effect of some parameters on the emission level and characteristics from internal-combustion engines. The project begins with an introduction of general information on the nature of emissions of exhaust gases, including the toxicity and causes of emissions for both spark-ignition and diesel engines. The paper then shifts to an up-to-date information of the published research work on the subject matter.

1.2. Emissions from internal combustion (IC) engines

Carbon Dioxide (CO2): CO2 is a greenhouse gas that is a major contributor to global warming and climate change. It is a natural byproduct of the combustion process and is directly related to the amount of fuel burned.

Nitrogen Oxides (NOx): NOx compounds, such as nitric oxide (NO) and nitrogen dioxide (NO2), are formed during high-temperature combustion. They are responsible for the formation of smog, acid rain, and respiratory problems. NOx emissions also contribute to the depletion of the ozone layer.

Particulate Matter (PM):PM includes tiny solid particles and liquid droplets that are emitted in the exhaust. These particles can be harmful when inhaled, causing respiratory problems and other health issues. Diesel engines are known for producing a significant amount of particulate matter.

Carbon Monoxide (CO):CO is a colorless, odorless gas that can be harmful when inhaled in high concentrations. It interferes with the body's ability to transport oxygen and can cause health problems. It is a product of incomplete combustion.

Hydrocarbons (HC): Hydrocarbons are unburned fuel molecules emitted from the engine. They can react in the atmosphere to form ground-level ozone, a major component of smog. Ozone can cause respiratory problems and damage crops.

Sulfur Dioxide (SO2):SO2 emissions result from the combustion of sulfur-containing fuels, such as high-sulfur diesel. SO2 contributes to acid rain, which can harm ecosystems, damage buildings, and affect human health.

Volatile Organic Compounds (VOCs): VOCs are unburned hydrocarbons that can evaporate from the engine or its exhaust. They are precursors to the formation of ground-level ozone and smog.

1.3. Emission and their effects

Emission Type	Effects
Carbon Dioxide (CO2)	Global warming, climate change
Nitrogen Oxides (NOx)	Smog, respiratory problems
Particulate Matter	Respiratory problems, air pollution
Carbon Monoxide (CO)	Health problems, air pollution
Hydrocarbons (HC)	Smog, ground-level ozone

1.4. Problem Statement

In day-to-day life number automobiles are increasing which directly increases the level of pollution. This pollution affects very badly on human and environment. Humans are facing lots of health issues due to this pollution. As technology becomes legs of development, we cannot stop this technology but we can control the pollution which is done by technology.

2. LITERATURE REVIEW

[1]. Andrés F. Duque Amaya, Adalberto Gabriel Díaz Torres, Diego A. Acosta et. al. discussed and studied mathematical model of emissions was developed in a Twingo D7F engine. The effects of variations in compression ratio, fuel/air equivalence ratio, spark advanced and combustion duration under pollutant emissions were studied. Analysis and data collection were performed in an engine bank using a data acquisition system integrated to an Interactive Engineering Environment. A control strategy was implemented to guarantee emissions reduction and concluded that In this work was developed an environment model based on the explosion of isooctane fuel to quantify and reduce the main emissions in a Twin go D7F engine. Analysis and data collection of the Twin go D7F engine were performed in the EAFITUniversity bank engines. Parametric study was performed to reduce HC, CO, NOX emissions and improve oxygen consumption from variation of engine operation parameters. air–fuel ratio (A_F = 14), spark timing (−15◦ CAD) and compression ratio (RC = 9) were optimum values to reduce emissions in this engine.

[2]. G Balaji,DPremnath, R Yuvaraj, Akshdeep Singh Kohli et. Al. Studied Emissions from the automobile contribute to major air pollution problems in cities as well as villages along with industrialized areas in developed and developing countries. Air pollution is one of the major factor that is the cause for global warming and the climate change problems. This paper focuses on mitigation using regular three way catalytic convertor to reduce the level of emissions of CO, NOx and HC along with a name blend biodiesel. Since most of the transportation vehicles rely solely on Petrol and Diesel for their operation. This results in large amount of carbon monoxide (CO), unburnt hydrocarbons (HC), nitrogen oxides (NOx), and particulate matters. Hence, for the experimental analysis of the three way catalytic converter Neem-diesel blend will be used as alternatives of petrol and diesel. Nearly all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.Thus an organized cultivation and methodical collection of Neem oil, is a potential bio-diesel substitute and will reduce the import burden of petroleum. And Concluded that the performance and emission characteristics of neem oil blend fuelled Compression Ignition engine with a Catalytic converter system were studied and analyzed. Based on the results derived from the experimental investigation, conclusions were drawn as summarized below.

1. The emission of NOx for neat neem oil blend decreases by 38.77% in presence of converter.
2. The emission of CO for neem oil blend decreased by 45.67% in presence of converter on comparison when converter isn't present.
3. The Brake Thermal Efficiency for neem oil blend decreases by 2.14% in presence of converter on comparison when converter isn't present. Also on comparison to diesel the BTE of neem blend with converter falls by 3.15%. In all the remaining loads when coupled with catalytic converter neem blend has better brake thermal efficiency than diesel.
4. The emission of HCfor neem oil blend decreases by 2.32% in presence of converter.
5. The emission of CO2 for neem oil blend increases by 47.41% when converter is placed. Also on comparison

to diesel the CO2 emissions of neem blend with converter rises by 1.75%

[3] Kim Timmermans, MSc, MichielVaneker,MD, PhD, Gert Jan Scheffer, MD, PhD PaulineMaassen, Stephanie Janssen , Matthijs Kox, PhD, Peter Pickkers et. al. studied Soluble urokinase-type plasminogen activator (suPAR) represents a marker for immune activation and has predictive value in critically ill patients. The kinetics of suPAR and its correlation with the immune response and outcome in trauma patients are unknown. Methods: Plasma concentrations of inflammatory cytokines and suPAR were determined in adult trauma patient (n = 69) samples obtained by the Helicopter Emergency Medical Services at arrival at the emergency department (ED) and at days 1, 3, 5, 7, 10, and 14. Results: Initial suPAR levels were unrelated to injury severity score and higher in nonsurvivors compared with survivors, although no difference was observed between early and late mortality. The area under the receiver operating characteristic curve to predict mortality was 0.6 (95% confidence interval, 0.48-0.72). Soluble urokinasetype plasminogen activator levels increased over time in 94% of patients, although suPAR increase did not precede death. Tumor necrosis factor α at the ED correlated with suPAR at that time point, whereas concentrations of other proinflammatory cytokines at the ED correlated with suPAR levels at days 1 and 5. Conclusions: After trauma, initial suPAR plasma concentrations are higher in nonsurvivors compared with survivors, but its predictive value is low. Soluble urokinase-type plasminogen activator levels increase over time after trauma, and concentrations at later time points are related to cytokine levels at. And concluded early suPAR concentrations are higher in nonsurvivors than in survivors, and levels at later time points are related to preceding cytokine levels. However, the predictive value of suPAR for mortality and, therefore, its clinical relevance is low. The steady increase over time related to the initial inflammatory response is not related to mortality.

[4] A. A. Abdel-Rahmanrevived and studied that the urban air pollution is a very complicated problem. The exhaust emissions from internal-combustion engines account for a major portion of this problem. It is realized that the content and concentrations of the exhaust emissions depend on various parameters. These parameters include engine design parameters, operational parameters; exhaust gas after treatment, fuel types, fuel additives and lubricants. The present review paper discusses the effect of some parameters on the emission level and characteristics from internal-combustion engines. The paper begins with an introduction of general information on the nature of emissions of exhaust gases, including the toxicity and causes of emissions for both spark-ignition and diesel engines. The paper then shifts to an up-to-date information of the published research work on the subject matter.

[5] VembathuRajesh,C.MathalaiSundaram, V. Sivaganesan,B. Nagarajan, S. Harikishore et. al. studied that The issue of reduction of harmful pollutants emitted from an internal combustion engine has gained large prominence as a part of climate change and global warming. Automobile and power generation systems are identified to be one of the largest contributors to atmospheric pollution. Some of the major pollutants emitted

from an engine are Oxides of Nitrogen (NOx),Carbon monoxide (CO),Unburnt Hydrocarbon (UBHC) and sootparticles. This paper presents a catalytic converter with emission reduction catalysts to be used for compressed ignition engine. The catalytic converter is developed based on the catalyst materials consisting of metal oxides such as aluminum oxide and titanium dioxide coated with wire mesh filter. Both the catalyst materials – aluminum oxide and titanium dioxide are inexpensive in comparison with conventional catalysts such as palladium or platinum. The objective of this research work is to control the NOx emission and to develop a low-cost three way catalytic converter. The emissions from the engine are measured using a five gasanalyser and the results are tabulated. And concluded that he current catalytic converters are utilizing precious metals like platinum and palladium for oxidizing the emission. To overcome the cost and to reduce the rare metal usage, this paper made the drive to develop an alternate source of oxidation catalyst for oxidation reaction and thus reduce the CO, HC and NOx emissions. The catalytic converter with Aluminum oxide and Titanium dioxide as catalysts reduces the harmful pollutant more efficiently and at a lower cost than the conventional catalytic converter.

3. METHODOLOGY

3.2. Methodology

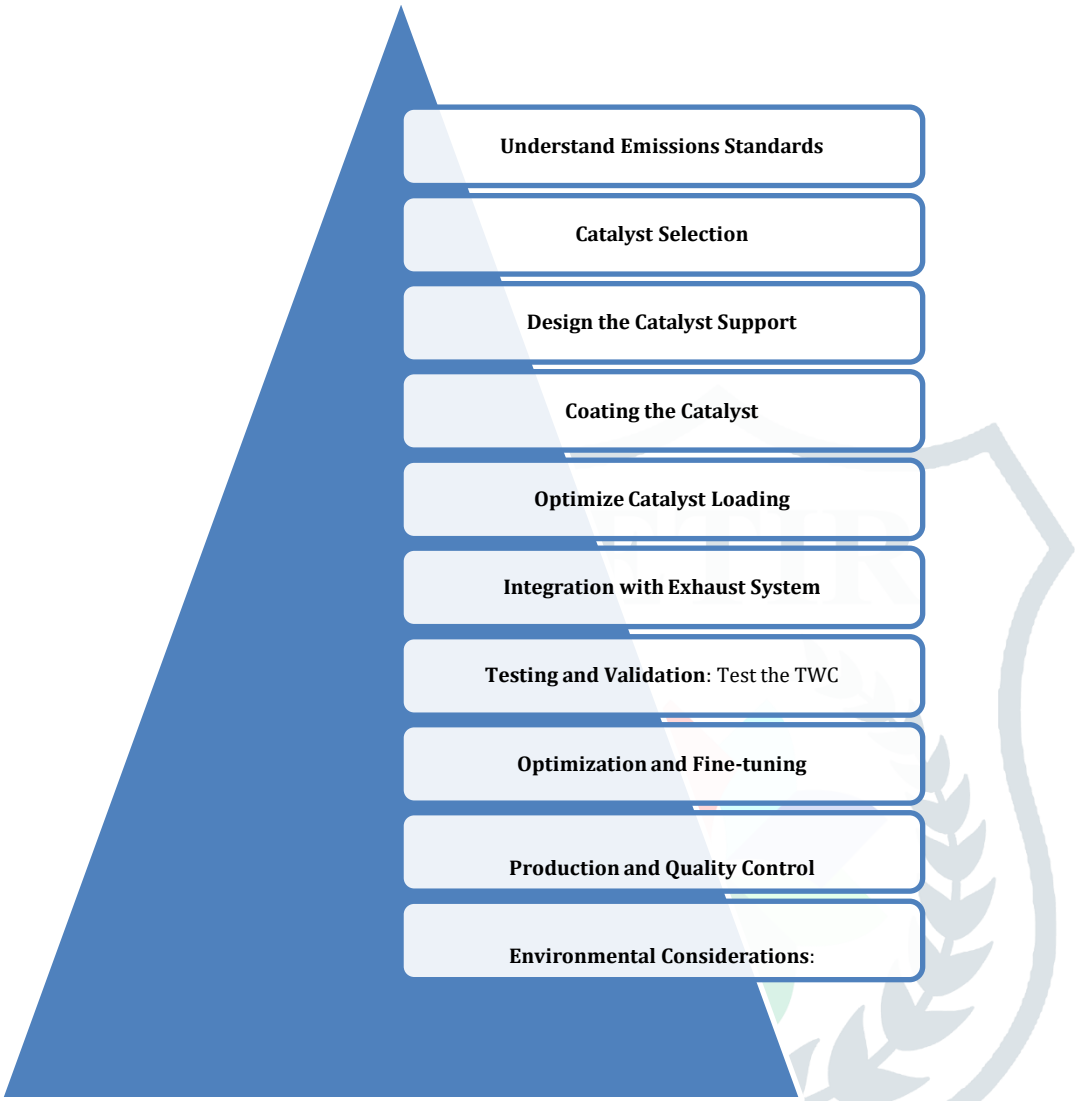

Fig.3.1.Methodology

3.2. How It Works

The catalytic converter works by promoting three essential chemical reactions:

- **Oxidation of Carbon Monoxide (CO)**: CO is converted into carbon dioxide (CO2).
- **Reduction of Nitrogen Oxides (NOx)**: NOx compounds are converted into nitrogen (N2) and oxygen (O2).
- **Oxidation of Unburned Hydrocarbons (HC)**: Unburned hydrocarbons are converted into carbon dioxide (CO2) and water (H2O).

4. DESIGN OF CATLYTIC CONVERTOR

4.1. Aluminum oxide

Aluminum oxide is an amphoteric oxide with the chemical formula Al2O3. It is commonly referred to as alumina, or corundum in its crystalline form, as well as many other names, reflecting its wide spread occurrence in nature and industry. Its most significant use is in the production of Aluminum metal, although it is also used as abrasive due to its hardness and as a refractory material due to its high melting point.

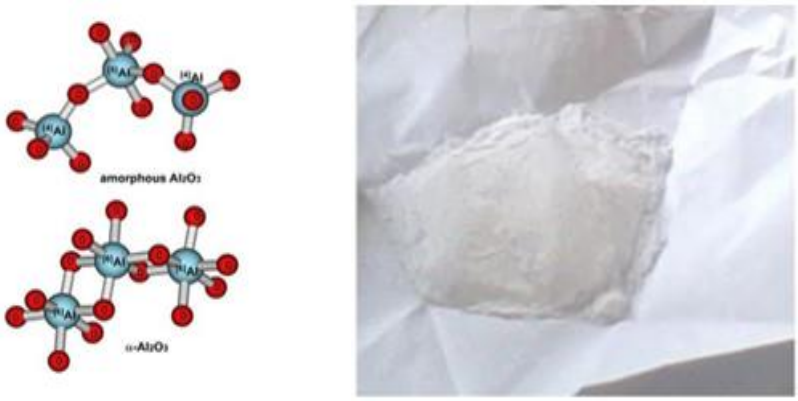

Fig.4.1. Aluminium Oxide and its Molecule

4.2. Chemical Reaction

1. **Oxidation of Carbon Monoxide (CO)**: $2CO+O2 \rightarrow 2CO22CO+O2 \rightarrow 2CO2$

2. **Oxidation of Hydrocarbons (HC)**: $CxHy+(x+y/4)O2 \rightarrow xCO2+(y/2)H2OCxHy+(x+y/4)O2 \rightarrow xCO2 +(y/2)H2O$

3. **Reduction of Nitrogen Oxides (NOx)**: $2NO+2CO \rightarrow N2+2CO22NO+2CO \rightarrow N2+2CO2$
$2NO+2HC+O2 \rightarrow N2+2CO2+2H2O2NO+2HC+O2 \rightarrow N2+2CO2+2H2O$

4. **Oxidation of Hydrogen (H_2)**: $2H2+O2 \rightarrow 2H2O2H2+O2 \rightarrow 2H2O$

5. COMPONENTS

5.1. Components Used

 Sheet Metal	MS (Mild Steel) sheet metal refers to a type of sheet metal made from low-carbon steel. It is a versatile material used in a variety of applications due to its strength, formability, and affordability. Here are some key features and common uses of MS sheet metal:
 Oxygen Sensor	An oxygen sensor, also known as an O2 sensor, is a critical component of a vehicle's emissions control system. It is located in the exhaust system and measures the amount of oxygen in the exhaust gases. The sensor then sends this information to the engine control unit (ECU), which uses it to adjust the air-fuel mixture to achieve the optimal ratio for combustion
 Carbon Gas Sensor	A carbon dioxide (CO2) sensor is a device that is used to measure the concentration of carbon dioxide gas in the air. These sensors are commonly used in indoor air quality monitoring systems, HVAC systems, and other applications where monitoring and controlling CO2 levels is important. Here's how a CO2 sensor typically works and its key features:

Arduino Nano Microcontroller

The Arduino Nano is a small, versatile, and easy-to-use microcontroller board based on the ATmega328P microcontroller. It is part of the Arduino family of boards and is designed for projects that require a compact and low-cost solution. Here are some key features and specifications of the Arduino Nano:

A 2x16 line LCD display is a type of liquid crystal display (LCD) module that can display 2 lines of text, with each line capable of displaying up to 16 characters. These displays are commonly used in embedded systems, such as microcontroller-based projects, to provide visual feedback and information to the user. Here are some key features and specifications of a 2x16 line LCD display:

5.2. Circuit diagram

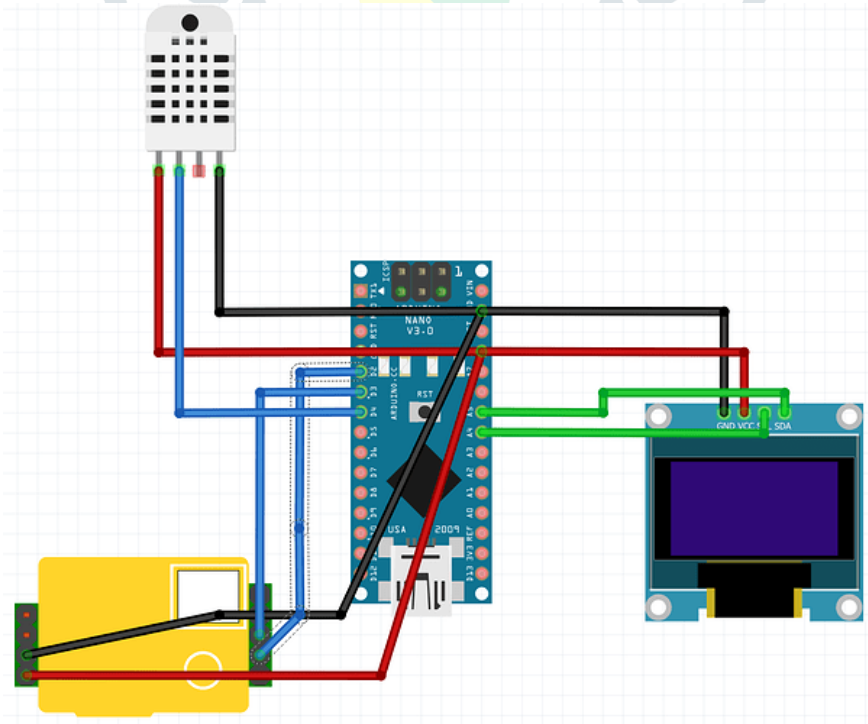

Fig.5.1. Circuit Diagram

4.3. 5.3. Observation and result

Before the Application of Catalytic Converter

Carbon dioxide = 37 %

Oxygen = 3%

After the Application of Catalytic Converter

Carbon dioxide = 17 %

Oxygen = 4 %

The carbon dioxide percentage is reduced by 20 % and the oxygen percentage is increase by 1%

5.4. Costing

Sr. No	Material	Rate (Rs)	Qty	Price (Rs)
1	Cylinder	1200	1	400
2	Pipes	50	1	50
3	Filter	200	1	200
4	Aluminum Oxide	1200	1	1200
5	Aluminum Coating	200	1	200
6	Micro Controller	900	1	900
7	Oxygen Sensor	450	1	450
8	Carbon Dioxide Sensor	450	1	450
9	PCB Circuit	350	1	350
10	Cables	120	1	120
11	Sheet Metal	90	1	90
12	Nut Bolt	10	10	100
13	Display	630	1	630
14	Hoses	120	1	120
15	Colour	200	1	200
16	Miscellaneous	3000	-	3000
Total				**9350**

6. ADVANTAGES , DISADVANTAGES AND CONCLUSION.

6.1. Advantages

1. Efficient Emissions Reduction
2. Compliance with Emissions Standards
3. Improved Air Quality
4. Enhanced Engine Performance

6.2. Disadvantages

Cost

Durability

6.3. Conclusion

A three-way catalytic converter (TWC) is an emission control device used in automobiles to reduce the toxicity of exhaust gases. It is a key component of the vehicle's exhaust system and works by converting harmful pollutants into less harmful substances through a chemical reaction.

The TWC operates in three stages: reduction, oxidation, and storage. In the reduction stage, nitrogen oxides (NOx) are reduced to nitrogen (N2) and oxygen (O2) through a reaction with carbon monoxide (CO). In the oxidation stage, unburned hydrocarbons (HC) and carbon monoxide are oxidized to carbon dioxide (CO2) and water (H2O). In the storage stage, oxygen compounds are stored on the catalyst surface until oxygen is available for oxidation.

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