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Design and Fabrication of Three-Way Catalytic Converter by using Al_2O_3 and SiO_2 Coating as aCatalyst and Access of Emission Characteristics in C.I. Engine

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Abstract—Catalytic converter is basically a device which is used to convert toxic harmful gases into less harmful gases from the exhaust of a automobile. Without this device, toxic gases which are emitted from the exhaust of an automobile can't be converted to less toxic gases. An existing and catalytic converter which is present currently in the market uses catalyst of Platinum group such as Palladium, Platinum and Rhodium which are highly expensive catalyst. Therefore, to improve the durability and to reduce the cost of the catalytic converter, we are replacing the coating of catalyst by Aluminium Oxide and Silicon Dioxide which have high thermal stability, durability and are available are cheaper rates. This project focuses on the methodology involved in the fabrication of new catalytic converter and analysing the emission rates of toxic gases like Nitrogen Oxides, Carbon Monoxide and hydrocarbons. The Silicon Dioxide coated converter reduces the NOx and CO emission and the Aluminium Oxide coated converter reduces the CO and HC emission. The nitrogen oxide gases have been reduced 20.38% at maximum load and 55.2% at minimum load using Silicon dioxide coated convertor. The hydrocarbon emission has been reduced up to 88.8% at maximum load and 80% at minimum load. CO emissions were reduced by 75% and 80% at maximum and minimum loads in both the converters.

Key word- Biodiesel, catalytic converter, Aluminum Oxide and Silicon Dioxide and Emission Characteristics

I. INTRODUCTION

Engine that are traditional are meeting tremendous situation with the exothermal combustion process in the cylinder as they emit high unburned hydrocarbon and carbon monoxide emissions. The Nitrogen oxides emission increases or decreases, and it is strongly combined with high combustion temperature that mainly depends on AirFuel ratio and fuel injection system. Therefore, the harmful toxic gases from the exhaust of an engine can be minimized by thermal or by a catalytic system.

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Temperatures which are regarded as very high for homogeneous exothermal oxidation can be produced by spark plug and insulation of the exhaust ports and manifold. The minimization of fuel utilization and the decrease of emanations have been two main thrusts for motor improvement all through the most recent decades. The main goal is in the money related enthusiasm of the vehicle proprietors. The second is forced by enactment, now and again likewise upheld by extract decreases or clients' requests for clean motors.

An exhaust system is a gadget used to decrease the poisonous quality of discharges from an inner burning motor. Exhaust systems, fit in arrangement with the fumes pipe of gas powered vehicles, change over 90% of HC, CO and NOx from the motor into less unsafe CO_2, NOx from the motor into less hurtful CO_2, nitrogen and water vapor, since exhaust systems were first fit to autos in 1974, in excess of 12 billion tons of destructive fumes gases have been kept from entering the world's environment. In excess of 96% of Automobiles fabricated today are outfitted with catalysts. An exhaust system is a gadget used to decrease the fumes contamination gases from an inward ignition motor.

II. METHODOLOGY

Procurement of raw material Cutting of catalytic converter

Impurities removalWire meshPreparations of chemical coatingCoating of wire meshHeatingDrilling Arrangement of wire meshWelding and Painting

III. PROCEDURE

A. Procurement of Raw Materials:

- CATALYTIC CONVERTER: At first, a three-way catalytic converter was bought using TATA INDICA converter from the market.
- CHEMICALS: Secondly, chemicals that are needed to coat the catalyst were bought from the market. They are Aluminium Oxide (Al_2O_3) and Silicon dioxide (SiO_2).
- WIRE MESH: Thirdly, wire mesh was purchased to replace the existing catalysts which were located in the existing catalytic converter.
- KEROSENE: Kerosene was used a cleansing agent, so that the wire mesh and other components can be cleaned using kerosene solution.

B. Cutting of Catalytic Converter:

The catalytic converter was cut into two halves so that the existing catalyst can be removed from the converter and the wire mesh can be fitted inside the converter again and so that tests can be carried out.

Figure 1: Existing Catalytic Converter

The catalyst inside was checked for impurities and other defects. It was found that there was burnt content inside the catalyst.

Then, the dimensions of the catalyst were measured so as to produce the same exact wire mesh replica of the existing catalyst. It was found that the dimensions were (16.2X 8.1) Length and Height respectively.

C. Impurities Removal

The impurities from the catalyst were removed by dipping the entire catalyst into kerosene. This process continued for more than 24 hours so that the impurities can be easily removed.

Later the catalyst was taken outside and checked whether the catalyst underwent reactions with kerosene. Then, the catalyst was kept in atmospheric conditions for 48 hours. After this process, the impurities were removed by burning the catalyst for 5-10 minutes and the unburnt carbon were separated from the catalyst.

After removing impurities, excess kerosene and impurities were removed using compressor. The air was blown inside the catalyst so that kerosene is completely removed.

D. WIRE MESH

The purchased wire mesh was checked for any impurities and defects. It was found that the wire mesh had grease, oil and dirt impurities. To remove these impurities the wire mesh has to be immersed in hot water. Before immersing, the entire wire mesh sheet was cut into rectangular template as per the existing catalyst diameter**.**

According to the dimensions, approximately 350 rectangular templates were cut from the bought wire mesh and this process was carried out using wire mesh cutter. After making circular templates, the templates were dissolved in hot water for more than 2 hours.

After dissolving process, the template was checked and inspected for further impurities and it was found that no impurities like oil or grease prevailed. Later, the wire mesh was dried at room temperature and kept aside for two days.

E. PREPARATIONS OF CHEMICAL COATING

- *SILICON DIOXIDE SLURRY:*

- 250 grams of Silicon dioxide was mixed with epoxy resin and then dipped into the wire mesh as required. Epoxy resin was used with Silicon dioxide since the solution acts as an adhesive or as a binding agent.
- Without using adhesive, it is impossible for a chemical to remain attached to the catalyst surface and without attachment of chemicals, the main principle of the converter would not be accomplished.
- Then it is kept outside for 12hours to dry completely.

- *Aluminium Oxide:*

- After preparing the Silicon dioxide, to prepare aluminium oxide, 100 grams of aluminium oxide powder was added to the epoxy resin gradually.
- Then, mixing aluminum oxide with the resin and the coating is made by dipping into it.
- Therefore, approximately for adding 100 grams in total, it will take 1 hour for mixing Aluminium oxide.
- After this process completed, the whole solution mix was kept at room temperature for 24 hours to check for any inconsistency in the prepared solution.

F. HEATING

- After coating process, the circular wire mesh templates were kept in muffle furnace for more than 3 hours in muffle furnace.
- This process ensures that the wire mesh is heated at 50oC for 3 hours constantly inside muffle furnace.
- This heating process ensures the removal of hydrates, carbonates or other unwanted components are decomposed and volatile materials are expelled due to heating at high temperature constantly in muffle furnace.

G. DRILLING

- Entire lot of wire mesh was arranged linearly and centre of each mesh were marked exactly so that the centre can be used for drilling purposes.
- Then the wire mesh was drilled at the centre using 6mm drill bit .After drilling, the entire mesh was arranged using 6mm bolt headed screw.
- Lastly, the wire mesh was arranged according to the dimensions of the existing catalyst and was closed using nut and washer.

H. ARRANGEMENT OF WIRE MESH

The mesh was arranged according to the dimensions of the existing catalytic converter and was checked for errors in dimension calculations.

Figure.2: Arrangement of Wire Mesh

I. WELDING

- The existing catalyst was replaced by the newly arranged wire mesh and was kept inside the catalytic converter and checked for any irregular spaces left for air flow and was found to be no spaces left.
- After checking for errors, the other half of the converter was welded with its half and it was done very carefully so that the high temperature of welding process doesn't affect the wire mesh inside.

J. PAINTING

- After the fabrication of the catalytic converter, it is very important to paint the converter to prevent further rusting and loss of metal due to exposure to atmospheric conditions.
- Spray painting was used to paint the converters, first a base coat was sprayed then another coating was sprayed. It was done in order to protect the welds.
- After spray painting it was kept for drying for 2 hours in the daylight.
- Therefore, the catalytic converter was painted black and the inlet and outlet flanges were painted in red for differentiation purposes.

IV. RESULTS

The main principle of this project is to reduce the harmful gases that are emitted from many applications of engines. This chapter focuses mainly on the results that are obtained from the tests conducted using our fabricated catalytic converter.

A. CO TEST RESULTS

- **WITHOUT CATALYTIC CONVERTOR**

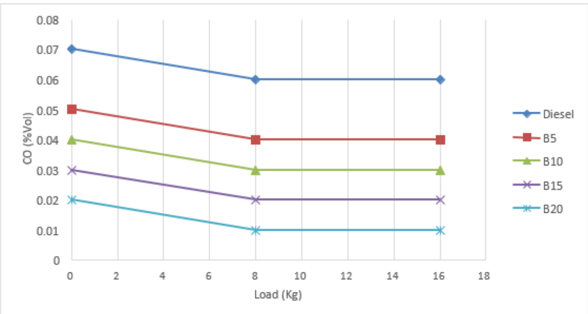


Figure.3:CO Results without Catalytic Convertor

Table-I: CO Emission without Catalytic Converter at Different Loads

LOAD(Kg) / BLEND	0	8	16
Diesel	0.07	0.06	0.06
B5	0.05	0.04	0.04
B10	0.04	0.03	0.03
B15	0.03	0.02	0.02
B20	0.02	0.01	0.01

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, CO emission has been reduced by 33.33%, 50%, 66.66% and 83.33% with B5, B10, B15 and B20 respectively when there is no catalytic converter when compared with Diesel.
- It can be observed from the graphs that at the minimum load, CO emission has been reduced to 28.57%, 42.85%, 57.14% and 71.42% with B5, B10, B15 and B20 respectively when there is no catalytic converter when compared with Diesel.

- *CATALYTIC CONVERTER WITH Al_2O_3 COATING*

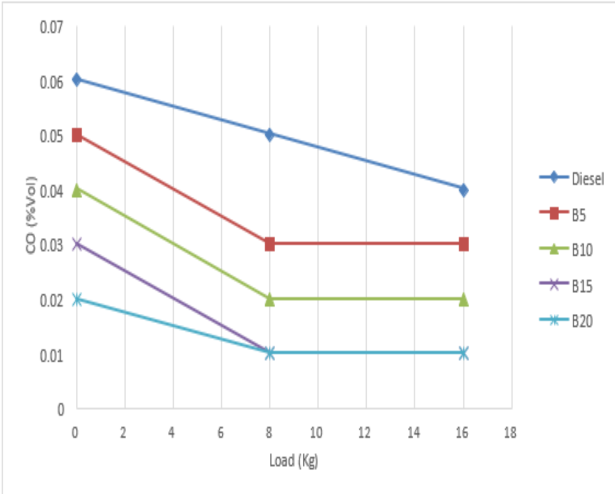


Figure.4:Catalytic Converter with Al_2O_3coating

Table-II: CO Emission with Catalytic Converter (Al_2O_3 coating)

LOAD(Kg) / BLEND	0	8	16
Diesel	0.06	0.05	0.04
B5	0.05	0.03	0.03
B10	0.04	0.02	0.02
B15	0.03	0.01	0.01
B20	0.02	0.01	0.01

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, CO emission has been reduced by 25%, 50%, 75% and 75% with B5, B10, B15 and B20 respectively in the case of Al2O3 coating when compared with Diesel.
- It can be also observed from the graphs that at the minimum load, CO emission has been reduced by 20%, 40%, 60% and 80% with B5, B10, B15 and B20 in the case of Al2O3 coating when compared to Diesel.

- *CATALYTIC CONVERTER WITH SiO2 COATING*

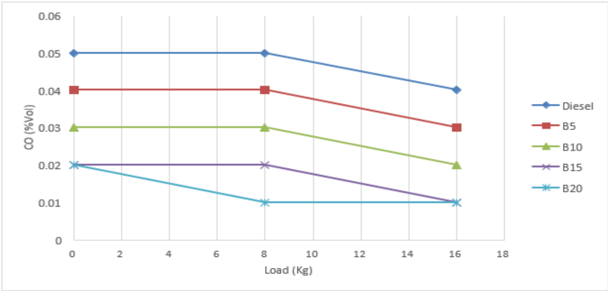


Figure.5: Catalytic Converter with SiO_2 coating

Table-III: CO Emission with Catalytic Converter (SiO_2 Coating)

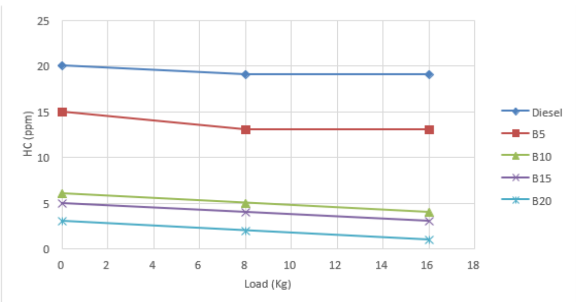
LOAD(Kg) / BLEND	0	8	16
Diesel	0.05	0.05	0.04
B5	0.04	0.04	0.03
B10	0.03	0.03	0.02
B15	0.02	0.02	0.01
B20	0.02	0.01	0.01

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, CO emission has been reduced to 25%, 50%, 75% and 75% with B5, B10, B15 and B20 respectively in the case of SiO2 coating when compared with Diesel.
- It can be also observed from the graphs that at the minimum load, CO emission has been reduced to 20%, 40%, 60% and 80% with B5, B10, B15 and B20 in the case of SiO2 coating when compared with Diesel

B. HC EMISSION

Hydrocarbons which are considered to be an undesirable product of exhaust emission needs to reduced at any cost. Hydrocarbons are formed more likely how carbon monoxide is formed. It is mainly formed due to incomplete combustion reaction inside the engine and this incomplete combustion leads to formation of hydrocarbons.



- *WITHOUT CATALYTIC CONVERTER.*

Figure.6:HC Emission without catalytic convertor

Table-IV: HC Emission without Catalytic Converter

LOAD(Kg) / BLEND	0	8	16
Diesel	20	19	19
B5	15	13	13
B10	6	5	4
B15	5	4	3
B20	3	2	1

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, HC emission has been reduced by 31.57%, 78.94%, 84.21% and 94.73% with B5, B10, B15 and B20 respectively when there is no catalytic converter when compared with Diesel.
- It can be observed from the graphs that at the minimum load, HC emission has been reduced by 25%, 70%, 75% and 85% with B5, B10, B15 and B20 respectively.

- *CATALYTIC CONVERTER WITH Al2O3 COATING*

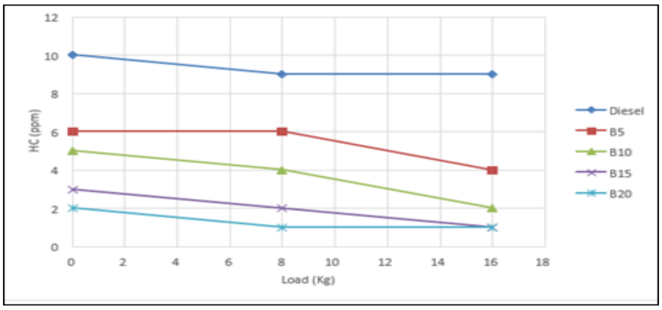


Figure.7:HC Emission- Catalytic Converter with Al_2O_3 coating

Table-V:HC Emission with Al_2O_3

LOAD(Kg) / BLEND	0	8	16
Diesel	10	9	9
B5	6	6	4
B10	5	4	2
B15	2	2	1
B20	2	1	1

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, HC emission has been reduced by 55.55%, 77.77%, 88.88% and 88.88% with B5, B10, B15 and B20 in the case of Al2O3 coating when compared with Diesel.
- It can be also observed from the graphs that at the minimum load, HC emission has been reduced by 40%, 50%, 80% and 80% with B5, B10, B15 and B20 respectively in the case of Al2O3 coating when compared with Diesel.

- *CATALYTIC CONVERTER WITH SiO2 COATING*

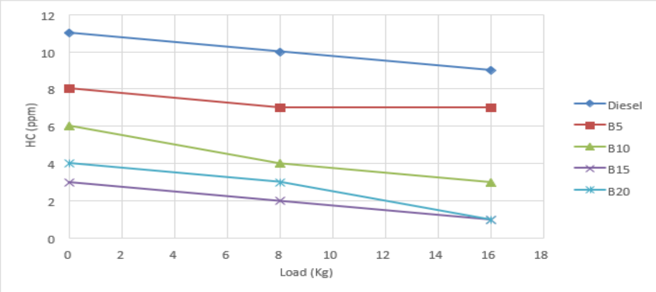


Figure.8:HC Emission- Catalytic Converter with SiO_2 coating

Table-VI: HC Emission with Catalytic Converter (SiO_2Coating)

LOAD(Kg) / BLEND	0	8	16
Diesel	11	10	9
B5	8	7	7
B10	6	4	3
B15	4	2	1
B20	3	3	1

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, HC emission has been reduced by 22.22%, 66.66%, 88.88% and 88.88% with B5, B10, B15 and B20 of SiO2 coating when compared with Diesel.
- It can be also observed from the graphs that at the minimum load, HC emission has been reduced by 27.27%, 45.45%, 63.63% and 72.72% with B5, B10, B15 and B20 respectively in the case of SiO2 coating when compared with Diesel.

D. NOx EMISSION

Oxides of nitrogen (NOx) are formed as the byproduct of combustion and also regarded as the most harmful gas than carbon monoxide and hydrocarbons. Nitrogen oxides are formed due to the conversion of nitrogen and oxygen that is present during combustion to their respective oxides and the combination or reaction between these two gasses.

- *WITHOUT CATALYTIC CONVERTOR*

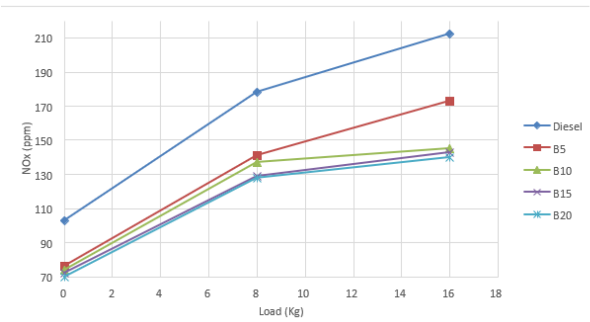


Figure.9: NOx Emission without catalytic convertor

Table-VII: NOx Emission without Catalytic Converter.

LOAD(Kg) / BLEND	0	8	16
Diesel	103	178	212
B5	76	141	173
B10	74	137	145
B15	72	129	143
B20	70	128	140

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, NOx emission has been reduced by 18.39%, 31.6%, 32.54% and 33.96% with B5, B10, B15 and B20 respectively when there is no catalytic converter when compared with Diesel.

- *Catalytic Convertor with Al2O3 coating.*

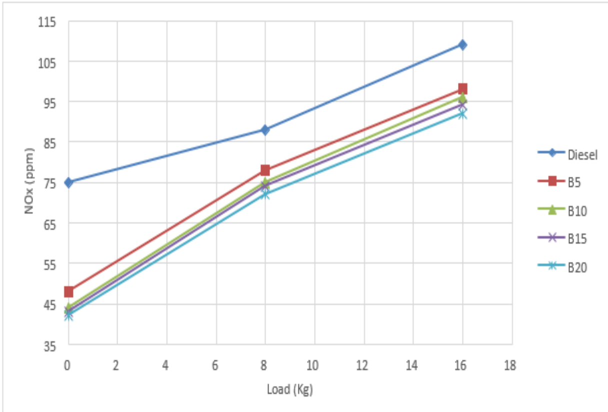


Figure.10: NOx Emission with Al_2O_3 coating.

Table-VIII: NOx Emission with Al_2O_3 coating.

LOAD(Kg) / BLEND	0	8	16
Diesel	103	178	212
B5	76	141	173
B10	74	137	145
B15	72	129	143
B20	70	128	140

- *INFERENCE*

- It can be observed from the graphs that at the maximum load, NOx emission has been reduced by 10.09%, 11.92%, 13.76% and 15.59% with B5, B10, B15 and B20 respectively in the case of Al2O3 coating when compared with Diesel.

- **Catalytic Convertor with SiO2 coating**

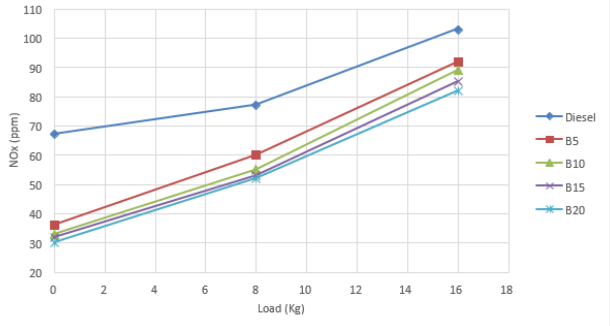


Figure.11: NOx Emission with SiO_2coating

Table-IX: NOx Emission with SiO_2 coating.

LOAD(Kg) / BLEND	0	8	16
Diesel	67	77	103
B5	36	60	92
B10	33	55	89
B15	32	53	85
B20	30	52	82

- *INFERENCE*

• It can be observed from the graphs that at the maximum load, NOx emission has been reduced by 10.67%, 13.59%, 17.47% and 20.38% with B5, B10, B15 and B20 respectively in the case of SiO2 coating when compared with Diesel.

• It can be also observed from the graphs that at the minimum load, NOx emission has been reduced by 46.26%, 50.74%, 52.23% and 55.22% with B5, B10, B15 and B20 respectively in the case of SiO2 coating when compared with Diesel.

E. SMOKE DENSITY

Smoke density is the measure of amount of gas that has been released by the engine and this density if it is low it is considered to good and if the density value is high it means that amount of smoke that has been released is too high. Now, let us consider the two-emission graph and consolidate how much have been reduced due to the influence of catalytic converter.

- *Without Catalytic Convertor*

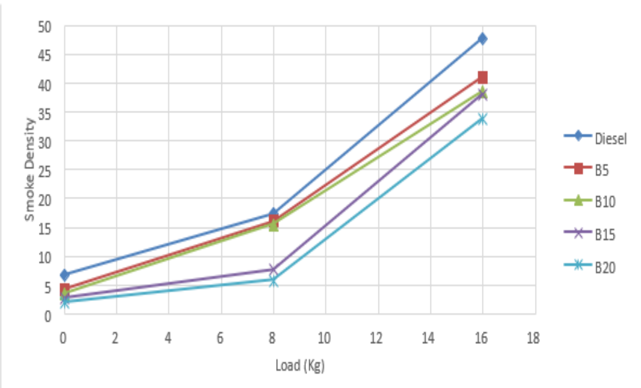


Figure.12: Smoke Density without Catalytic Convertor

Table-X: Smoke Density without Catalytic Convertor.

LOAD(Kg) / BLEND	0	8	16
Diesel	6.8	17.3	47.6
B5	4.3	16	41
B10	3.4	15.5	38.5
B15	2.7	7.6	38.1
B20	1.9	5.8	33.8

- *INFERENCE*

• It can be observed from the graphs that at the minimum load, Smoke density has been reduced by 36.76%, 50%, 60.29% and 72.05% with B5, B10, B15 and B20 respectively when there is no catalytic converter when compared with Diesel.

- *With Al2O3 coating*

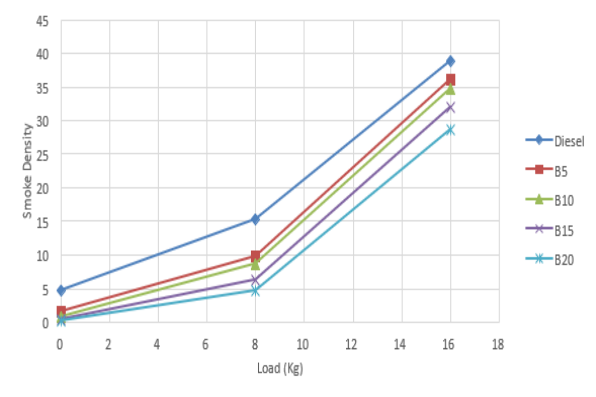


Figure.13: Smoke Density with Al_2O_3coating

Table-XI: Smoke Density with Al_2O_3 coating.

LOAD(Kg) / BLEND	0	8	16
Diesel	4.7	15.3	38.9
B5	1.6	9.8	36
B10	0.8	8.7	34.7
B15	0.3	6.2	31.9
B20	0.2	4.7	28.7

- *INFERENCE*

• It can be observed from the graphs that at the maximum load, Smoke density has been reduced by 7.45%, 10.79%, 17.99% and 26.22% with B5, B10, B15 and B20 respectively in the case of Al2O3 coating when compared with Diesel.

- *With SiO2 coating*

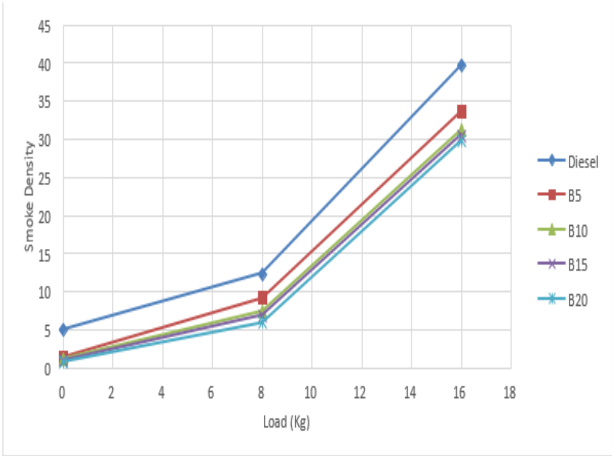


Figure.12 Smoke Density with SiO_2 coating

Table-XII: Smoke Density with SiO_2 coating.

BLEND \ LOAD(Kg)	0	8	16
Diesel	4.9	12.3	39.6
B5	1.4	9.1	33.6
B10	1.2	7.4	33.1
B15	0.9	6.8	30.5
B20	0.8	5.9	29.8

- *INFERENCE*

• It can be observed from the graphs that at the maximum load, Smoke density has been reduced by 15.15%, 16.41%, 22.97% and 24.74% with B5, B10, B15 and B20 respectively in the case of SiO2 coating when compared with Diesel.

F.XRD Report

- *Silicon Dioxide*

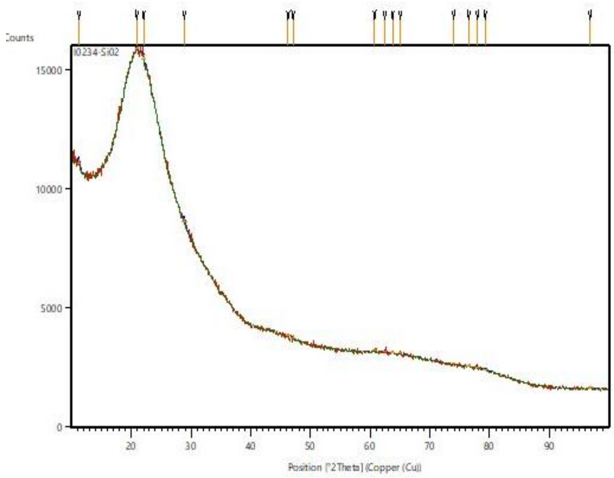


Figure.13: XRD Graphic of SiO_2

- *Aluminium Oxide*

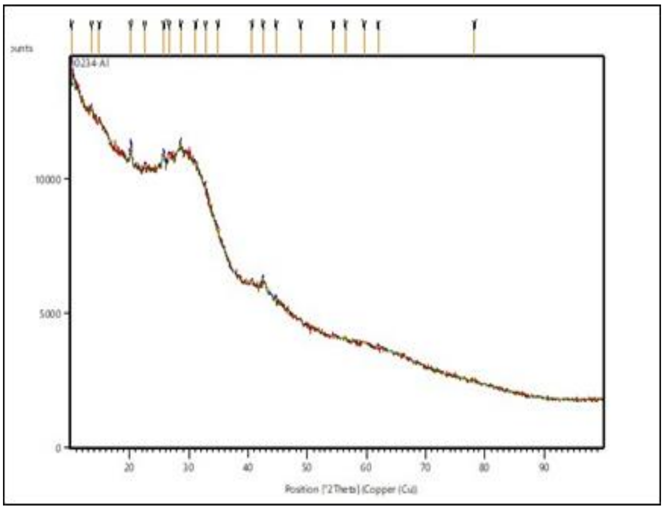


Figure.14 XRD Graphic of Al_2O_3

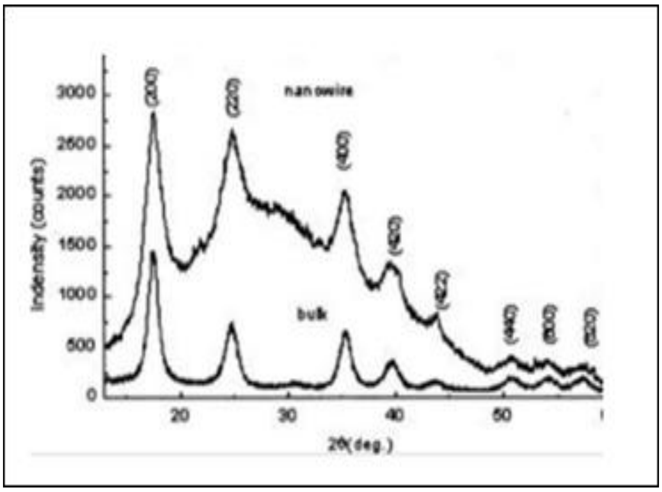


Figure.14 :Graphic of pure Aluminium Oxide

V. CONCLUSION

The main aim of our project has been successfully completed using our newly fabricated catalytic converter with the replacement of Coating by Silicon Dioxide and Aluminium Oxide.

• Firstly, the most important toxic gas Nitrogen Oxides (NOx) have been reduced up to 20.38% at maximum load and up to 55.22% at minimum load by fitting Silicon Dioxide coated catalytic converter.

• Secondly, the Carbon Monoxide (CO) gas which is a by-product of a incomplete combustion reaction has been reduced up to 75% at maximum load and up to 80% at minimum load after fitting our Aluminium Oxide and Silicon Dioxide coated catalytic converter.

• Thirdly, the Hydrocarbons (HC) which is again a by-product of a incomplete combustion reaction has been reduced up to 88.88% at maximum load and up to 80% at minimum load by fitting Aluminium Oxide coated catalytic converter.

The Silicon Dioxide coated converter reduces the NOx and CO emission and the Aluminium Oxide coated converter reduces the CO and HC emission.

- Finally, we would like to conclude that our project aim has been accomplished successfully and would try to improve our standards of our project in future.

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