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Emissions analysis in multi-cylinder SI Engine using metal oxide coated meshes as catalytic converter

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Abstract - *Internal combustion engines generate undesirable emissions during the combustion process. The emissions exhausted into the surroundings pollute the atmosphere and harmful to human beings. The emissions are CO, HC, NO_X, CO_2 etc… In the present investigation, an attempt has been made to control the by using metal oxide coated meshes as the catalytic converter. The phase of work is after treatment process in which different types of low cost catalytic converters are used to reduce the emissions of CO, CO_2, HC and NO_x by keeping the low cost catalytic converter in the form of coating in the mesh in the exhaust manifold. The results obtained from the experiments using the coated meshes as the catalytic converter were analyzed. The emission control achieved by adopting this technique was found effective.*

Key Words: Multi-cylinder, SI Engine, Catalytic converter, Mesh coated with Magnesium oxide, Copper Oxide and Cobalt oxide.

1. INTRODUCTION

Success of any modern technology is decided by the utilization of society harmless to human beings. In the automobile industry, Engines are the backbone classified into two major categories viz. 1.Internal combustion engine and 2.External combustion engine. In Internal Combustion (IC) Engines, combustion takes place inside the engine, whereas in External Combustion (EC) Engines combustion takes place outside the engine. Among the various types of engines, the most used engines are reciprocating IC engines. Higher thermal efficiency can be obtained with moderate working pressure of the fluid therefore the weight to power ratio is less in IC engines. Catalytic converter is an exhaust emission control device that converts toxic gases and pollutants in exhaust gas from a spark ignition engines to less toxic pollutants by catalyzing a redox reaction. Catalytic converters are used with internal combustion engines fuelled by either petrol or diesel including lean-burn engines as well as kerosene heaters and stoves. The performance analyses of spark ignition engines were carried out at exhaust treatment with catalytic converter and it has been reported that the catalytic converters can be designed with the composite structure of Copper Oxide (CuO) and Aluminum Hydroxide (AlOH).

2. EXPERIMENTAL SETUP

Five gas analyzers were used for the measurement of HC, CO, NO_X and CO_2. Experiments were initially carried out on the engine in order to provide base line data. The engine was stabilized before taking all measurements subsequently. The experiments were repeated by keeping different catalyst coated filter in the exhaust. A multi cylinder Four Stroke Petrol Engine was used. Engine details are given in Table-1.

Table -1: Engine Specification

Parameter	Details
Engine	Four-Stroke Multi cylinder SI Engine
Make	Premier Automobile Limited, India
Rated power	7.5 kW
Maximum speed	4500rpm
Bore diameter	68mm
Stroke	75mm
Displacement volume	1089cc
Compression ratio	7.3:1
Number of cylinders	Four
Cycle	Four
Cooling	Water
Lubrication	Forced Lubrication
Starting system	Battery Ignition System

The experimental set up is shown in Fig 1.

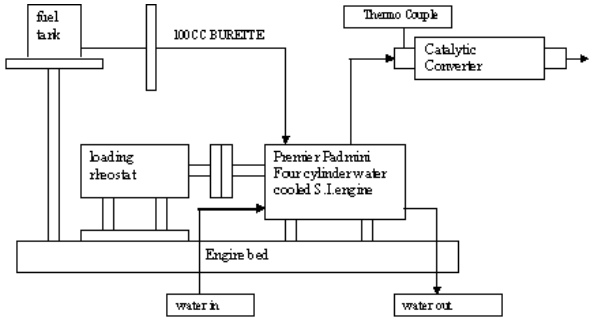


Fig 1: Layout of Test Engine

An electrical Dynamometer is used for loading the engine, the specification which is shown in table-2.

Table -1: Alternator Specification

Parameter	Details
Loading device	Electrical
Rated power	7kW
Rater speed	1500rpm

3. Methods and Materials

In multi-cylinder SI engine, the engine was run at a constant speed of 1400 rpm. Then the emission characteristics for various loads were measured using the exhaust-gas analyser. These emission values are used as the base-line data for comparing the emission control efficiencies of the metal oxide coated catalytic converters. Then, the wire-meshes coated with different metal-oxides were introduced in the exhaust-line of the engine and the emission characteristics were measured for different load conditions. Schematic diagram of the Test Engine with Catalytic Coated Filters are shown in Fig 2 and Fig 3.

Fig 2: Test Engine

Fig3: Catalytic Coated Filter

3.1 Coating of metal-oxides over the mesh

Three types of metal oxide coated catalytic converters and three combinations of three catalytic converters were used for the purpose of the experiment. For coating the metal-oxides, the HINDHIVAC Vacuum Coater was used. It consists of a cabinet containing a vacuum pumping system together with all electrical components necessary for the coating process.

Fig 4: Coated meshes

Metal oxides selected included magnesium oxide, copper oxide and cobalt oxide on the basis of economic considerations.

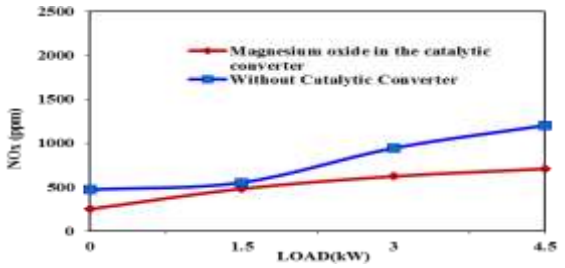
3.2 Exhaust Gas Analyser

Measurement was done with the help of Automatic Emission Analyser QRO – 402. The analyser is configured to perform a measurement by applying non-dispersive infrared (NDIR) method for analysing CO, HC and CO_2 and electro-chemical method for analysing NO_2 and O_2. In NDIR analysing method, an infrared flashing lamp is attached at one end of the sample cell and a detecting sensor at the other end, so that it can detect the component of gas and in turn its density.

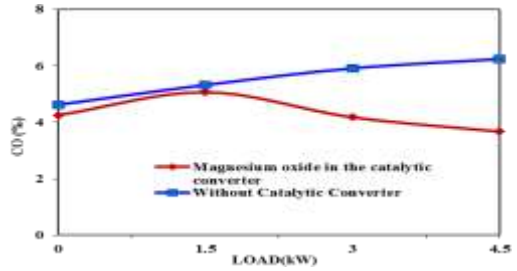
4 Results and Discussion

4.1 Emission after using Magnesium Oxide as the catalytic converter:

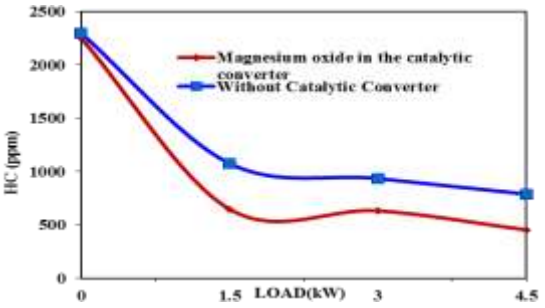
The variation in emission of NO_X, CO_2, HC and CO when Magnesium Oxide coated catalytic filter used in the exhaust line, is presented in Graphs 1, 2, 3 and 4 respectively. The maximum of the percentage reduction of each pollutant is shown in table 3.



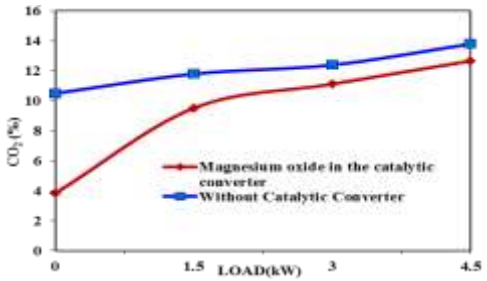
Graph 1



Graph 2



Graph 3



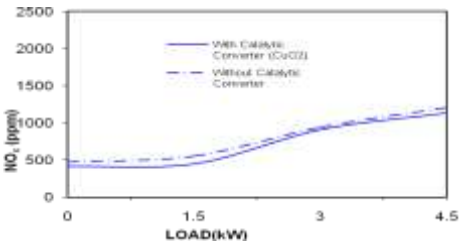
Graph 4

Table 3	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	53.06
CO	43.27
HC	44.55
CO_2	66.66

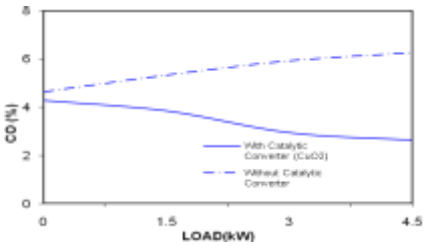
Results obtained from the experiments shows that the Magnesium Oxide coated Catalytic filter effectively controls the emission of NO_X and CO_2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

4.2 Emission after Using Copper Oxide Mesh as the Catalytic Converter

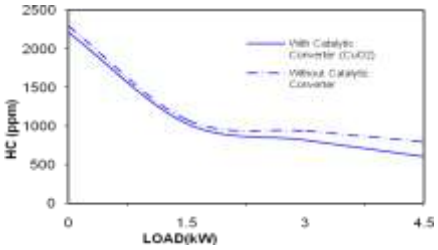
The variation in emission of NO_X, CO_2, HC and CO when Copper Oxide catalytic Mesh used in the exhaust line, is presented in Graphs 5, 6, 7 and 8 respectively. The maximum of the percentage reduction of each pollutant is shown in table 4.



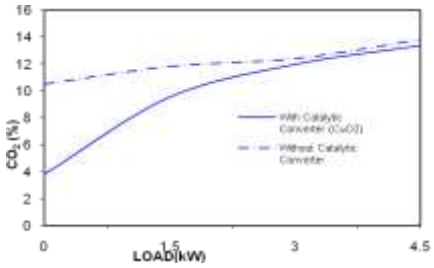
Graph 5



Graph 6



Graph 7



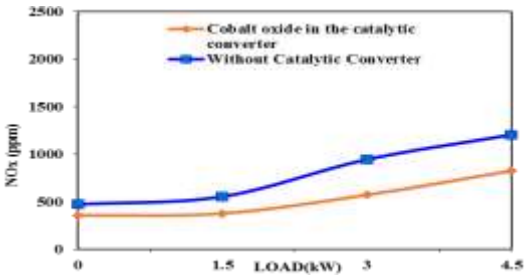
Graph 8

Table 4	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	7.80
CO	6.49
HC	63.79
CO_2	13.33

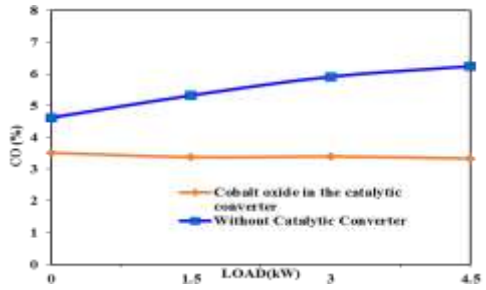
Results obtained from the experiments shows that the Oxidized Copper Mesh filter effectively controls the emission of HC when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

4.3 Emission after using Cobalt Oxide as the catalytic converter

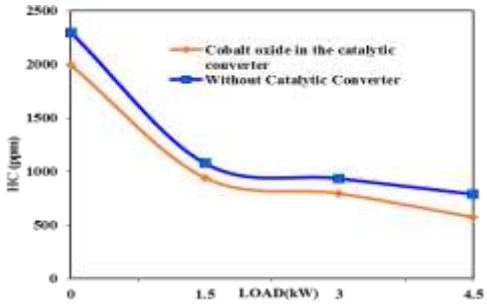
The variation in emission of NO_X, CO_2, HC and CO when Cobalt Oxide coated Catalytic filter used in the exhaust line, is presented in Graphs 9, 10, 11 and 12 respectively. The maximum of the percentage reduction of each pollutant is shown in table 5.



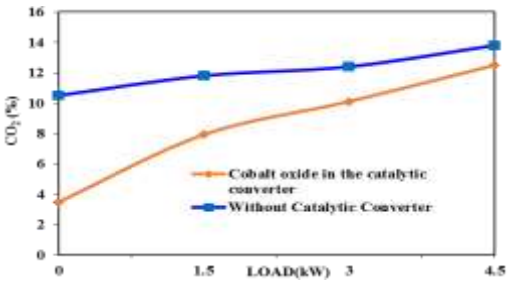
Graph 9



Graph 10



Graph 11



Graph 12

Table 5	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	26.00
CO	63.69
HC	13.16
CO_2	70.19

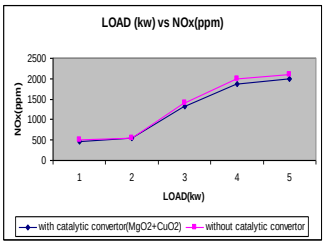
Results obtained from the experiments shows that Cobalt Oxide coated Catalytic filter effectively controls the emission of CO and CO2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

By using the above catalytic converter of Magnesium Oxide coated filter reduces the emission of NO_X by 53.06 percent and Copper Oxide Mesh by 63.79 percent of HC and Cobalt Oxide Catalytic converter reduces the emission of CO and CO_2 by 63.69 and 70.19 percent.

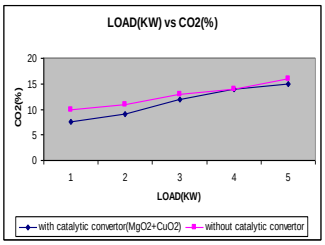
From the results obtained it is found that combinations of these three catalysts are used simultaneously reduce all the pollutants.

4.4 Emission after using the combination of Magnesium Oxide and Copper Oxide Mesh in the catalytic converter

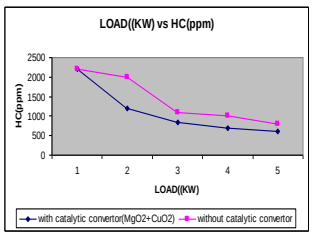
The variation in emission of NO_X, CO_2, HC and CO when Magnesium Oxide and Copper Oxide catalytic Mesh used in the exhaust line, is presented in Graphs 13, 14, 15 and 16 respectively. The maximum of the percentage reduction of each pollutant is shown in table 6.



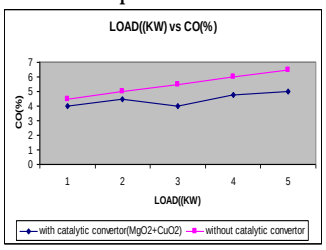
Graph 13



Graph 14



Graph 15



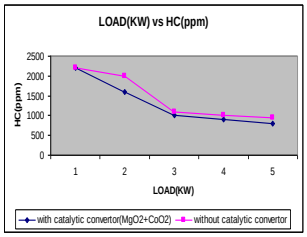
Graph 16

Table 6	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	46.27
CO	37.75
HC	60.90
CO_2	58.66

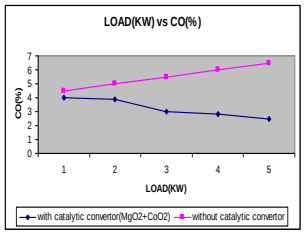
Results obtained from the experiments shows that Magnesium Oxide and Copper Oxide Catalytic Mesh effectively controls the emission of HC and CO_2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

4.5 Emission after using the combination of Magnesium Oxide and Cobalt Oxide in the catalytic converter

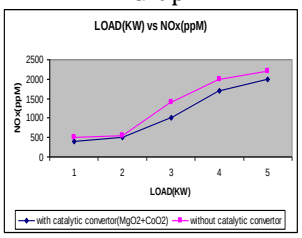
The variation in emission of NO_X, CO_2, HC and CO when Magnesium Oxide and Cobalt Oxide catalytic Mesh used in the exhaust line, is presented in Graphs 17, 18, 19 and 20 respectively. The maximum of the percentage reduction of each pollutant is shown in table 7.



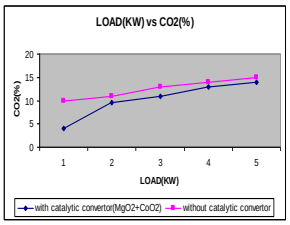
Graph 17



Graph 18



Graph 19



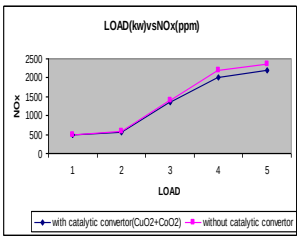
Graph 20

Table 7	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	49.01
CO	60.63
HC	39.84
CO_2	69.66

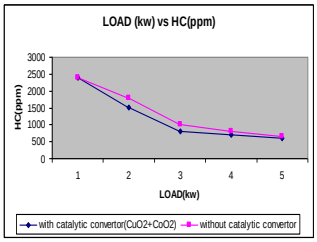
Results obtained from the experiments shows that Magnesium Oxide and Cobalt Oxide Catalytic filter effectively controls the emission of CO and CO_2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

4.6 Emission after using the combination of Copper Oxide Mesh and Cobalt Oxide in the catalytic converter

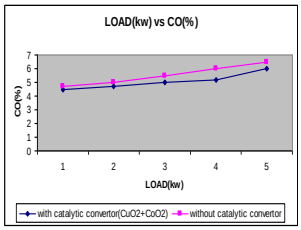
The variation in emission of NO_X, CO_2, HC and CO when Copper Oxide Mesh and Cobalt Oxide catalytic Mesh used in the exhaust line, is presented in Graphs 21, 22, 23 and 24 respectively. The maximum of the percentage reduction of each pollutant is shown in table 8.



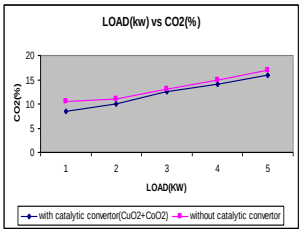
Graph 21



Graph 22



Graph 23



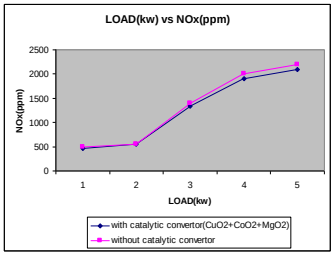
Graph 24

Table 8	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	23.32
CO	55.11
HC	56.19
CO_2	61.67

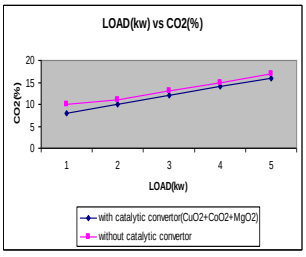
Results obtained from the experiments shows that Copper Oxide Mesh and Cobalt Oxide Catalytic filter effectively controls the emission of HC, CO and CO2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

4.7 Emission after using the combination of Magnesium Oxide, Copper Oxide Mesh and Cobalt Oxide in the catalytic converter

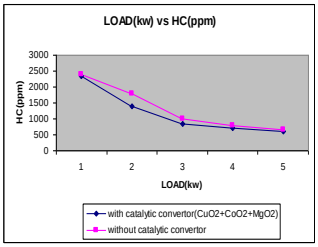
The variation in emission of NOX, CO2, HC and CO when Magnesium Oxide, Copper Oxide Mesh and Cobalt Oxide catalytic Mesh used in the exhaust line, is presented in Graphs 25, 26, 27 and 28 respectively. The maximum of the percentage reduction of each pollutant is shown in table 9.



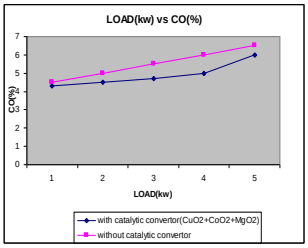
Graph 25



Graph 26



Graph 27



Graph 28

Table 9	
Pollutants	**Maximum Reduction in Percent @ optimum**
NO_X	23.32
CO	55.11
HC	56.19
CO_2	61.67

Results obtained from the experiments shows that Magnesium Oxide, Copper Oxide Mesh and Cobalt Oxide Catalytic filter effectively controls the emission of HC, CO and CO_2 when the engine runs at the optimum load of 4.5 kW also the converter efficiency is more at this optimum load.

5 CONCLUSIONS

Following are the conclusions based on experimental results.

- The use of Magnesium Oxide coated filter reduces the emission of NO_X by 53.06 percent.
- When Oxidized Copper Mesh catalytic filter is used, the maximum reduction of HC emission achieved is 63.79 percent.
- Cobalt Oxide Catalytic coated filter reduces the emission of CO and CO_2 by 63.69 and 70.19 percent.

From the conclusions it is found that the MgO, CuO and CoO were best catalyst to control the emission from the engines. When all these catalyst combination were used, it may yield better results simultaneously in order to reduce the pollutants NO_X, HC, CO and CO_2.

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