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DECREASE THE CARBON MONOXIDE AND UNBURNT HYDROCARBON FROM A TWO STROKE S.I. ENGINE USING A CATALYTIC CONVERTER

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Abstract: It has aimed in this paper to decrease the carbon monoxide and unburnt hydrocarbon from a two stroke S.I. engine using a Catalytic Converter (C.C.). It has been found the content of the carbon monoxide increases in the deal range and decreases with the increase in the speed of the engine. It can be seen that at stoichiometry fuel air mixtures the emission of hydrocarbon (HC) and carbon monoxide (CO) are substantially low. Catalytic reaction of the converter converts HC and CO to carbon dioxide (CO2) and water (H2O) through a simple oxidation process. A Catalytic device essentially consists of an active catalyst deposited on a suitable support system through which the engine exhaust is allowed to pass, resulting in the oxidation of CO to CO2. In this paper a palletized ceramic bed using a 13-X Zeolite coated with silver has been employed as the oxidizing agent in the exhaust passage and the changes occurring in the engine performance parameters as well as the reduction in CO & HC emission due to employment of these agents has been of presented. There is marginal improvement in the performance parameters at higher loads with Catalytic Converter. It is observed that the amount of CO & HC has been reduced with the negligible decrement in engine performance. Reduction in CO is a function of bed temperature. Maximum reduction of 78% and 68% of CO is achieved at 3000rpm and 3500rpm respectively at maximum load.

Keywords: Jet Impingement, Dimple Surface, Turbulent Flow

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INTRODUCTION

The Rapid urbanization with its corollaries like industries, I.C. Engines, locomotives etc have increased the level of air pollution to all extent that it is difficult to get pure air for living beings on earth. I.C. Engines generated pollution forms a major share to the present total air pollution. The combustion of fuels leaves behind exhaust products which contain poisonous gases. Hence the pollution control to an acceptable minimum level is absolutely essential for conventional vehicles using fossil fuels.

I.C. Engines consumes large amount of fossil fuels providing a huge amount of gases, exhaust products consisting primarily of CO2, unburnt hydro carbons (UBHC), CO and NOx. The latter three have adverse or serious effect on health. NOx and HC combine to form smog, which affects the plant and animal life.

The presence of CO is a result of incomplete combustion due to insufficient amount of air in the air-fuel mixture or insufficient time for completion combustion. The UBHC emissions are the direct results of incomplete combustion.

Emission from the Gasoline powered vehicles are generally classified as

- Exhaust emission
- Crank case emission
- Evaporative emission

EXHAUST EMISSIONS:

The important emissions from a gasoline engine are CO, NOx and particulate containing lead components. These emissions vary with air-fuel ratio, spark timing and engine operating conditions.

CRANK CASE EMISSIONS:

Crank case emissions consist of engine blow by which leaks from the engine mainly during the compression stroke of the engine and oil vapors generated in the crank case. The quality of blow by depends on the engine design and its operating conditions. Worn out piston rings and cylinder liners lead to a large increase in the engine blow by. The emission from the crank case mainly contains HC and accounts nearly 25% of the total HC emission from a vehicle. This type of emission depends on engine load conditions.

EVAPORATIVE EMISSION:

Evaporative emissions are the result of the fuel characteristics and may be dealt with by changing the properties of gasoline such as changing the volatility of fuel and replacing C4 and C5 olefinic hydrocarbon in the fuel with C4 and C5 parafinic hydrocarbons. Evaporative emissions generally account to about of 20% of total emissions from a vehicle.

METHODS TO CONTROL AUTOMOBILE EXHAUST EMISSIONS

Reduction in emissions can be obtained by renewing pollutants from the exhaust gas in the engine exhaust system. Devices developed to achieve the this includes

1) Catalytic Converters (using Oxidizing catalysts, reducing catalysts).

2) Thermal reactions.

3) Throttling valves at the exhaust port.

4) Traps and filters for particulates.

During 1970's commonly used emission control devices were Exhaust Gas Recirculators (EGR), spark retarding and auxiliary air injection. But these approaches are associated with poor fuel economy and engine performance. With the usage of CC much of the emissions can be controlled without sacrificing the fuel economy and performance of the engine. In the available literature the catalyst element used in the CC are platinum, rhodium and palladium. These elements used are in combination. But the cost of these elements is high due to the use of platinum.

CATALYTIC CONVERTER:

The Catalytic Converters used in spark ignition engines consists of an active catalytic material in a specially designed metal casing, which directs the exhaust gas flow through the catalyst bed. Commonly used active materials are Zeolite, glass wool dipped in copper sulphate, platinum, rhodium etc.

Catalytic Converters are the most effective devices for controlling exhaust emission. Their placement in the exhaust system of vehicles began from the year 1975. Introduced by Cheswick and Wright in U.K., apart from reducing the emissions it also attenuates the sound from the exhaust system. Thus mufflers become lighter. The Catalytic Converter is located ahead of the muffler in the exhaust system. The extreme heat in the converter oxidizes the exhaust emission that flow out of the engine. When the Catalytic Converters were introduced much of the emission control jobs would be taken out of the engine and moved to the exhaust system. This allowed the manufacturers to retune the engine for better performance and fuel economy.

PRINCIPLE OF CATALYTIC CONVERTERS:

A catalyst is a substance that causes increment in the rate of a chemical reaction without actually becoming the part of the chemical reaction, without being consumed in the process. A Catalytic Converter uses a catalyst to cause change in the elements of the waste exhaust gases as they pass through the exhaust system.

Some of the catalyst metals used in Catalytic Converters are platinum, rhodium, Zeolite etc. These rare elements are thinly coated on a substrate supported inside the converter shell. The neutral substance is a ceramic material designed to withstand the high temperature of the exhaust gases and additional heat that is caused by the chemical change of the catalytic reaction. When heat is applied the catalytic process causes the molecules to rearrange themselves into less harmful elements.

Oxidation Process:

The process through which HC and CO are reduced to relatively harmless by products is the reaction taking place in Catalytic Converters and the reaction is oxidation reaction. When the exhaust gases pass through the converter with the oxygen, oxidation takes place, reducing the harmful gases to water and carbon dioxide, which are less harmless parts compared to the other exhaust gases.

Oxidizing Reaction:

$$HC\&CO + heat + O2 \longrightarrow \text{Mild Reaction}$$

$$HC\&CO+O2 \xrightarrow{\text{Ag coated 13-X Zeolite Catalyst - strong rxn}} H2O + CO2$$

DESIGN AND FABRICATION:

The active materials employed for CO and HC oxidation or NO reduction must be distributed over a large surface area so that the mass transfer characteristics between the gas phase and the active catalyst surface are sufficient to allow close to 100% conversion with high catalyst activity. The ability of the catalyst wash coat to be applied to the surface of the ceramic substrate depends on the nature of porosity and large pore size for good adherence. The design and fabrication of the unit is based on the back pressure of the exhaust gases from the engine, which should be minimized with proper muffler design.

Requisites of the unit:

There are fundamental characteristics that a Catalytic Converter should posses in order to obtain higher efficiency of operation and economy of fuel.

1) Short warm up period after a cold start: - The catalyst must reach its working temperature quickly to counter the high level of exhaust HC and CO during the engine warm up.

2) Low Backpressure: - Engine backpressure due to introduction of the converter in the exhaust pipe should be minimized.

3) Versatility of design: - The design should be versatile so as to be adaptable to vehicle space requirements.

4) Vibration resistance: - As it is a solid unit, it should resist attrition, road shocks and vibrations.

5) High thermal and mechanical durability: - The bed structure, the chamber body covering must be designed to withstand as high temperature as possible caused by ignition failures and should have sufficient mechanical strength to withstand daily usage.

6) Low maintenance and simple installation

DESIGN OF BED:

The amount, type and size of catalyst impose limits on the overall design of the oxidation unit (especially the size and pressure drop through the unit). The back pressure is the basic criteria considered for the shape and size of the bed.

Preparation of Bed material:

In order to accomplish the reaction of the catalyst with CO and HC gas a palletized type of bed structure is selected (13-X Zeolite is coated with silver in proportion 10:1). 50gms of Silver Nitrate crystals are mixed with minimum amount of distilled water to make Silver Nitrate solution. 500gms of cylindrical pellets of 13-X Zeolite are then soaked in $AgNO_3$ solution and as the solution is completely absorbed these pellets are dried to remove the moisture. Then the pellets are heated in an electrical furnace to 600oC, to oxidize the nitrate from the alumina surface. A closed conical shaped wire mesh with the base diameter is used to hold the above prepared silver coated 13-X Zeolite.

REQUISITES OF CARRIER:

1. High temperature stability.
2. It should resist attrition.
3. Highly porous.
4. High mechanical strength.

Carrier Specifications (Table1):

1) Sample : 13-X Zeolite.
2) Size and form : 1.5mm or 3.0 diameter, cylindrical pellets
3) Bulk density : 560 kg/m
4) Bed Crushing strength : 90%
5) Equilibrium : 21%

Absorption capacity at 30o C and 15% RH by Wt.

INSTRUMENTATION AND EXPERIMENTATION:

The present work was carried out on a 2-stroke single cylinder air cooled S.I. Engine.

TECHNICAL DETAILS OF THE ENGINE (TABLE 2):

1) Engine type : Single cylinder, 2-stroke petrol engine.
2) Bore : 65mm.
3) Stroke : 75mm.
4) Capacity : 250cc.
5) Compression ratio : 8.2:1.
6) Brake horsepower : 16Hp.

7) Maximum speed : 5000rpm.

8) Cooling system : Air cooled.

9) Carburetor : Jikro.

The experiments were carried out on a two stroke single cylinder, air cooled S.I. Engine. The schematic representation of the test set up is shown in fig 2. The 13-X Zeolite specifications and engine specifications are given in table 1 and table 2 respectively. The tests were conducted in two stages. The engine performance and exhaust gas analysis without CC (muffler only) was made in the first stage while with the same setup with a CC the test was conducted in the second stage.

The engine was loaded by a belt type dynamometer. Fuel flow measurements were carried out by volumetric method. The exhaust gas temperature (EGT) measurements were carried out with the help of dial type thermometer. The air flow was measured by air box. The back pressure was measured by using a U-tube manometer. The exhaust emission measurements were carried out by using standard instruments. The engine was run at gear II, with 25% and 40% throttle valve opening and load varied from zero to maximum in suitable steps. Various measurements such as load , fuel flow , air flow, EGT, exhaust emission and back pressure were measured at each operating point for both conditions (i.e. with and without CC).

Figures and Graphs:

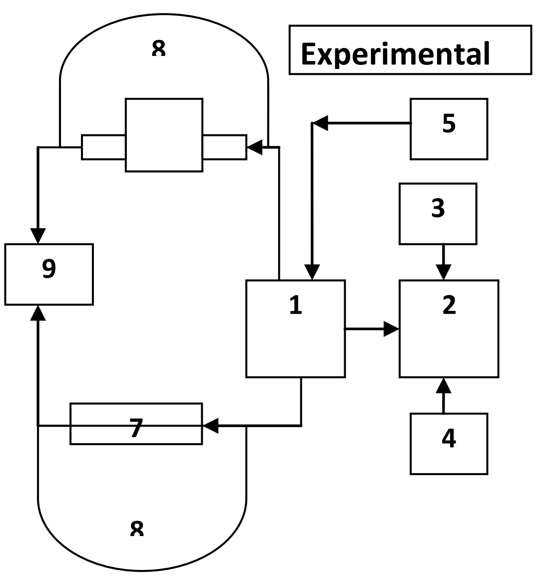

Fig 1. Experimental Setup

PARTS LIST:

1) ENGINE

2) DYNAMOMETER

3) COOLING WATER

4) LOAD CELL

5) FUEL TANK

6) SILENCER WITH C.C.

7) SILENCER WITHOUT C.C.

8) MANOMETER

9) TO EXHAUST GAS ANALYSER

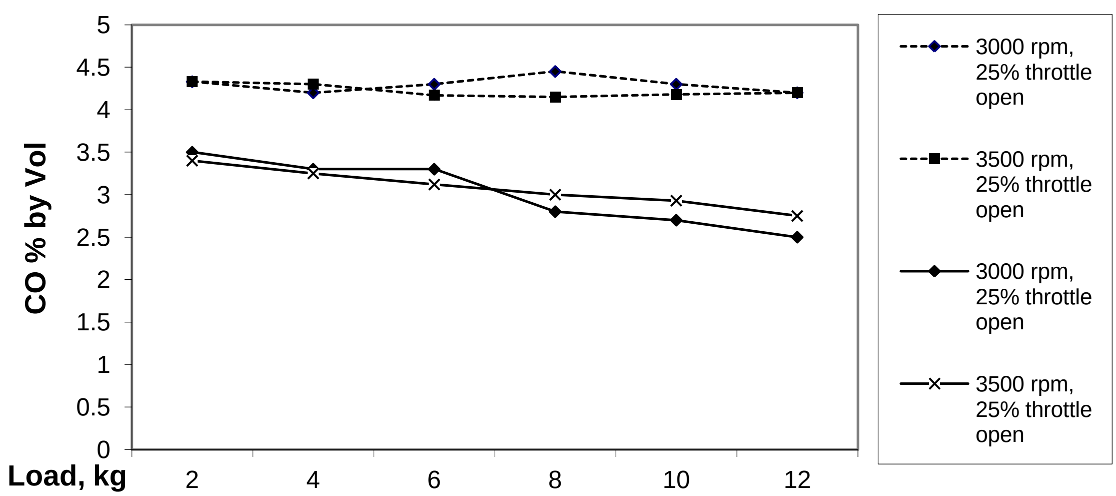

Fig 2. Load vs. CO % by vol

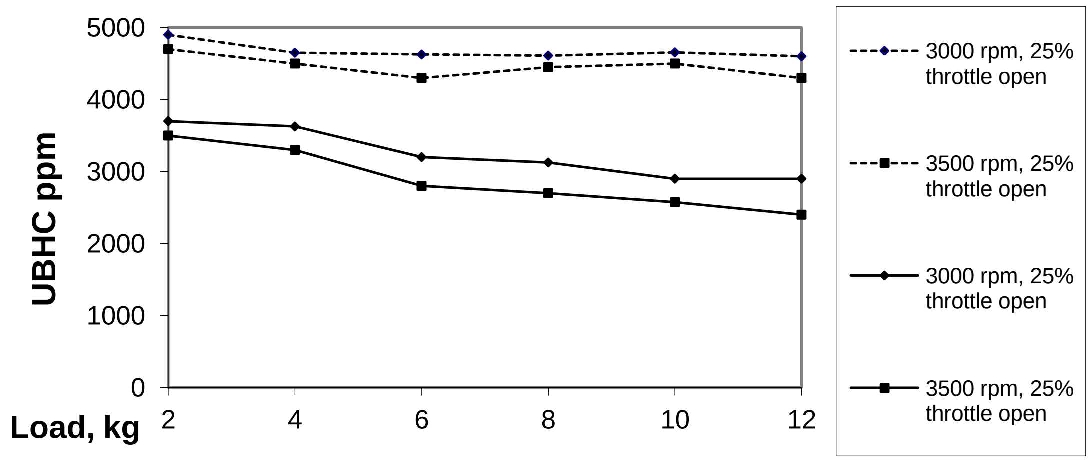

Fig 3. Load vs. UBHC

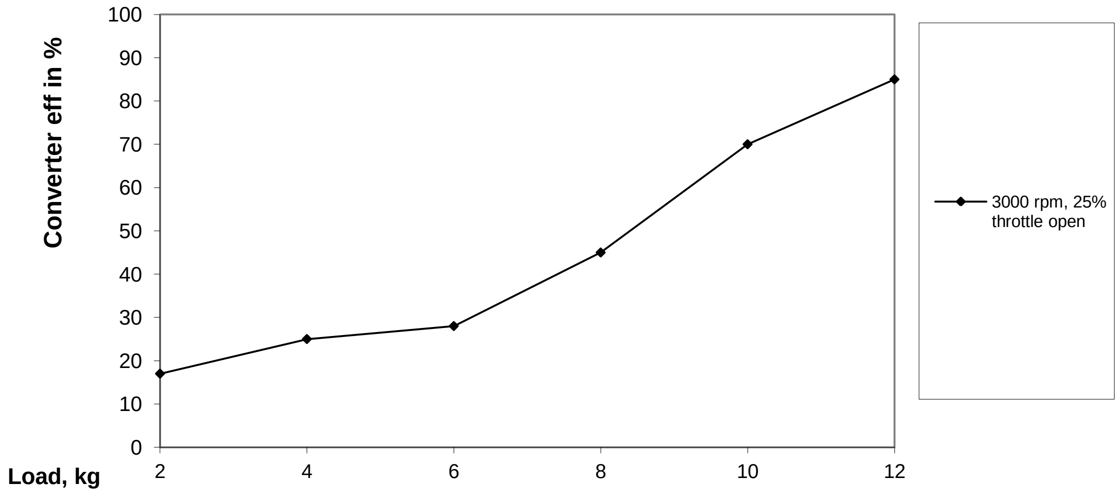

Fig 4. Load vs. Converter η

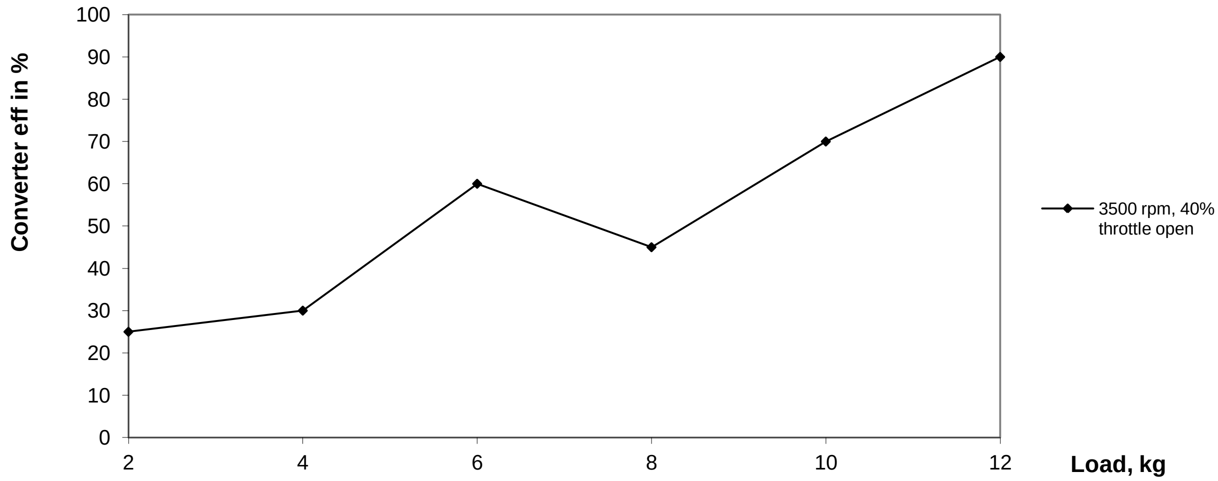

Fig 5. Load vs. Converter

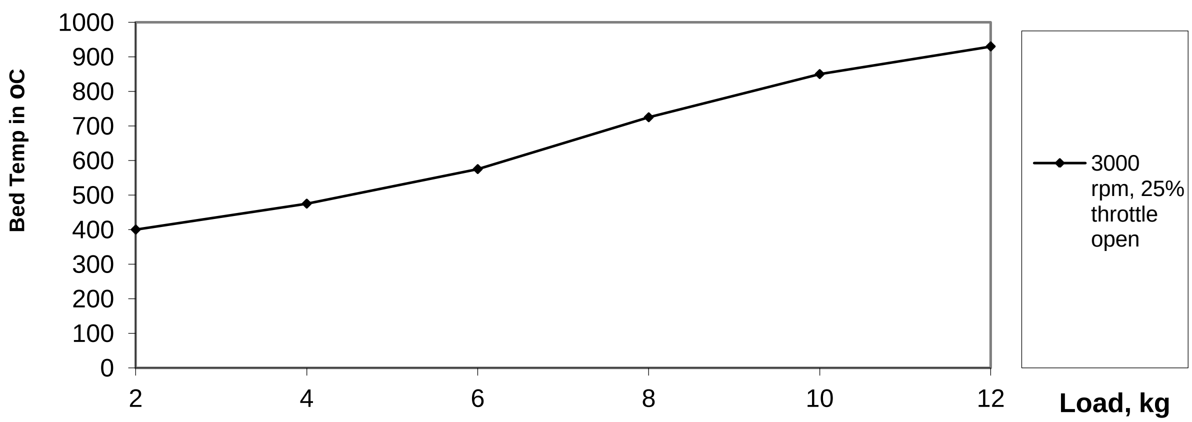

Fig. 6 Load Vs. Bed Temperature

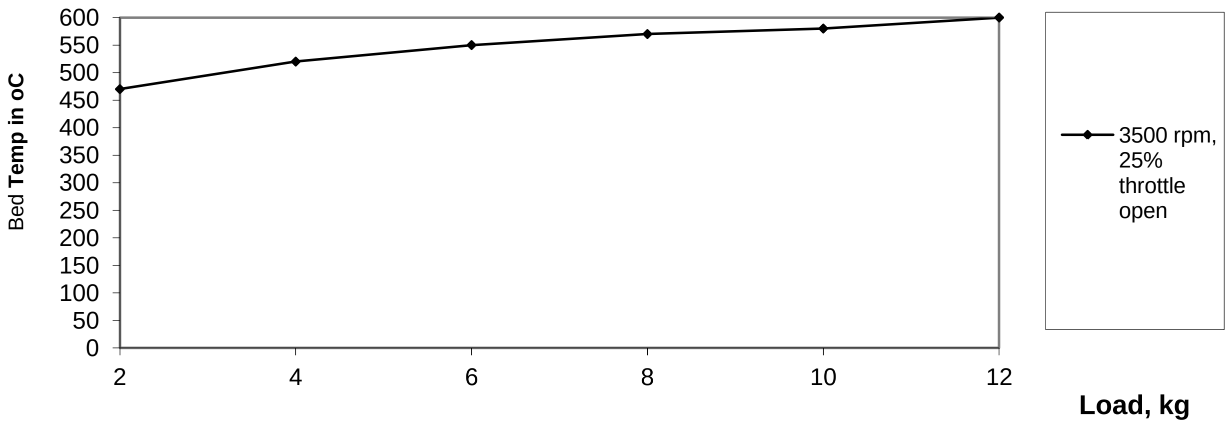

Fig. 7 Load Vs. Bed Temperature

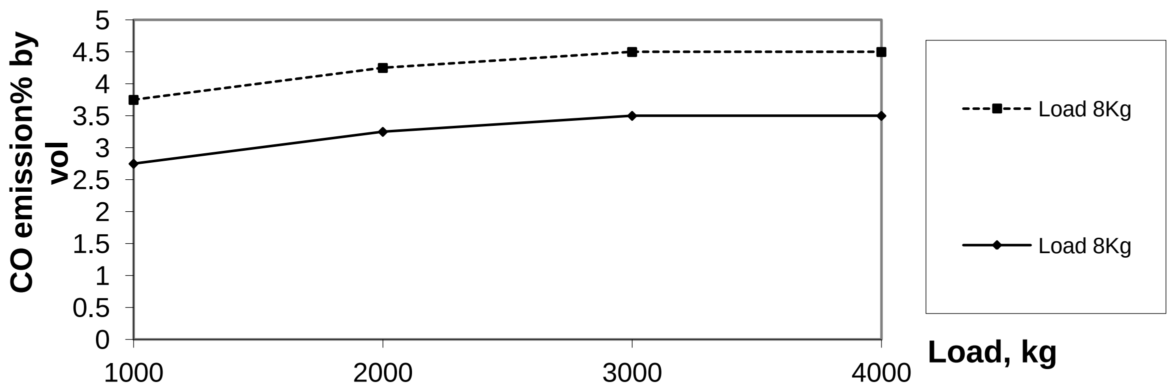

Fig. 8. Load Vs. CO%

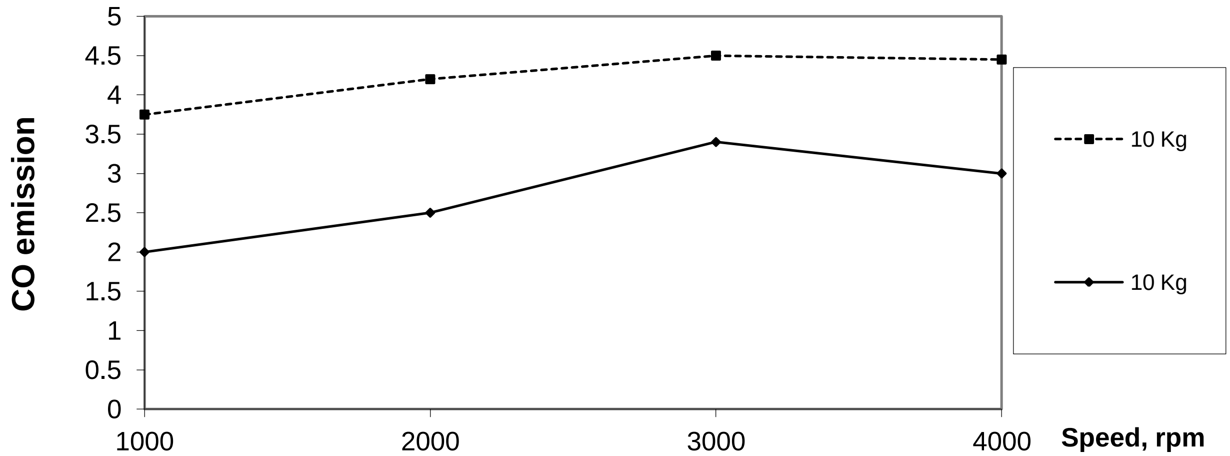

Fig 9. Speed vs. CO emission

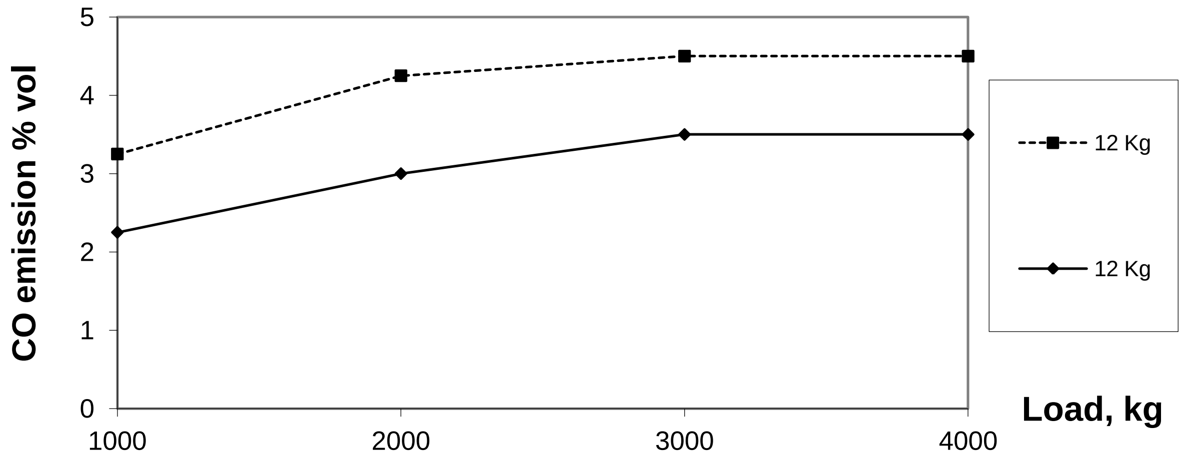

Fig 10. Load vs. CO emission %vol

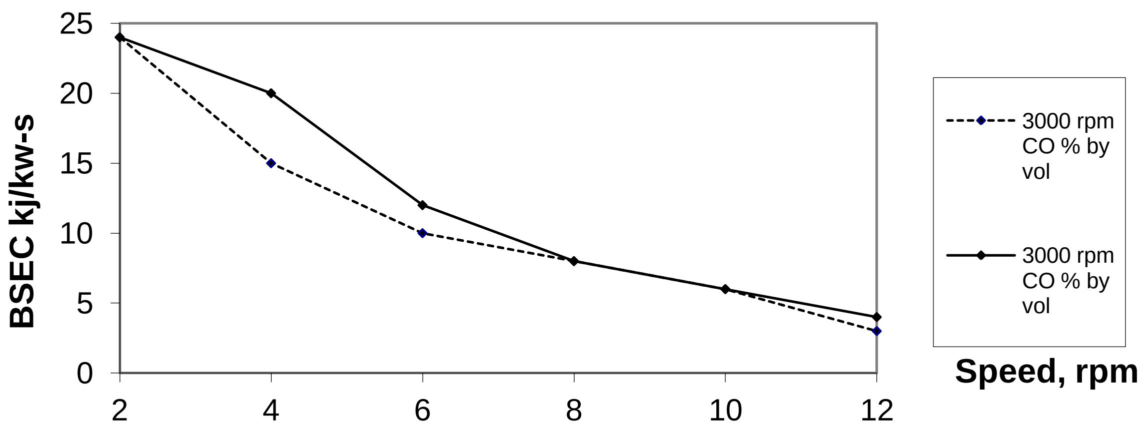

Fig 11. Speed vs.BSEC

CONCLUSION

The following are the conclusions based on the investigations carried out on a palletized catalytic converter.

1. 13 X Zeolite coated with Ag can effectively be used to reduce CO & UBHC from the tail pipe emission.
2. There is a marginal improvement in the performance parameter at higher loads with CC.
3. There is a substantial decrease in CO and UBHC emission through out the load range.
4. Palletized CC under discussion is cost effective as compared to the CC using noble metals.
5. Reduction in CO and UBHC is a function of bed temperature.
6. Practically there is no much change in back pressure between with and without CC.

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