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# Reduction Of $Co_2$ Emission By Using Zeolite 13x In Four Stroke Spark Ignition Engine

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***Abstract:*** ***Carbon di oxide is the major contribution gas for greenhouse effect and global warming. Therefore the world is in an urge to control the emission of $CO_2$. The main objective of this research is to reduce the emission of $CO_2$ from the exhaust in the petrol engine. Three way catalytic converter has already been employed in reduction of harmful pollutants such as Hydrocarbons, $NO_x$, CO that causes adverse effect in human being. The $CO_2$ is left freely from the exhaust in the atmosphere, where major composition from the exhaust is occupied by nitrogen and carbon dioxide.Zeolites are micro porous, alumina silicate minerals commonly used as commercial adsorbents and catalysts. They may occur naturally but are also produced industrially on a large scale. The additional arrangement of zeolite 13x inside a wire mesh which is used as additional component next to the catalytic converter. This research focuses on bringing down the level of carbon dioxide through the new devise called "catalytic converter using zeolite13x" which reduces the pollution drastically by absorbing the carbon dioxide and putting it to good use in a constructive manner.So that the emission of $CO_2$ can be controlled.***

***Keywords: Carbon di oxide, catalytic converter, Zeolites***

## I. INTRODUCTION

Global warming is a huge factor affecting our world. This should be taken into consideration and solutions should be brought up with alternatives to resources and technology available in our society at the present.Carbon dioxide plays a major role in global warming and the increase in the level of carbon dioxide affects our environment in many ways such as climate changes, destruction of the greenness in our environment.Due to the combustion of fossil fuels, deforestation, and the increased release of $CO_2$ from the ocean due to the increase in the earth's temperature by about 35% since the beginning of the age of industrialization. $CO_2$ can contribute to acid rain in much the same way that $CO_2$ in soft drinks and beer makes those beverages acid. All living things emit carbon dioxide when they breathe, carbon dioxide is widely considered to be a pollutant when associated with cars, planes, power plants, and other human activities that involve the burning of fossil fuels such as gasoline and natural gas.

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This research focuses on bringing down the level of carbon dioxide through the new devise called "catalytic converter using zeolite13x" which reduces the pollution drastically by absorbing the carbon dioxide and putting it to good use in a constructive manner.Cheng-Hsiu Yu, Chih-Hung Huang, Chung-Sung Tan (2012) conducted experiment on reduction of emission of $CO_2$ in power plant by using absorbent and adsorbent. In order to reduce the emission of $CO_2$ absorption methods like alkonolamine based absorbent, ionic based absorbents and blended absorbents are used with the help of absorption-stripping technology and higee technology. The operation of physical absorption is based on Henry's Law. $CO_2$ is absorbed under a high pressure and a low temperature, and desorbed at reduced pressure and increased temperature. This technology has been widely applied to many industrial processes including nature gas, synthesis gas and hydrogen production with high $CO_2$ contents. Adsorption includes physical adsorbents such as carbonaceous material, Zeolite, ordered mesoporous silica and metal organic frame works. The chemical adsorption includes amine based materials such as amine impregnated, amine grafted by toluene reflex, SC-propane and by direct synthesis, lithium based materials and calcium based materials. Therefore from this study it has been showed that physical adsorption is more suitable for $CO_2$ capture but on the other hand chemical modified adsorbent have been proved to be feasible.Tomonori Fukasawa et al. (2016) proposed the synthetic zeolite production method called Synthesis of zeolite from coal fly ash by microwave hydrothermal treatment with pulverization process. Coal fly ash was hydrothermally treated with a NaOH aqueous solution at 373K using microwave heating with zirconia beads. The author investigated the effect of the pulverization of coal fly ash on the generation rate and crystalline phase of synthesized zeolite.The author concludes that it is expected to be a simple method for controlling the ion concentration because only pulverizing beads are added during the mixing of the slurryLeonidas Ntziachristos et al. (2004) proposed the emission control option for power two wheeler in Europe. The emission contribution of motor cycle and mopeds in Europe in the period of 1999-2002 is studied. The emission control option such as durability of emission control system, in use compliance, on board diagnostics, road worthiness, evaporation control, PM specific measures are specified. From the above control options the author concludes that in order to improve the rising HC contribution RW are quiet effective at reasonable cost. But the most expensive measure is the adoption of Euro 3 emission standard for mopeds which is also a most effective method. Conrad Piasecki, 2016 provided Estimation of the effects of new emission standards on motorcycle emissions by means of modelling.

The author implies that the increase in world population and global economic performance associated with the ever increasing demand for energy and mobility particularly in emerging markets leads to a series of socio economic and political changes. HBEFA (Hand Book Emission For Road Transport) includes the emission factors for powered two wheelers and TREMOD (Transport Emission Model) an emission tool consists of real emission and fuel consumption data of all road traffic vehicles. The development of road traffic emissions is characterised by the superposition of technological improvements to reduce fuel consumption and emission of vehicles.Hence the major problem identified in the emission of $CO_2$ is, it is not considered as a major pollutant. In this research zeolite is used which comes under the chemical adsorption method to capture the $CO_2$ emission from the exhaust of the petrol engine. Zeolite 13x is the adsorbent used to adsorbs the $CO_2$ and water. The setup is placed next to the 3-way catalytic converter that helps to adsorb the $CO_2$. The zeolite 13x beads arranged inside a wire mesh covered by a metallic shell. Holes are formed in the form of cylindrical pattern for easy flow of exhaust gas and to avoid back pressure.

## II. EXPERIMENTAL SETUP

**Fig.1. Experimental setup**

Engine Specifications

| | |
|---|---|
| Model | : GK200 |
| Type | : 4 stroke, Air cooled, single cylinder, horizontal shaft |
| Displacement | : 197cc |
| Engine net power | : 2.2kw/3HP at 3600 rpm |
| Engine Max. Net Torque | : 7.9Nm at 2500 rpm |
| Fuel tank capacity | : 3.3 litre (kerosene), 0.35 litre (gasoline) |
| Ignition system | : Flywheel magneto ignition, transistor type Magneto |
| Air cleaner | : oil bath type |
| Dry weight | : 17kg |
| Dimensions LxWxH | : 330x405x425mm |

## III. ZEOLITE CATALYTIC CONVERTER

Gases sent out from the engine exhaust are sent in to the catalytic converter. At the end of the catalytic converter a special arrangement is made to trap the $CO_2$. The arrangement consists of a reaction chamber, wire mesh, zeolite balls, inlet pipe and outlet pipe. Reaction chamber is constructed with sheet metal in the form of cylindrical shape where reaction occurs. Wire mesh is placed inside the reaction chamber to hold the zeolite balls. In order to avoid the back pressure cylindrical holes are made inside the wire mesh for the easy and continuous flow of the exhaust gas.

The exhaust gases coming out from the exhaust is sent into a specially arranged reaction chamber where the reaction occurs. This setup can be used as an extra arrangement next to the catalytic converter in petrol engine.

At the end of the expansion stroke the exhaust gases such as HC, $CO_2$, CO, $NO_X$ are sent out from the engine to the catalytic converter. Inside the 3-way converter the CO & HC is oxidized to $CO_2$ & H2O with the help of palladium/platinum catalyst. $NO_X$ is reduced to $N_2$ & $O_2$ with the help of rhodium/platinum catalyst. The $CO_2$ coming out from the catalytic converter is sent into the reaction chamber where it get adsorbed by the zeolite 13x balls.

## IV. OBSERVATIONS

**Specifications of Engine**

Displacement of single cylinder petrol engine = 197cc

Exhaust pressure = 1.5 bar

Exhaust temperature = 313K

**Table-I: Observations without catalytic converter**

| Load (grams) | Voltage (volts) | Current (ampere) | Time for 10cc fuel consumption (sec) | Speed (rpm) | $CO_2$ (%) | CO (%) | $NO_X$ (%) | HC (ppm) | $O_2$ (%) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 240 | 0 | 47 | 2840 | 2.14 | 2.698 | 39 | 1137 | 14.97 |
| 200 | 230 | 0.25 | 39 | 2810 | 3.38 | 4.323 | 38 | 1219 | 11.79 |
| 400 | 230 | 1 | 38 | 2790 | 4.05 | 5.349 | 36 | 1440 | 9.68 |
| 600 | 225 | 2 | 34 | 2710 | 4.20 | 6.782 | 48 | 925 | 9.63 |

**Table-II: Observations with catalytic converter**

| Load (grams) | Voltage (volts) | Current (ampere) | Time for 10cc fuel consumption (sec) | Speed (rpm) | CO2 (%) | CO (%) | NOX | HC (ppm) | O2 (%) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 240 | 0 | 47 | 2840 | 1.32 | 2.98 | 15 | 1788 | 10.69 |
| 200 | 230 | 0.25 | 39 | 2810 | 2.45 | 4.23 | 21 | 1129 | 8.93 |
| 400 | 230 | 1 | 38 | 2790 | 3.06 | 6.14 | 40 | 2098 | 6.53 |
| 600 | 225 | 2 | 34 | 2710 | 3.76 | 6.59 | 41 | 1114 | 4.83 |

## V. CALCULATIONS

Density = P/RT

P- Exhaust pressure in $N/m^2$, R- Gas constant in kJ/kgK, T- Exhaust temperature in K

Density = (1.5x105) / (287x313)
= 1.6698kg/m3

Volume flow rate = for 1 revolution engine cc x flywheel rotation in rps

Mass flow rate = volume flow rate in m3/s x density in kg/m3

Flywheel rotation in rps = flywheel rotation in rpm/60

**For N1=2840rpm**

Flywheel rotation in rps = N/60 = 47.33rps
Volume flow rate = (197/2) x 47.33
= 4662.005cc/sec
= 4662.005x10-6$m^3$/s
Mass flow rate =4662.005x1.6698 =7.7846x10-3kg/s

**For N2=2810rpm**

Flywheel rotation in rps = N2/60 =46.833rps
Volume flow rate = (197/2) x 46.833
= 4613.0505cc/sec
= 4613.0505x10-6$m^3$/s
Mass flow rate = 4613.0505x1.6698
= 7.70287x10-3kg/s

**For N3=2790rpm**

Flywheel rotation in rps = N3/60 = 46.5rps
Volume flow rate = (197/2) x 46.5
= 4580.25cc/sec
= 4580.25x10-6$m^3$/s
Mass flow rate = 4580.25x1.6698
= 7.648x10-3kg/s

## VII. RESULTS

**Table-III: emission of $CO_2$ from the exhaust at various loading conditions**

| S.No. | Load (grams) | Speed (rpm) | Mass flow rate x10-3 (kg/s) | $CO_2$ Without Catalyst (%) | $CO_2$ With Catalyst (%) | Difference between without and with catalyst (%) | Percentage of Reduction (%) |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 2840 | 7.78 | 2.14 | 1.32 | 0.82 | 38.31 |

**For N4=2840rpm**

Flywheel rotation in rps = N4/60 = 45.166rps
Volume flow rate = (197/2) x 45.166
= 4448.851cc/sec
= 4448.851x10-6$m^3$/s
Mass flow rate = 4448.851x1.6698
= 7.4286x10-3kg/s

## VI. DESIGN CALCULATIONS

$CO_2$ adsorption capacity of the zeolite 13x
= 0.01062mmol/g

Average mass of the $CO_2$ coming out from the vehicle per second = 7.6405x0.04
= 0.304g

Molar mass of the $CO_2$ = 44.01g/mol
Mass of the 1 mol of $CO_2$ = 44.01g
0.304g of CO2 contains = 0.304/44.01
= 6.907x10-3mol
= 6.907mmol

From the adsorption capacity,
1g of zeolite 13x can adsorb 0.01062mmol of CO2
Then, 6.907mmol of CO2 can be adsorbed by
= 6.907/0.01062
= 650.37g of zeolite.

650mL volume occupied by the zeolite weighs 400g. Then 650.37g of zeolite occupies ((650/400)x650.37)1056.85mL
= 1056.85x103 $mm^3$

Take diameter (D) =100mm

Volume of the reaction chamber
= $(\pi/4)*D^2*L$
1056.85x103 = $(\pi/4)x(100)2xL$
1056.85x103/$((\pi/4)x(100)2)$ = L
Length of the reaction chamber (L) =134.56mm

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 4 | | | | |
| 2 | 200 | 2810 | 7.702 | 3.38 | 2.45 | 0.93 | 27.51 |
| 3 | 400 | 2790 | 7.648 | 4.05 | 3.06 | 0.99 | 24.44 |
| 4 | 600 | 2710 | 7.428 | 4.20 | 3.76 | 0.44 | 10.47 |

From the tabulation it is inferred that the reduction percentage of CO2 ranges from 38% -10% at no load condition to various loading conditions.

### A. LOAD Vs $CO_2$ CONTENT

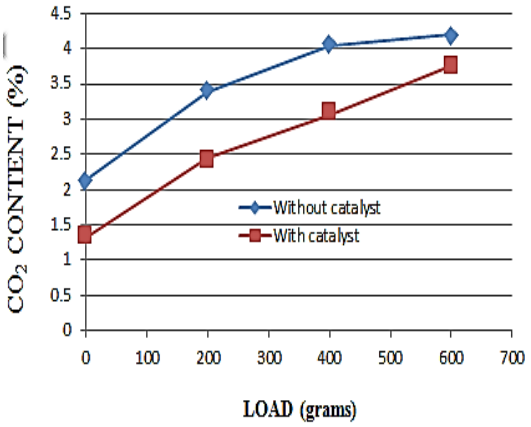


**Fig.2. variation of $CO_2$ emission with and without catalyst against different load**

### B. SPEED Vs $CO_2$ CONTENT

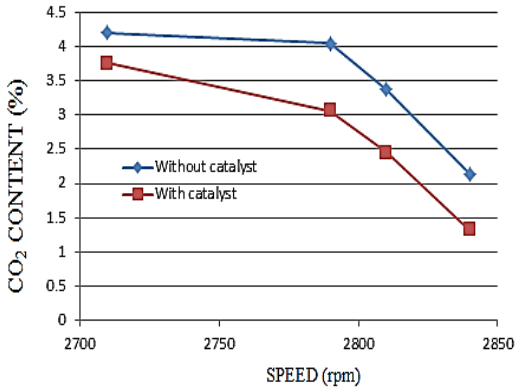


**Fig.3. variation of CO2 emission with and without catalyst against different speed**

### C.SPEED Vs MASS FLOW RATE

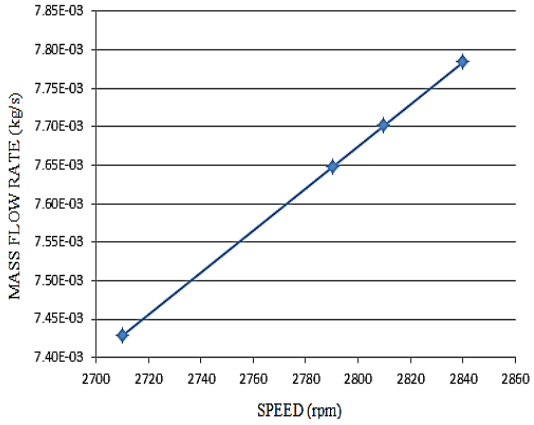


**Fig.4. variation of mass flow rate with respect to speed**

## VIII. CONCLUSION

This research helps the automobile industry to reduce the CO2 emission by the new catalytic converter. The catalytic converters are used to reduce the emission of CO, NOX, Hydro carbons where the CO2 is left freely in the atmosphere that causes raise in earth's temperature and results in global warming and greenhouse effect. The zeolite catalytic converter is employed to adsorb the emission of CO2 in this research. The reduction in CO2 emission helps to create an eco-friendly, sustainable environment and also reduces the global warming.

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