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Original Article

Conversion of Exhaust Co2 into Useful Chemicals

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Abstract: *Today, one of the toughest challenges faced by the Mankind is the increasing of pollution at an alarming rate. It is causing an Environmental imbalance and contributes to the Greenhouse Effect. Automobile Exhaust is the majorsource of Pollution. The majority of the Environmental Pollution is due tothe Two-Wheeler Automobiles due to their large number. Thereare two methods to control Pollution namely, Pre-PollutionControl and Post Pollution Control. This Project is based on thePost-Pollution control method in Two-Wheeler Automobiles. APollutant Absorber device isfabricated to absorb the harmfulgases (CO, CO2 and HC) in the exhaust. A Chemical Mixture is placed in the Pollutant Absorber to convert the absorbed gasesinto a useful chemical that has market value.*

Keywords: *Pollution Control, Exhaust Gases, CO2, CO, Carbon Absorber, Automobiles, Two Wheeler.*

INTRODUCTION

Due to the present high world oil price and concernsover Carbon-Di-Oxide (CO2) Emissions, it is important toassess possible increases in Fuel use and emissions. Environmental Pollution by vehicles is caused due to TailPipe Exhaust Emissions depending on changes in DrivingCycles, Engine Condition, Fuel Composition and Air-Fuel Ratio. Malfunction of Engine Devices, especially FuelInjection System, increases the emissions of the main ExhaustComponents. Vehicular Emissions consist of Carbon-DiOxide, Carbon Monoxide, Nitrogen Oxides, Hydrocarbonsincluding Lead, Particulate Matter etc. Global Warming is caused by Carbon-Di-Oxide emissions and other heat-trappinggases that are emitted primarily by the burning of Fossil Fuels.CO2 is the most critical human-sourced greenhouse gas due to its contribution to Global Warming. The Past Century has seena dramatic increase in the atmospheric concentration of heattrapping gasses, due to human activity. If this trend continues,Scientists project that the earth's average surface temperaturewill increase between 2.5°F and 10.4°F by the year 2100. Oneof these important heat-trapping gasesisCarbon-Di-Oxide(CO2).

Carbon Monoxide (CO) is considered as ToxicPollutant, whose effective reduction can be achieved by usingCatalytic Converter.Carbon-Di-Oxide (CO2) and Carbon Monoxide present in the tail pipe exhaust emissions can be reduced bymaking the exhaust emissions to react with the ChemicalMixture made up of Calcium Hydroxide (Ca(OH)2) andSodium Hydroxide (NaOH) placed in a pollutant absorberdevice fitted to the tail pipe of a two wheeler. Carbon-DiOxide (CO2) and Carbon Monoxide (CO) react with Chemicalmixture and get converted into useful products such asCalcium Carbonate (CaCO3) and Sodium Carbonate(Na2CO3).When Activated Charcoal is mixed with the abovechemical mixture, the level of Carbon Monoxide (CO) in the exhaust emissions is reduced further. The percentage ofCarbon-Di-Oxide (CO2) and Carbon Monoxide (CO) in theexhaust emissions is found out using a Crypton Five Gas Analyzer instrument. The analysis is carried out with differentproportions of Calcium Hydroxide (Ca(OH)2) and SodiumHydroxide (NaOH). The percentage reduction in the level of Carbon Monoxide (CO) and Carbon-Di-Oxide (CO2) isobtained from the Emission Test results. Thakur Mukesh [1] has proposed an innovativedesign of Catalytic Converter for Two-wheeler Automobilesusing Nano-particles as catalyst. The proposed method is very effective in the prevention of Environmental Pollutioncontributed from Two-wheeler Automobiles. It involves theuse of Copper Nano-Particles which is cheaper compared toother Nano Particles. A.Hoen [2] concluded with threeconditions to meet the long term climate targets. (1)Substantial changes in Travel Behavior, Travel Demand andPublic Acceptance, (2) Availability of Zero-Carbon or LowCarbon Fuels, (3) Availability of Advanced VehicleTechnology. R.Mehdiyev [3] developed a Two-StageCombustion Mechanism, a new constructed Single CylinderSpark ignition engine with high compression ratio producesabout 10% higher power and consumes about 8% less fuel atfull load than its Counterpart Diesel Engine, andsimultaneously emits Low exhaust emissions including CO2.

According to Chun Xiao Li [5], in order to reduce vehicle'sCO2 emissions, proposed a Dynamic Traffic Light Controlscheme. It was the first proposed scheme, to use ElectronicToll Collection (ETC) devices to obtain Real Time TrafficFlow information for a traffic control Centre. Bharat.S.Patel[6] discussed Automotive Exhaust Emissions and its impact,Automotive Exhaust Emission control by Platinum (Noble)metal based catalyst in Catalytic Converter.

METHODOLOGY

Identification of Chemical

Carbex is a unique soda lime absorbent which finds uses inthe removal of Carbon-Di-Oxide and acidiccontaminantsfrom gases streams. It is an active form of a mixture ofHydroxides (Calcium andSodium Hydroxides) which hashigh affinity for Carbon-Di-Oxide. It is made in the form of2.5-5.0 mm pellets processed to minimize dusting. Theuniform shape allows a Uniform Gas Flow, Low PressureDrop and consistent bed packing. It does not containPotassium Hydroxide or Barium Hydroxide and only a verylow level of Sodium Hydroxide. It carries minimum risk ofharmful anesthetic degradation compounds being generated.Carbex is available in two forms

- Non-indicating type which does not change coloron adsorbing Carbon-Di-Oxide
- Indicating type which changes color from Pink toWhite or White to Violet as it adsorbs Carbon-DiOxide

Saturation Test

While administering general anesthesia, the patient'sexpired gases, which contain Carbon-Di-Oxide, are passedthrough an Anesthetic Machine breathing circuit filled withSoda Lime Granules. Medical Grade Soda Lime has indicatingdye that changes color when the soda lime loses its CarbonDi-Oxide absorbing capacity. The Flow-thru Filter is easilyattached to the tailpipe of the vehicle. The Filter Matrix istreated with a basic chemical compound. The Vehicle Exhaustis then diverted into the Carbon-Capture Filter, which trapsCO2 in a Flow-by Chemical reaction.TheFilterMatrixactsasa Carbon sink, capturing harmful CO2. Once the Filter issaturated with Carbon, it can be easily removed from thedevice and exchanged for a new filter or rinsed and rechargedwith base material for reuse. The captured CO2 from thesaturated filter is Water-Soluble and can then be safelyconverted into a useful industrial solid. The process provides asafe method of Carbon storage.Every gallon of Gasoline burned in a Car's Engineproduces CO2 which is about 14% by Volume is in theexhaust. 30 to 50 percent of CO2 in the exhaust may becaptured by a mix of potassium Hydroxide and Waterdispersed within the ceramic wool support of a CO2 filter. Thecaptured CO2 changes the base media (pH 10) chemically intoa mildly acidic composition - about the pH of a blueberry. TheFilter is then removed experiencing surface saturation and isrinsed in a tank of water. The CO2 dissolves in the water, andCalcium Hydroxide or Potassium Hydroxide is added. TheResult is immediate.

Calcium Carbonate or PotassiumCarbonate forms in the water due to the abundance ofdissolved CO2 from the filter.Vehicle filters are made to trap CO2 from Tail PipeExhaust before it's released to the atmosphere. This is done byoffering a soap-like chemical of opposite polarity, Potassium(K) (+). In this case, the CO2 (-) sticks to the Potassium (+)with a little help from Water (H2O). Gasoline + Air burns tocreate energy to move the car. Leftover waste including CO2goes into the air we breathe. CO2 is trapped as much aspossible, before it goes out of the Tail Pipe. Filter Materialmixed with Potassium Hydroxide (KOH) is used. The ExhaustCO2 + H2O meets KOH in a Flow-by Reaction. Immediately amolecule is formed that becomes a soluble, slightly negative,Potassium Bi-Carbonate (KHCO3) ion. The CO2 is nowcaptured and stays that way until the filter is removed andrinsed in a tank of water. The CO2 collected in the KHCO3will dissolve in water. To safely store the captured CO2, asmall amount of additional KOH is sprinkled into the water.This action creates a Chemical reaction with the dissolvedCO2 to make Potassium Carbonate (K2CO3), which turns thewater milky white. The tiny white particles are now solid,Potassium Carbonate and settles to the bottom of the tank as athick paste. The harmful Greenhouse Gas, CO2 is sequesteredas Carbonate.Two-cycle Engines are another example. These littlemotors are very smoky and often prevalent on Motorizedrickshaws in the streets of India. A Pre-Treatment is requiredfor this Exhaust as well. Exhaust Particles (Smoke), arecontrollable. Then, a zone for CO2 capture follows as in theforegoing. For best capture efficiency, High Surface Area isneeded to expose the base support material to the exhaustflow. Exhaust Flow is not restricted. Expect around 14% ofthe total volume flow to beCO2measuredbyNon-DispersiveInfrared, a common method). Expect to capture some of theCO2.The Filter Support material is reticulated. The HighSurface area's pH

value is lowered as saturation builds andrinse is required often. Save the water. Add CalciumHydroxide or Potassium Hydroxide to precipitate Carbonate.Re-Charge the filter with KOH. Expect to capture 7% or aboutOne-Half of the total 14% CO2 by volume coming out of thepipe at Idle Speed. Expect the collection value to be less - about 4% - at 2500 and 3500 RPMs.

III.	EXPERIMENTAL SETUP
Engine	: Pulsar 150 cc attached Eddy Current Dynamometer
Condition: Cruising at Top Gear	
Speed	: 3500 ± 100 rpm

The Engine is started and allowed to run at Idle Conditionfor a minute and then the Normal Reading of Exhaust Gas istaken for 5 minutes using Crypton 5 Gas Analyzer. ThePollutant Absorber device, designed allows the Exhaust Gas topass through the Chemical Mixture at 3 different places so asto increase the contact base area. Then the Emission Test istaken for 5 minutes for each Chemical Mixture by keeping theSensor at the Exhaust of the container. The readings aretabulated for 5 different gases showing their Percentage ofContent by Volume. From the Tabulations obtained, The aimof the experiment is to find which Chemical Mixture reducesthe content of both CO and CO2

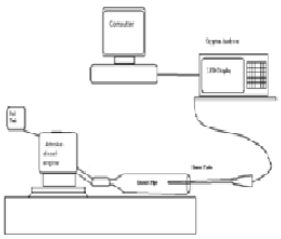

Figure 1: Experimental Setup without Model

Crypton 290 Series Gas Emission Analyzer

The Vehicle Emission Gases were analyzed, with andwithout Chemical Mixture, by using Crypton 290 Five GasAnalyzer. The Crypton Gas Analyzer is a fully MicroProcessor Controlled Exhaust Gas Analyzer employing NonDispersive Infra-Red (NDIR) Techniques .The Analyzereasures Carbon Monoxide, Carbon-Di-Oxide, Hydrocarbons, Nitrogen-Di-Oxide .A further channel isprovided employing Electro-Chemical measurement ofOxygen. Zero may be commanded at any time by theOperator, and automatically executed by the Analyzer. AnAutomatic Auto Zero Check is performed every three minutes when the analyzer is switched ON. The Analyzer is designedfor long term stability

Chemicals Used

1. Calcium Hydroxide
2. Sodium Hydroxide
3. Water
4. Activated Charcoal

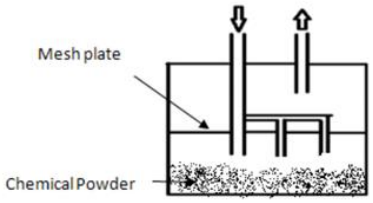

Figure2: Line Diagram of Fabricated Model

Figure 3: Photo of Fabricated Model

Compositions of Chemical Mixtures

Table1: Composition of Chemical Mixtures

	$Ca(OH)_2$ (%)	NaOH (%)	H_2O (%)	Activated Charcoal (%)
Mixture 1	95	5	-	-
Mixture 2	75	15	5	5
Mixture 3	75	5	20	-
Mixture 4	85	5	10	-

OVERALL REACTION

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O + Heat$

The Reaction can be considered as a Strong Base Catalyzed, Water Facilitated Reaction.

Mechanism:

$CO_2 + H_2O \rightarrow CO_2$ (aq.)

(CO_2 dissolves in Water - Slow and Rate determining)

CO_2 (aq.) + NaOH $\rightarrow$ $NaHCO_3$

(Bi-Carbonate Formation at High pH)

$NaHCO_3 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O + NaOH$

(NaOH Recycled. So it's a Catalyst)

Each mole of CO2 (44g) reacted produces One Mole of Water (18g)

EMISSION TEST RESULT

Emission Results of CO2:

Table 2: Percentage of Volume of CO2 in Exhaust Gas

S.NO.	NAME OF THE CHEMICAL	CO2 CONTENT (%)
1	Without chemical	4.534
2	Mixture 1	1.514
3	Mixture 2	1.534
4	Mixture 3	1.527
5	Mixture 4	2.440

Table 2 shows the % content of Volume of CO2 inthe Exhaust Gases with and without the Chemical in various proportions. Fig.4 represents the variation of CO2 content withrespect to time during the Emissions test with the Fabricated Model.

It is found that the percentage of CO2 content isreduced in the SECOND mixture when compared to the others. This implies that when addition of charcoal and waterwith the normal chemical mixture reduces the CO2 content.Since 5 Gas Analyzer is used for Emission Test, the reactionof emission gas other than CO2 with chemical mixture canalso be found. Table 3 shows the percentage reduction of CO2content in the Exhaust Gases due to the presence of theChemical mixture in various proportions as compared to theEmissions Test without Chemical Mixture. The data iscollected for a Time of 200 seconds after which the ChemicalMixture got saturated and completely converted into CalciumCarbonate

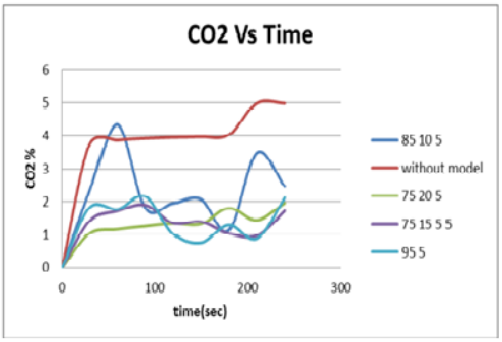

Figure4: Variation of CO_2 vs Time

Table 3: Percentage Reduction of CO2 for Various Chemical Compositions

Composition	% Reduction in CO_2
Mixture 1	66.67
Mixture 2	66.16
Mixture 3	66.32
Mixture 4	46.18

Emission Results of CO :

Using the Crypton 5 Gas Analyzer, the % content of CO is also studied along with the study of CO2 content. Table 4 shows the % content of CO in exhaust gases andalso the reduction of % Content of CO in Emission Gases due to the presence of Chemical Mixtures in various Compositions.

Table 4: Percentage Reduction of CO for Various Chemical Compositions

S. No	Name of the Chemical	Co-Content	% Reduction in Co-Content
1	Without Chemical	4.665	-
2	Mixture 1	2.181	53.25
3	Mixture 2	0.992	78.74
4	Mixture 3	2.291	50.89
5	Mixture 4	1.295	72.24

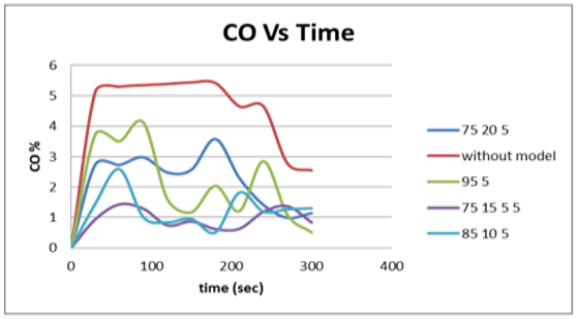

Figure 5: Variation of CO_2 vs Time

In Fig 5 percentage of CO content is reduced for theSECOND mixture to a considerable extent compared to the other mixtures. A reduction of 78.74% is certainly goodcompared to other mixtures.

Emission Results of Hydrocarbons (HC)

Using the Crypton 5 Gas Analyzer, the % content ofCO is also studied along with the study of CO2 content. Table4 shows the % content of CO in exhaust gases and also thereduction of % Content of CO in Emission Gases due to thepresence of Chemical Mixtures in various Compositions.

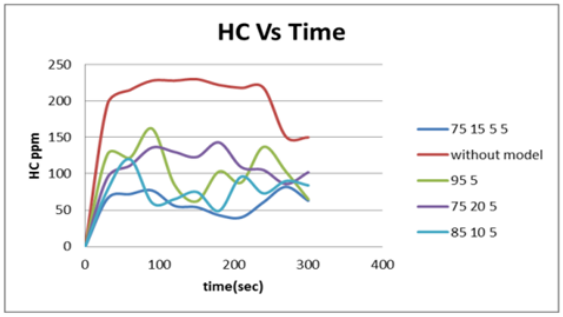

Figure 6: Variation of HC Vs Time

Table 5: Percentage Reduction of HC for various Chemical Compositions

S. No	Name of the Chemical	HC Content	% Reduction in HC Content
1	Without Chemical	205.6	-
2	Mixture 1	105.4	48.74
3	Mixture 2	61.4	70.13
4	Mixture 3	114	44.55
5	Mixture 4	77	62.55

In Fig 6 the percentage of HC content is reduced inthe SECOND mixture to a considerable extent compared to the other mixtures. A reduction of 70.74% is certainly goodcompared to other mixtures.From the above Emission Test Results, It can beshown that the SECOND Mixture performs well in reducingall the primary polluting gases to a considerable extentcompared to all the other mixtures. Fig.7. compares all themixtures based on their reduction capacities of Carbon-DiOxide, Carbon Monoxide and Hydro Carbons. From Fig.7.The Mixture 2 is selected as final mixture for the proposedwork.

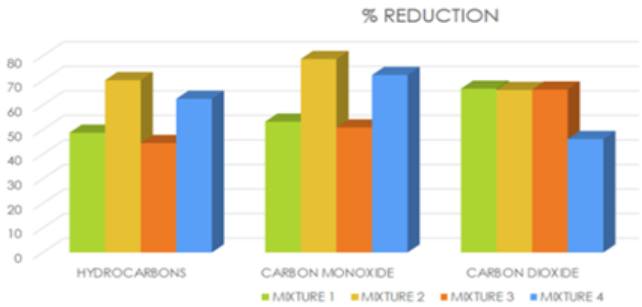

Figure 7: Comparison of Various Mixtures based on their Reduction Capacities of CO2, CO and HC

COST ANALYSIS

The Cost Sheet of the Fabricated Model is shown in Table .6.The total cost amounted to Rs.553. The Cost Sheet was shownto demonstrate the profit of the above fabricated Model.

Table 6: Cost Sheet of Fabricated Model

Name of the Material	Cost in Rs.
Copper 1mm Thick (1.25*2FT)	370
Copper Tubes (1/2'' DIA)	120
Copper Tubes (1/4'' DIA)	35
Stainless Steel Mesh (1 Sq.Ft)	20
Sodium Hedroxide (1 kg)	8
Total	553

Cost of the Raw Material Used (Ca(OH)2): Rs. 15/kgCost of the Product Formed (CaCO3) : Rs. 30/kgThe Market Value of the Product formed i.e. CaCO3is higher compared to the raw material because of it's manyuses such as:Ingredient of Cement in Construction IndustryPurification of Iron OreAdditive for Drilling Fluids in the Oil IndustryUsed as a Filter Material for Latex Gloves in SlurryForm

INFERENCES

Observing the Results, it's learnt that Mixture 2 i.e,75% Calcium Hydroxide, 15% Water, 5% Sodium Hydroxide,5% Charcoal. This Composition reduces all the three MainGases (CO2, CO, HC) that are polluting the atmosphere. Theabsorbed CO2 converts Calcium Hydroxide into CalciumCarbonate.

RESULTS AND DISCUSSIONS

1. As per the results obtained, it can be concluded thatthere is about 60% reduction in CO and CO2 level. Hence CO2 gas emitting to the atmosphere in g/km isreduced. Thus the present work can control or reduce the Global temperature if we implement this in variousCO2 emitting environment.
2. In addition to control of CO2 emission. The proposedmethod converts exhaust gases into useful chemical, Calcium Carbonate and it can be marketable. Thus forevery 0.5 liter of Gasoline the container holding the chemical mixture gets completely converted into Calcium Carbonate. Which can be replaced? Thus the work reduces not only CO2 emission but also getsconverted into a chemical which has market value
3. Since the Pollutant Absorber device is modeled as aPrototype, it can contain only up to 500g. But in real time, the container can be designed to hold up to 2 kg.Thus the Chemical mixture kept inside consumes 2 liters of petrol to completely convert into CalciumCarbonate.
4. For every 0.5 liter of Gasoline, the Chemical Mixture(500g) present within the model gets completely saturated and converted into Calcium Carbonate.
5. 5. The future scope of this project is that it can beimplemented to Thermal Power Plants, where moreamount of fossil fuel gets burnt and it emits CO2 in alarger extent. It causes 57% of global emission that causes greenhouse effect.

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