REDUCTION OF VEHICULAR EMISSION USING WASTE PORCELAIN AS ADSORBENT

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ABSTRACT

The combustion of fossil fuel is one of the major sources of greenhouse gas carbon dioxide, which supplies more than 98 percent of worlds energy needs. New technologies are required which utilizes fossil fuels with less greenhouse emission. Vehicular exhaust gases like carbon monoxide (CO), carbon-di-oxide (CO_2) and hydrocarbon (HC) are highly toxic. These components cause major problem to health and environment. In the study waste porcelain is converted into an alkali activated material with the ability to absorb CO_2, CO and HC. The synthesized adsorbent was able to remove CO by 95%, HC by 100% and CO_2 by 27%, for 10 minutes exposure to exhaust gas and with a lifespan of 720 miles (50% efficiency) for just 200 grams, also the fact that the material is cheap (Rs. 500/kg). The adsorbing material will be able to keep the pollution levels low and under control.

Key words: Adsorption, Emission reduction, Emission control, CO_2, CO, HC

INTRODUCTION

Due to human activities, release of CO_2 into atmosphere is increased extensively; hence amount sequestered in biomass, the oceans and other sinks exceeded. Fossil fuels supply more than 98% of the world's energy needs, but combustion of fossil fuels is one of the major sources of the greenhouse gas carbon dioxide (CO_2). Summer smog is caused by exhaust gases like carbon monoxide (CO), carbon-di-oxide (CO_2) and hydrocarbon (HC) which is released from vehicular exhaust. Average traffic speed reduced due to traffic congestion. The combustion is incomplete at low speed and hence pollution is more per trip. Scientific experts now believe the nation faces an epidemic of illnesses that are exacerbating by air pollution. These illnesses include cardiovascular disease, asthma, chronic obstructive pulmonary disease, lung cancer, and diabetes. New approaches and novel ideas for CO_2 management and to reduce anthropogenic CO_2 emissions is needed and hence carbon capture and storage (CCS) are considered potentially the most effective means to alleviate the problem. CO_2 capture via gas absorption is an alternative process. Selective adsorption on solid media such as zeolites, activated carbons, alumina, hydrotalcite-like compounds, metal oxides, and metal organic frameworks (MOFs) is

preferred. Hence an attempt has been made to study the efficiency of Waste Porcelain adsorbent in reducing exhaust gases from vehicular exhaust gas.

MATERIALS AND METHODS

The setup consists of a silencer that is attached to the end of the exhaust pipe of a car. The silencer contains two meshes filled with waste porcelain as adsorbent (Figure 1). The exhaust gas coming out of the silencer after passing through the two meshes is measured for the concentration of CO_2, CO and HC using an exhaust gas analyser.

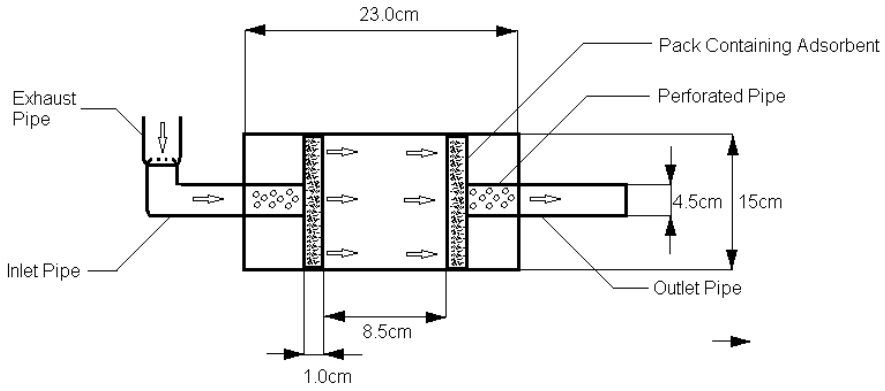

Figure 1. Schematic Diagram of Filtration Unit

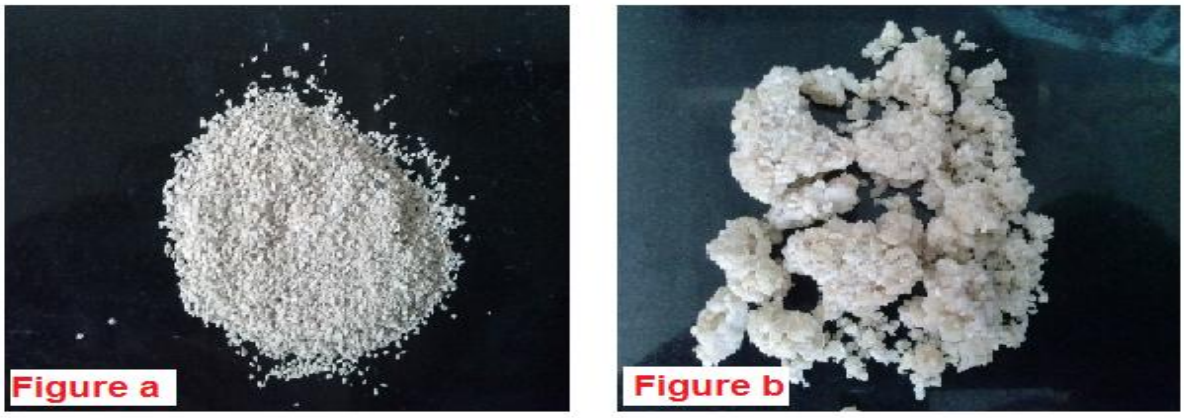

Figure 2. a. Crushed Waste Porcelain and b. Final adsorbing material

Preparation of Waste Porcelain Adsorbent

Mix 10g powdered waste porcelain with 12g of NaOH powder and ground to obtain homogeneous mixture. This mixture is heated in a nickel crucible at 600°C for 6 hours. The resultant material was cooled to room temperature and ground again to obtain fused material. Final material (0.5g) is added to a 10mL polymethylpentene tube with 2mL distilled water. This is then vigorously agitated by reciprocal shaker at room temperature to obtain aged material.

After agitation for 24 hours, aged materials was heated for 12 hours in a water bath at 80°C to obtain the product. The aged material product were filtered, washed with distilled water and dried in a drying oven at 60°C overnight to obtain the final adsorbent (Figure 2.b).

Experimental Procedure

The waste porcelain adsorbent that is prepared has to be filled into the meshes until they are full, after which the meshes are closed. The closed meshes are then inserted into the silencer, after which the silencer is closed. The closed silencer is then fixed into the end of the exhaust pipe of the car. The car is then started after which the silencer should be once checked for leakages, if leakages are found they should be blocked, as the exhaust moves through the fixed silencer CO_2, CO and HC are adsorbed onto the adsorbent. The amount of reduction in CO_2, CO and HC is found using exhaust analyser. The reading in exhaust gas analyser are got by inserting the probe of the analyser into the the fixed silencer. Readings are noted at different time intervals till the adsorbent reaches saturation.

RESULTS AND DISCUSSION

Investigating the Concentration of CO in Exhaust with the Adsorbing Media

The results are as shown in Table 1 indicates that without the adsorbing media the concentration of CO is 0.409 % by volume was just below the limit of 0.500 % volume. This value is then reduced by 95.35% when the adsorbing media is introduced into the silencer. The Table 1 also shows that the removal efficiency slowly reduces as the material slowly saturates. Thus from the study it can be concluded that the concentration of CO can be greatly reduced by introducing adsorbing media.

Investigating the Concentration of CO_2 in Exhaust with the Adsorbing Media

The results are as shown in Table 2 which depicts that without the adsorbing media the concentration of CO_2 is 6.97 % volume. This value is then reduced by 27% when the adsorbing media is introduced into the silencer. The removal efficiency in the next trial done on the next reduces to 15% and increases to 25%. Similarly on the next trial removal efficiency reduces to 17% and increases to 20%. This is due to lower temperature and pressure when the trial begins with the gradual increase in both temperature and pressure. Thus from the study it can be concluded that to reduce the concentration of CO_2 further higher pressure is required along with adsorbing media.

Table 1. Concentration of CO in exhaust gas

Sl. No.	Time (min)	Measured Level (% Vol)	% Removal
Without Adsorbing Media			
1	0	0.409	-
With Adsorbing Media			
1	10	0.019	95.35
2	60	0.042	89.73
3	90	0.061	85.08
4	120	0.063	84.60
5	150	0.067	83.62
6	180	0.069	83.13
7	210	0.070	82.88
8	250	0.073	82.15

Table 2. Concentration of CO_2 in exhaust gas

Sl. No.	Time (min)	Measured Level (% Vol)	% Removal
Without Adsorbing Media			
1	0	6.97	-
With Adsorbing Media			
1	10	5.08	27.12
2	60	5.92	15.06
3	90	5.84	16.21
4	120	5.37	22.95
5	150	5.20	25.39
6	180	5.76	17.36
7	210	5.66	18.79
8	250	5.52	20.80

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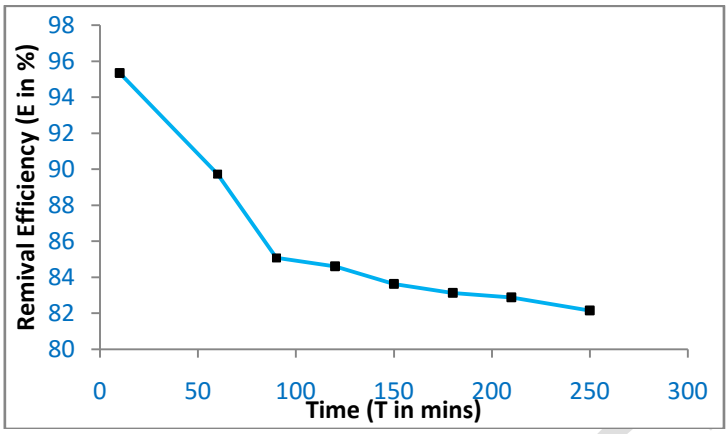

Figure 3. Removal Efficiency of CO

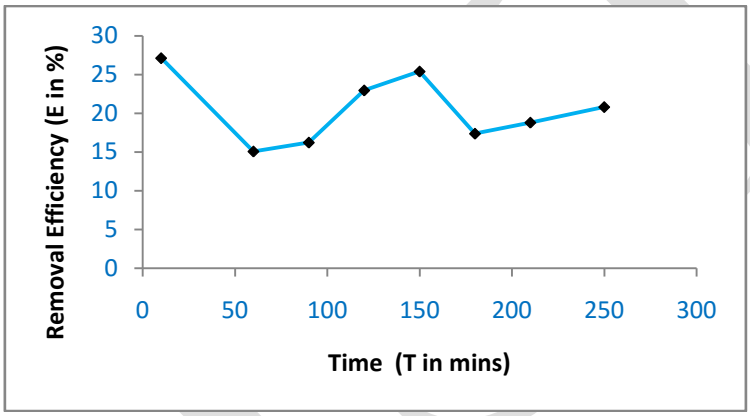

Figure 4. Removal Efficiency of CO_2

Table 3. To find equation to reach saturation level taking concentration of CO (C)

Sl. No.	T (min)	C (% Vol)	E (% Removal)	$\log_e(E)$	$T*\log_e(E)$	T^2
1	10	0.019	95.35	4.5575	45.575	100
2	60	0.042	89.73	4.4968	269.778	3600
3	90	0.061	85.08	4.4436	399.924	8100
4	120	0.063	84.60	4.4397	532.548	14400
5	150	0.067	83.62	4.4263	663.945	22500
6	180	0.069	83.13	4.4204	795.672	32400
7	210	0.070	82.88	4.4174	927.654	44100
8	250	0.073	82.15	4.4085	1102.125	62500
	Σ=1070			**Σ=35.6079**	**Σ=4737.221**	**Σ=187700**

The equations obtained are

$$8A + 1070b = 35.6079$$
$$1070A + 187700b = 4737.221$$

On solving for A and b,

$$A = 4.527$$
$$b = -5.6822 * 10^{-4}$$
$$a = e^{A} = 92.48$$

Calculation to find equation to reach saturation level

The CO removal efficiency (E) and Time (T) shown in the Table 1 is used to find the equation to reach the saturation level of adsorbing media. The equations obtained are as shown below. The curve obtained using the obtained equation is shown in Figure 5.

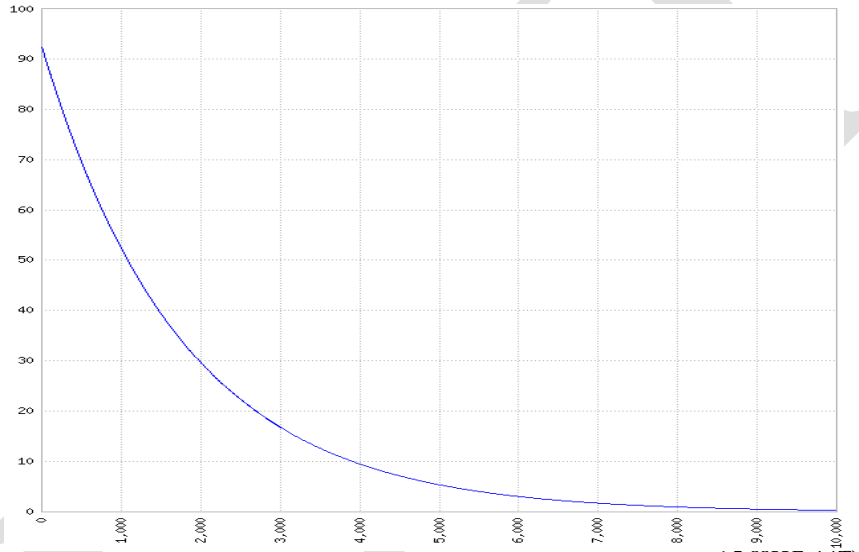

Figure 5. Curve formed using equation $E = 92.48e^{(-5.6822E-4 *T)}$

Calculating the time required for the material to reach saturation level of the adsorbing media

Using curve fitting equation for exponential curve.

ie., for exponential curves $y = a*e^{bx}$

Taking y as efficiency (E) and x as time (T)

Equation changes to $E = a*e^{bT}$

Equations are

1) To calculate efficiency (E) for given time (T)
   $E = 92.48e^{(-5.6822E-4 *T)}$
2) To calculate time (T) for given efficiency (E)
   $T = 1/-5.6822E-4 \ln(E/92.48)$

Table 4. Time required for the material to reach saturation level

Efficiency (%)	Equation for T	Time, T in min or hr.
50	1/-5.6822E-4 ln(50/92.48)	1082 mins or 18hr 2mins
25	1/-5.6822E-4 ln(25/92.48)	2302 mins or 38hr 22mins
5	1/-5.6822E-4 ln(5/92.48)	5135 mins or 85hr 35mins

Cost Benefit of Adsorbing Media with Catalytic Converter

In the study an attempt has been made to calculate the cost incurred for total quantity of adsorbent required based on average life of car and compared with the amount required for catalytic converter. The calculation worked out to be 50 % less cost if adsorbent is used.

CONCLUSION

- Results from the exhaust gas analyser shows that the adsorbent was successful in reducing the concentration of CO by upto 95%, the concentration of CO_2 by upto 27% for 10 minutes
- Time required for the material to reduce to a removal efficiencies of 50%, 25% and 5% are 18hr, 38hr and 85hr respectively obtained from curve fitting equation
- The analysis of the cost incurred to keep emissions low can be reduced by using adsorbent along with catalytic converter
- Adsorbent can aid in extending the life of a catalytic converter and thereby reducing the cost that might be incurred in replacing the catalytic converter at the same time keeping the emissions under control

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