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DEVELOPMENT AND FABRICATION OF POLLUTION FILTER FOR PURIFICATION OF CARBON BASED COMPONENTS FROM EXHAUST GASES

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Abstract

The use of motor vehicles is a major cause of air pollution, which is a serious problem for the planet. Over 70% of air pollution is thought to be caused by cars, and this percentage is rising at a fast pace. In situations when cars are moving at low speeds, such as while stuck in traffic, etc., the amount of petrol they emit increases. As a result, a lot of effort has to go into this to safeguard the environment from gases like CO, NOx, etc. The main goal is to create a device that can be easily attached to any car's exhaust outlet or silencer, takes in exhaust air, filters it to remove harmful elements, oxidises it, and then releases it into the atmosphere. The device should be simple, inexpensive, and easy to maintain. We have created a prototype of the filter system after designing it in Autodesk Inventor.There has been a 48% decrease in total carbon emissions.

Keywords: Activated carbon granules, carbon emissions, filter, adsorption.

INTRODUCTION

A system designed to remove dangerous gases from an engine's exhaust is known as an exhaust gas filtration system (EFS). To put it simply, emissions are the gases released into the atmosphere from an automobile's exhaust system. Among the many pollutants released by the engine are nitrogen oxides (NOx), hydrocarbons, and carbon-based components, all of which are excellent candidates for

The effects of pollution on both the environment and living things have been extensively discussed.

Needforexhaustgasesfiltration

- Cars are ubiquitous, yet there is a pressing need to lessen their impact on the environment by reducing the emissions of certain exhaust components. It is more effective to filter the exhaust gases to levels below what is considered acceptable, meaning that they are absorbed entirely rather than released into the atmosphere, in order to preserve the environment.
- It is possible to decrease the amount of the main gases that cause the greenhouse effect, such as CO2 and CO.
- Cleanup of a vehicle system, including the removal of soot, dissolved contaminants, unburned fuels, and particulate matter. The refined components of flue gases, such as carbon, sulphur, ammonia, etc., may be collected and stored as raw materials. For example, carbon dioxide can be extracted from flue gases and transformed into liquid CO2, which has a broader range of uses.
- Cars are a generally well-received source of carbon emissions, therefore reducing their impact on the environment may help accomplish climate change mitigation objectives.
- When compared to other procedures, such as electrolyte-based separation and chemical dissolved

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separation, pollution filtration is the most efficient.
• The most dependable and effective methods of reducing pollution caused by engine emissions are always being sought for.

affordable ways for cleaning exhaust gases must be developed.
To solve the issue caused by pollution from cars, we need full purification systems that do not release any exhaust fumes.
• Since independent filtering devices are expensive and difficult to maintain, they are often not included in vehicle exhaust systems.Hence, the process of exhaust filtering is being disregarded for soot, particulate matter, and hydrocarbons.

2. LITERATUREREVIEW

1) The technique of purifying exhaust gas using sorbents derived from fly ash was discussed in an article written by A.Ściubidło and I. Majchrzak-Kucęba from the Institute of Advanced Energy Technologies at Czestochowa University of Technology in Poland. Part of their job is coming up with a sorbent made of fly ash that can separate NO2 from exhaust gases at ambient temperature.Polyethylene glycol was utilised to modify NO2 adsorbers Na-X, SBA-15, and MCM-41. The sorption capacity for NO2 removal was evaluated using simulated gas streams and a thermo gravimetric analyzer. The results showed that SBA-15(FA) had an improved sorption capacity of 3.2 mg NO2g-1 after impregnation with PEG, up from 1.6 mg NO2g-1 before. According to the findings, the sorbent zeolite Na-X- (FA) 44.7 mg NO2g-1 exhibited the maximum sorption capacity.This article was published in ELSEVIER Fuel 258 (2019) 116126.
2) The authors of the following works: Yang Li, Xiangyang Xing, Jianzhong Pei, Rui Li, Yong Wen, Shengchoo Cui, and Tao Liu developed a material for automobile exhaust gas purification that relies on visible light catalytic breakdown of g-c3N4 / BiVO4. Involved testing the efficacy of composite photocatalytic materials prepared using one-step calcination and bi-dispersion direct mixing in purifying vehicle exhaust gas.3. A technology study focusing on reducing greenhouse gas emissions, published in 2014 by the Hindawi Publishing Company, discusses carbon dioxide separation from flue gases (// Published in Ceramics International / ELSEVIER).something that Mohammed Son Golzadeh conducted,

When the CO_2 content in the stream is low, the bulk absorption and adsorption methods proposed by Mansoorehsoleimani, Maryam takhtravanchi, and Reza sonyolzedeh work well; when the concentration is high, cryogenic distillation and the membrane process work well.
4) In a study conducted by Jialiu, Jan Baeyens, Yimindeng, Tianwei Tan, and Huilizhang, the chemical CO_2 capture by carbonation - decarbonation cycles is centred around reducing CO_2 emissions from combustion. The researchers developed a method that is both cost-effective and easy to operate in comparison to conventional methods. To determine the optimal material, they performed a macro thermo gravimetric experiment to screen two main candidates, Mg O and Mg (OH)2.
(// printed in 2020-11-054) Journal of Environmental Management.
Five, S. Rajadurai, M. Afnas, S. Ananth, and S. Surendher's study on materials for vehicle exhaust systems compares and contrasts the physical, chemical, and mechanical properties of materials used in both standard and specialised applications. The presentation covers the effects of additions like Ti, Mo, Mn, and Si.[March 2014] (IJRDET, ISSN 2347-6435, Volume 2, Issue 3).

6) Lalitzipre, Prathmeshaher, Prathmeshjalgonkar, Mohammed altaf, and Prof. T.Z. Quazi's work on designing and optimising exhaust systems for internal combustion engines focused on reducing weight, compacting the system, and developing an active back pressure control valve, which is the major feature.Volume 9, Issue 5, May 2018, IJSER, ISSN 2229-5518.

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7) Vilas Elavande, Akshaytajane, Mahesh Jadhav, and Rumdeorathod's article on the design and testing of car exhaust systems. Their job include enhancing the design and comparing it to the current system.(//The International Journal of Research in Engineering and Technology, Volume 3, Issue 11, November 2014//).
8) Kenneth Alfred Rogers conducted thesis work on the adsorption of gases, including hydrogen, methane, carbon dioxide, and mixtures thereof, on activated carbon at temperatures ranging from 212 to 301 K and pressures up to 35 atm.The endeavour

Several techniques and procedures were used to identify the most appropriate adsorption material, with an emphasis on creating a characteristic curve based on adsorption potential theory.
9) The cleaning of exhaust gases from marine diesel engines in the Arctic area is a project headed by Jon Bernodusson of the Icelandic Transport Authority's Research & Development department. The main conclusion of this experiment is that scrubbing, even with only water spray, is a successful method for cleaning diesel exhaust gases on ships. Adding other ingredients, such a calcium and urea solution, to the water spray may greatly enhance the removal of CO_2 and NO_x.
10) Johan Wall Karlaskrona's thesis is titled "Dynamics Study of an Automobile Exhaust System." The creation of a computationally cheap theoretical system mod and the establishment of a foundation for better design were the primary goals. Experimental examination and modelling of a standard exhaust system are carried out.
Eleven) Ajinkya B. Patil and Rajaram M. Shinde collaborated on a stationary diesel engine's catalytic converter design using the engine's specifications and input from a conversation about the materials used for the converter.(Originally published in the April–June 2015 issue of the Journal of Basis and Applied Engineering Research, ISSN 2350–0077, pp.

3. INTRODUCTIONTOEXHAUSTGAS FILTERATION SYSTEM

Activated carbon membranes based on absorption for the purpose of filtering contaminants from exhaust gases. The project's focus is on activated carbon based on absorption, namely in the form of a separator membrane. The exhaust from a four-stroke, one-cylinder petrol engine is the primary source of CO_2, CO, and HC emissions, and this research aims to mitigate their effects. This will be accomplished by developing a membrane-based filtering system that also has the capacity to adsorb.Granular activated carbon (GAC) with an apolymer and resin support membrane will be our adsorption material of choice.

physical substance. We will be using EPOXY as the polymeric resin. A module core or active carbon core often adsorbs the concentrated CO_2, CO, and HC from the exhaust gases as part of the process.

Exhaust gas filtration system (Figure 3.1)

Parts of a system that cleans exhaust gas include:

• An expander directs the exhaust gases from the tailpipe into an exhaust system pre-filter (EPS). The engine's exhaust gases are compressed to 0.4-0.5 MPa, but they need to be compressed to 101.5 kPa to achieve maximal adsorption. We join the system using an expander, but the core can tolerate pressures up to 2 MPa.
Two 1 inch mild steel pipes with threads on both ends make up the system's connector pipes.
We employ an automated pressure release valve with a sensitive spring to counteract the stolen engine's back pressure limit.The gas is released outside via the valve whenever the internal pressure rises beyond the back pressure limit, causing the system to bypass.
Attaching the expander, pressure release valve, and GAC module is made possible by a connector junction known as a T joint.
• GAC module: This adsorption material is activated carbon, and the module is a capillary tube that contains it. Mild steel is its main component.

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A core made of granular activated carbon and epoxy resin may absorb CO2, CO, and HC from exhaust gases. This technology is known as an activated carbon core.

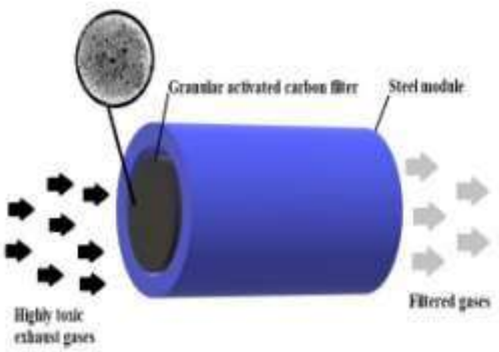

Figure3.2GACcore

GACModule

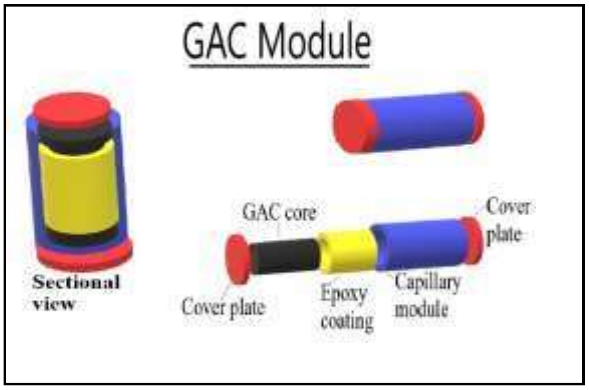

Figure3.3GAC Module

Thegranularactivatedcarbonmodulesetupconsist of the following

1) Cover plates: Which are made up of mild steel sheet and has vented holes to allow the exhaust gases to flow in them.
2) Capillary Module: A module is tube or athin casing which holds the adsorption material in this case the GAC, made of mild steel sheet forged to cylindrical shape and spot welded.
3) Epoxy coating: The Epoxy is the polymeric resin that is used to support and enhance the properties of adsorption. The inner shell of the module is lined with epoxy coasting and in a proportion of 1:3 mole density theepoxy is mixed with GAC to improve the bond ability and bulk compressibility of the core.
4) GACcore:Granularactivatedcarboncoreis a composite made up of activated carbon as the matrixbase component and the epoxyas a bind reinforcement.

3.3PropertiesofCoconutshellbasedgranular activated carbon

Properties	**Criteria**	**Value/Range**
Density	Apparent Density	0.78g/cm^3
	BulkDensity	80%-100%
Pressure	Maximum	~2Mpa
Temperature	Maximum	800ºC
	Minimum	300ºC
PSD(particulate sizedistribution)	Effectivesize	10 %(0.1)
	Uniformity	60 %(0.6)
Surfacearea	Approximately	1000 m^2/g
Iodinenumber	With0.02% concentration	1000@gas phase 800–900@ liquidphase
Poresize	Averagerange	10-28Å(10^{-10}m)
Allowable pressuredrop	minimum	190-250 Lpm/m^2

4.NUMERICALSIMULATION

<u>Enginespecifications</u>

Fueltype	Petrol
Numberofstrokes	4 Stroke
Numberofcylinders	Singlecylinder
Engineemission complaint	BS-IV
Coolingtype	Aircooled
Bore(D)	50 mm
Stroke(L)	57mm
Volume(CC)	113 cc
MaximumTorque(τ_{max})	8.1Nm@5000rpm
Maximumpower(P_{max})	7bhp@7500rpm

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A) Volumeflowrateofexhaustgases

VolumeflowrateofexhaustgasesV$_f$=Swept volume × Number of strokes per hour

Sweptvolume=$\frac{\pi}{4} \times D^2 \times L$=111919.238mm^3

V$_f$= $\frac{\pi}{4} \times D^2 \times L \times \frac{N}{2} \times 60$=23.5m^3/sec

B) Totalconcentrationofcarbonemittedfromthe engine C

Foragasolineengine
FC=100×ρ/[(0.1154)×[(0.866×HC)+ (0.429× CO) + (0.273 × CO_2)]]
Here
FC=fuelconsumptioninkilometreperlitre=Std50 kmpl
ρ= Densityofpetroltaken =0.78g/cm^3
HC=Hydrocarbonemittedfromtheengine=0.4 g/km = Max 3000 ppm
CO=Carbondioxideemittedfromtheengine=1.403 g/km = Max 3(weight %)
CO_2=Carbondioxideemittedfromtheenginein g/km
CO_2=12.91/0.273=47.29~47.3g/km
FinallytheconcentrationofHC=0.4g/km,CO= 1.403g/km,CO_2=47.3g/km
Totalconcentrationofcarbonbasedcompounds emitting from the engine C
=HC+CO+CO_2=49.1 g/km
ConcentrationofCarbonbasedcomponents C
= 49.1 (g/km) = 4.91 mg/L

C) Carbonusagerate(CUR)

The amount of carbon in the activate from that is neededtoadsorbtheconcentrationoftotalcarbon emitted

CarbonusagerateCUR= $\frac{(C1-C2)Vf}{(\frac{a}{m})}$
=1.005752*10^{-5}g/sec=0.64060 g/day

D) Changeoutperiod COP

Thecopisassumedtobehalfyearly,whichgives COP as 180 days

E)AdsorptionvolumeV

AdsorptionvolumeforexhaustgasfiltrationV= $\frac{(CUR*COP)F_S}{\rho^2}$
V=$\frac{(0.640609\times180)2.5}{0.624^2}$=740.348 cm^3
AssumedminimalDiameterD=6.5cm
AreaofadsorptionA=33.183cm^2
LengthofbedL= 22.31106289cm~22.3cm

Finaldimensionsofabsorptionmodule

Diameter of the adsorption core D =6.5 cm
Length of the adsorption core L=22.3cm
Thickness of resin film t_r = 0.1D = 0.65 cm
Module diameter D_m= D + t_r= 7.15~7.2 cm
Thickness of capillary module T = 1 mm

F)Quantityofgranularactivatedcarbon

MassofGAC(m)=Density*Adsorbervolume
=461.977~462grams

5. DESIGNANDDEVELOPMENT

The components are developed using Autodesk Inventor2020andtheobtainedpartdrawingare below:

1) GACCore

GAC Core ipt.png

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2) Epoxyfilm

EPoxy film.ipt.png

3) Grateplate

Grate plate.ipt.png

4) Casing

Casing.ipt.png

GAC MODULE.idw.png

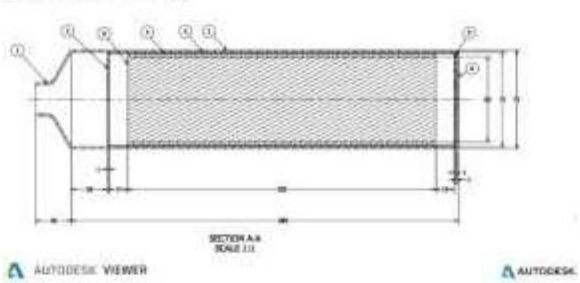

Figure5.1GACmodulesectionalview

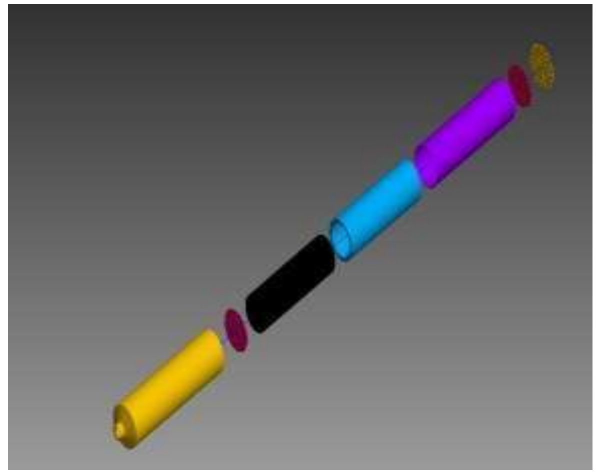

Figure5.2Explodedview

6. FABRICATION

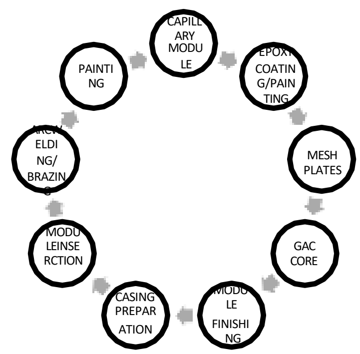

Figure6.1stepoffabrication

1) Capillarymodulefabricationbyspot welding

Figure6.2Metalsheetcutting

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Figure6.3Spotweldingmachine

2) Epoxy liner/coatingbymanualbrush painting
3) Great/mesh platesfabricationby cutting and poking

Figure6.4Grateplates

4) GAC core fabrication by manual compacting.

Figure6.5activatedcarbonblendedwithepoxy

Figure6.6ModulestuffedwithGAC

5) Modularfinishing/assembly
6) Casingpreparation
7) Modularinsertion
8) Welding

Figure6.7EFSprototype

7. CONCLUSION

This research aims to solve a way to minimise carbon emissions by employing a filter, which are a significant concern for internal combustion engines (IC engines) caused by fuel combustion. A membrane filtering system for exhaust gas has been developed and prototyped using Autodesk Inventor; it operates on the concept of adsorption and membrane separation. A 46% decrease in total carbon emissions was achieved by using this filter. Carbon dioxide, hydrocarbons, and carbon monoxide are its primary adsorbents.Both the design and the fabrication of the prototype have been shown.

7. References

[1] Exhaust gas purification process using fly ash-based sorbents, an articulated work put by A.Ściubidło, I.Majchrzak-Kucęba of institute of advanced energy technologies, Czestochowa University of technology, Poland. Their work comprises of designing a fly ash based sorbent for NO_2 capture and separationfromexhaustgasat room temperature. They concluded that after impregnation with PEG the sorption capacity of SBA-15(FA) increased from1.6 mg NO_2g^{-1} to 3.2 mg NO_2g^{-1}. The results show that highest sorption capacity characterized zeolite Na-X-(FA) 44.7 mg NO_2g^{-1} sorbent.(// published in ELSEVIER/Fuel/ 258(2019)116126/).

[2] Automobile exhaust gas purification materialbased on physical adsorption of tourmaline powder and visible light catalytic decomposition of g-c_3N_4 / $BiVO_4$,a workcarried byYang Li,XiangyangXing, Jianzhong Pei, Rui Li, Yong Wen, Shengchoo Cui, Tao Liu. Consist of preparing the composite photo catalytic material by the method of one step calcination and bi-dispersion direct mixing and their automobile exhaust gas purification efficiencies were tested.(// Published in ceramics international / ELSEVIER).

[3] Carbon dioxide separation from the flue gases, a technological review emphasizing reduction in greenhouse gas emission published in Hindawi publishing company (volume 2014,Article ID 828131) a work carried by Mohammed songolzadeh, Mansoorehsoleimani,Maryamtakhtravanchiand Reza sonyolzedeh has suggested bulk absorption and adsorption process for CO_2 separation from thestream with low CO_2 concentration and for high CO_2 concentration cryogenic distillation ,membrane process are found to be efficient.

[4] The chemical CO_2 capture by carbonation – decarbonation cycles a work carried by Jialiu, Jan baeyens, Yimindeng, Tianwei tan, Huilizhang focusses on the abatement of CO_2 emitted from combustion and establishes a method which is less expensive and has low operation cost compared to standard methods, two major material Mg O and Mg $(OH)_2$ were screened and the macro thermo gravimetric experiment was conducted to knew the yield and a best suited material was found.

(// published in Journal of environmentalmanagement 260(2020)110054).

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[6] Design and optimization of exhaust system for internal combustion engines work carried by Lalitzipre, Prathmeshaher, Prathmeshjalgonkar, Mohammed altaf, Prof.T.Z.Quazi for practical reduction of weight compacting the system and the main feature of introducing a active back pressure control valve.(//IJSER, ISSN 2229-5518, Volume 9, Issue 5, May 2018//).

[7] Design and testing of automobile exhaust system, a paper submitted by Akshaytajane, Mahesh jadhav, Rumdeorathod, Vilas elavande. Their workcomprises over the improvement of design and comparing it with existing system.(// IJRET, ISSN 2321- 7308, Volume 03, Issue 11, Nov 2014//).

[8] Adsorption on activated carbon of hydrogen, Methane, Carbon dioxide gases and their mixture at 212Kto301Kanduptothirty-fiveatm,athesiswork carried by Kenneth Alfred roger. This project focussesoverobtaininganadsorptionpotential

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theory characteristic curve, many methods and approaches were employed to find a best suitable adsorption material.

[9] Project of exhaust gas cleaning form marine diesel engine in the arctic region by JonBernodusson, Subject Leader, Research and Development Icelandic Transport Authority. This project majorly concludedutilising scrubbing as a means to clean exhaust gases from diesel engines aboard ships, even solely using water spray, has proven effective. The removal of CO2 and NOx can be increased significantly by including additional substances, such as solution of calcium and urea,with the water spray.

[10] Dynamics study of an automobile exhaust system is a thesis work by Johan wall karlaskrona. Majorly focused on forming a basis for improving design and the development of a computationally inexpensive theoretical system mods. The modelling simulationandexperimentalinvestigationofatypical exhaust system are performed.

[11] Design of catalytic converter for stationary diesel engine by AjinkyaB.Patil, RajaramM.Shinde has worked on designing a catalytic converter from engine specification and a discussion over materials for catalytic converter were contributed overmaterials for catalytic converter were contributed.(// published in journal of basis and applied engineering research ISSN 2350-0077, Volume 2 , April – June 2015 PP//).