iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** XII **Month of publication:** December 2023

DOI: https://doi.org/10.22214/ijraset.2023.56946

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XII Dec 2023- Available at www.ijraset.com

Air Carbon Filter

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Abstract: All over the globe, billions of people use vehicles in their day to day life. It includes public and private transport as well. Vehicles running on fossil fuels emit large amount of carbon and volatile organic compounds. These compounds are hazardous for the environment as well as for the human beings. These emissions contributes greatly in increasing pollution and global warming. This pollution leads to many respiratory health diseases. The Air Carbon filter helps to reduce the release of these hazardous elements and carbon in the environment. These carbon filters work on the principle of adsorption using activated carbon. It also adsorbs odour and foul smell to emit clean and fresh air.
Keywords: Air Carbon Filter, Activated carbon, Adsorption, Pollutants, Air Pollution, Filtration Technology.

I. INTRODUCTION

Vehicle emissions have become a significant contributor to air pollution worldwide, particularly in urban areas. Numerous pollutants, such as nitrogen oxides (NOx), volatile organic compounds (VOCs), particulate matter, and carbon monoxide (CO), are produced when fossil fuels are burned in engines. These pollutants not only help to create smog, but they also seriously endanger the health of anyone who breathes in contaminated air. These emissions have a negative impact on respiratory health, cardiovascular health, and general well-being in addition to causing smog and contributing to poor air quality. Effective air carbon filters that use activated carbon to target and absorb pollutants generated by automobiles are becoming more and more necessary in order to address these issues. These filters are essential for minimising the negative impacts of vehicle emissions on air quality and human health. A developing market exists for efficient air carbon filters that make use of activated carbon to counter the negative impacts of automobile emissions. These filters are an essential part of managing the environmental and health concerns related to transportation since they significantly reduce the impact of vehicle emissions on air quality. Following a specialised treatment procedure, activated carbon has exceptional adsorption capabilities that make it highly efficient at removing a variety of air pollutants.

High surface area and a complex network of tiny pores on activated carbon give it its enormous adsorption capacity. An air carbon filter's activated carbon functions as a very effective absorbent when vehicle emissions travel through it. Adsorption takes place when the contaminants in the exhaust gases come into contact with the activated carbon. The porous nature of the activated carbon attracts and traps the contaminants, preventing their release into the environment. In locations with heavy traffic, such as cities and congested metropolitan centres, the usage of air carbon filters in automobiles is very crucial. They may efficiently lower the amount of contaminants that enter the cabin by integrating these filters into vehicle ventilation systems, giving occupants a healthier and more comfortable environment.

With its distinct adsorption abilities, activated carbon is essential to this filtration procedure. These filters use activated carbon that has been processed to have a large surface area and innumerable tiny pores that enable it to adsorb a variety of airborne contaminants. VOCs (Volatile Organic Compounds) are one of the main contaminants that air carbon filters are designed to remove. These substances, which are released as a result of gasoline evaporation and vehicle exhaust, can be detrimental to human health and contribute to the creation of smog and ground-level ozone. VOCs can be effectively absorbed by activated carbon, which can lower their concentration and lessen their negative effects on air quality.

In addition to VOCs, certain nitrogen oxides (NOx) released by moving cars can also be captured by air carbon filters that use activated carbon. Even while the amount of NOx that can be removed merely through activated carbon adsorption is constrained, some types of activated carbon can chemically react with NOx to transform it into less dangerous molecules. The effectiveness of air carbon filters in lowering nitrogen oxide emissions is improved by this extra capability. Additionally, air carbon filters can help to lessen smells brought on by vehicle emissions, such as the odour of petrol or diesel exhaust. These filters' activated carbon can neutralise and absorb these pungent substances. The air carbon filter has a perfect filter size, a good air flow and can be maintained feasibly.

II. LITERATURE REVIEW

This papers discusses about the current progress in air filtration technology considering the two different strategies for air filtration, the first one is about the optimization of the structure of the filter and the second one is based on the enhancement of electrostatic interaction. Three different structure-based techniques are reviewed, including fiber morphology modification, component hybridization, and multilayer stacking, and then three interaction-based approaches that operate by imposing charge are discussed, such as induction charging, triboelectric charging, and corona charging. Furthermore, two types of active air filtration applications are comprehensively discussed as interaction-based approaches. The review concludes by discussing the current limitations and future prospects of air filtration technologies, including applications beyond air purification. The controlling and optimization of these structural properties provide a route to design high-performance air filters. For taking into consideration, the fiber diameter is a fundamental design factor for a air filter that has been the most intensely discussed because of its extreme influence on filter structure.

Air filters are frequently used after looking at the concern of harmful volatile organic compounds like ethylbenzene, and xylene isomers (BTEX) benzene, toluene etc. Filters were found on the basis of particles sizes. The study tells us that this harmful organic compound can cause problems related to respiratory system (allergy, asthma, and inflammation). Cabin filters are typically designed to reduce concentrations of any incoming substances. Particles pass through a filter, their random movements cause them to be removed by the filter fabric (material used for filteration) through interception. Particles with larger diameter cannot be pass through filter paper or fabric. First air passes through a 6-inch flexible aluminum pipe . Two turbulence mixing blades were installed inside the pipe in order to create the needed turbulence for incoming air flow, including air mixing for both gases and particles.at the end it has 12v battery with specific resistance ,allowing to replicate the operation of the fan.in this paper 11 filter was tested which tells how big is a particle .This study tells us how important the carbon filter is and should be used to reduce the organic waste that comes out.

Activated carbon-based air filters (ACBAFs) are used to remove harmful contaminants and impurities in the air, such as VOCs, CO2, NO2, and SO2. There are two techniques used to improve indoor air quality: adsorption and filter-based techniques. Adsorption is a surface phenomenon in which solid surfaces attract gas molecules or liquid solutions. Activated carbon is the adsorbent used to remove air contaminants. Adsorption can occur through physisorption or chemisorption. Increasing the specific surface area of the activated carbon can improve the adsorption capacity. The adsorption process involves solute diffusion near the solid surface, diffusion into the pores of the particle, and adsorption to the pore wall surface. ACBAFs are made from different carbonaceous materials, such as coconut shells, activated charcoals, fiber rejects, and commercial fibers. ACBAFs can be produced by physical or chemical activation processes. The choice of activation method depends on the density of the carbon material used. Coconut shell, activated charcoal, and bamboo charcoal-based activated carbon have high thermal and chemical stability and good adsorption capabilities for harmful gases. The performance of ACBAFs depends on the activated carbon used and the filtration process.

The article describes the methodology used in the Prospective Urban and Rural Epidemiological (PURE) Air Household Air Pollution study, which collected personal and household air samples in multiple sites in China and India. Filters with different mass concentrations were selected based on their absorbance levels for analysis using image-based reflectance (IBR) technique and compared to other methods. Calibration samples consisting of varying amounts of pure elemental carbon were also generated for analysis. The manual smoke stain reflectance (558) method and the IBR method were used to measure the reflectance of the filters. The article also describes the measurement chamber, illumination system, camera, and photo acquisition method used in the IBR method. Finally, the effect of the chamber on the absorbance data was investigated, and it was found that it did not significantly affect the data.

A great deal of understanding of the mass transfer mechanisms involved has been established over the past 50 years due to the widespread usage of filtering systems based on activated carbons in industrial applications . Unexpectedly, the use of activated The use of carbon filters in buildings has been sporadic, and one cause is likely the paucity of data on these systems' actual efficacy in actual building operating setups. This subject is investigated in the current study by examining the ability of packed-bed activated carbon filters to enhance the indoor air quality of homes and offices. The technique relies on dynamic simulations with a filter model that takes into consideration advective transports, boundary layer diffusion surrounding the activated carbon grains, diffusion, and adsorption/ desorption within the grains. A lot of focus has been placed on using elemental models that are tailored to the unique requirements of indoor air quality as opposed to industrial applications. The model specifically takes into consideration the impact of temperature, humidity, and competition for adsorption between all the species present in the air. The filter's breakthrough time for different pollutants at typical indoor concentration levels serves as a gauge of its air-cleaning efficiency.

The variety of impurities discovered in indoor areas, this demonstrates that the subject of filter performance cannot be addressed worldwide, and the question of how frequently the filtering media must be changed is not as straightforward as one might believe.

The majority of outdoor air purifier methods are derived from related gas treatment technologies and industrial waste gas. Dust removal, gas purification, and sterilising technology are the three primary divisions of the technology. Filtration purification, activated carbon adsorption purification, water washing purification, electrostatic purification, plasma purification, photocatalytic purification, and other purification techniques are the principal methods for purifying outdoor air. In this case, atmospheric dust removal technology has been used to develop outside air dust removal technology. The two most popular techniques are electrostatic dust reduction and fibre filtration. The most popular methods for gas purification and sterilisation are activated carbon filtration for gases and ozone and UV radiation, respectively. We now use HEPA, washable, and carbon filters for purification. The air blower fan first draws air in from all four sides. After the washable filter, a HEPA filter purifies the air.

Once more, it is purified after passing through an activated carbon filter. Finally, monitoring occurs as all of the purified air exits. The sensors are used to read or sense the air quality during the dispensing process and provide the main controller with the necessary information. One exhaust fan has been fixed to allow air suction by applying pressure to the air. Better air quality filters are used to remove all of the air, and data can be viewed on a display.

III. METHODOLOGY/EXPERIMENTAL

A Construction and Working Principle of Air Carbon Filter using Activated Carbon.

Graph(1)

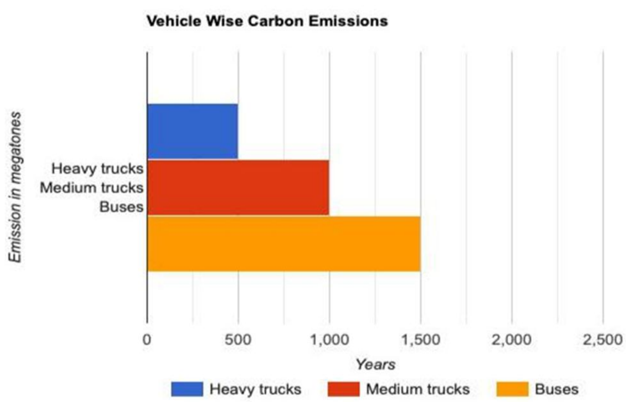


Fig.(1

To start with the working of air carbon filter numerous points of reference were taken into consideration. Data was collected and compiled the information on the environmental impacts of carbon emissions produced by commercial and heavy-duty vehicles. Studies on air pollution, greenhouse gas emissions, and their impact on air quality and climate change were conducted. Data from Air Quality Monitoring Stations was researched which are stationary devices set up in various locations to measure various pollutants in the air, such as particulate matter (PM2.5, PM10), ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO). For greenhouse effects Remote sensing and satellites were studied which are satellites equipped with remote sensing instruments can provide data on various atmospheric components and pollutants. These instruments can measure things like greenhouse gases (e.g., carbon dioxide, methane), aerosols, and temperature profiles. Mobile Monitoring units were studied which involve vehicles equipped with air quality sensors and instruments that drive around specific areas, collecting data on pollutant levels, emissions, and variations across different locations. The databases of Emission inventories were also analyzed which estimated the amounts of various pollutants and greenhouse gases released into the atmosphere from various sources, such as industrial processes, transportation, and energy production.

Based on the datasets which were collected and studied thoroughly research was conducted for selection of proper material. For the materials used in a vehicle's exhaust system, durability and heat resistance are essential. A material selection study for an air carbon filter using activated carbon involves considering various factors to choose the most suitable materials for the filter's construction. Analysis for different types of materials commonly used in air filter construction, including the frame, support media, and sealing materials was performed.

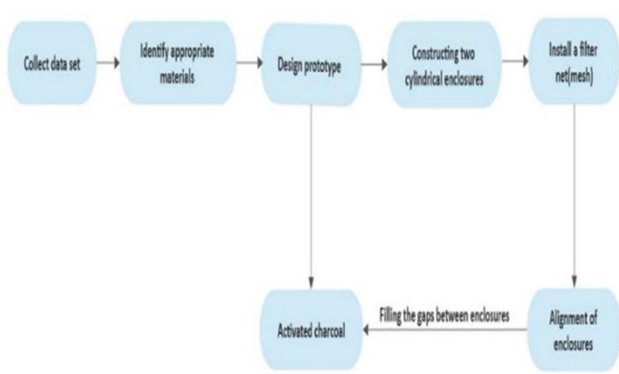
The material to be chosen should also be compatible with activated carbon as it should not react with or adsorb the activated carbon's surface area. Chosen materials should resist degradation from exposure to air pollutants, temperature fluctuations, and moisture. Finally Stainless Steel was selected as the best suited material which met all the criteria mentioned above.

Further techniques for activation of charcoal carbon were taken into consideration. Activated carbon is created by the process of "activation," which involves heating carbon-rich materials, typically charcoal or carbonaceous substances, to high temperatures in the presence of an activating agent or gas. This process creates a highly porous structure with a large surface area, making activated carbon highly effective for adsorbing gases and impurities. So start with crushing the carbonized material(charcoal) into a fine powder or small granules. Mixed the crushed charcoal with water to form a paste-like consistency. The water helps open up pores within the charcoal structure. Then placed the formed charcoal paste in a sunny area with good air circulation to allow the water to evaporate over time. During the sun drying process, physical and chemical changes occur within the charcoal. The heat from sunlight contributes to the activation process. The combination of water's swelling effect on the charcoal structure and the drying process leads to the creation of pores and an increased surface area. The sun's heat may cause chemical reactions within the carbon structure, enhancing its adsorptive properties. The combination of sunlight and air exposure helps facilitate the drying process and promotes the development of pores and internal structure within the charcoal. The precise activation achieved through this process can vary based on factors like the type of carbon source, particle size, drying conditions, and local climate.

In the fabrication process place the cylindrical encasements parallel and attach a filter net, derived from heat-resistant materials, onto both of them. For this we have to determine the dimensions and specifications of the cylindrical encasements, including diameter and length. Calculation of the volume of activated carbon needed to fill each encasement adequately is to be performed. Applying foam gaskets or rubber seals to the ends of the encasements to ensure an airtight fit between the encasements and other components. Installing a filter net of the same material on both cylindrical encasements. Fitting the smaller cylindrical encasement in the bigger encasement with proper alignment. Filling the gap between the two encasements with activated carbon. Fill each encasement with the calculated amount of activated carbon ensuring that the carbon is distributed evenly throughout the encasement.

Finally installing the carbon filter on the silencer/exhaust of the vehicles. Carefully positioning the air carbon filter near the chosen installation location, aligning it with the mounting points. Using clamps or brackets to secure the filter in place. Tightening them securely but avoid over-tightening, which could damage the filter housing. Ensure there are no gaps or leaks between the filter housing and the vehicle's exhaust system. Using gaskets or high-temperature sealants to create an airtight seal around the filter connections.

Block diagram(1)



Fig(2)

IV. RESULTS AND DISCUSSIONS

Air carbon filters have been extensively studied and proven to be highly effective in improving indoor air quality. Air carbon filters highlight their impressive pollutant removal efficiency, odor control capabilities, versatility in applications, and the associated health benefits.

These findings affirm the effectiveness of air carbon filters in improving indoor air quality and emphasize their importance in creating a healthier and more comfortable indoor environment.

The adsorption efficiency of activated carbon in an air carbon filter can be mathematically derived using the concept of adsorption capacity and the initial and final concentrations of the targeted pollutant. Assumptions for the derivation are The mass transfer resistance within the activated carbon particles is negligible and the adsorption process is independent of the concentration of the pollutant (non-competitive adsorption). The adsorption process follows Langmuir adsorption isotherm, which is commonly used to describe adsorption onto a surface. Symbols:

Qe: Equilibrium adsorption capacity of the activated carbon (mass of pollutant adsorbed per unit mass of activated carbon) at the given conditions.

C0: Initial concentration of the pollutant in the air entering the filter.

C: Concentration of the pollutant in the air leaving the filter.

V: Volume of air passing through the filter. m: Mass of activated carbon in the filter. Derivation:

The amount of pollutant adsorbed onto the activated carbon is given by the Langmuir adsorption isotherm equation:

$Qe = (k * C0) / (1 + k * C0)$

The mass of pollutant adsorbed onto the activated carbon is given by:

$m\_adsorbed = Qe * m$

The mass of pollutant removed from the air is the difference between the initial and final masses of the pollutant: $m\_removed = C0 * V - C * V$

The adsorption efficiency (E) is the ratio of the mass of pollutant adsorbed to the mass of pollutant removed:

$E = (m\_adsorbed / m\_removed) * 100$

Substituting the expressions for m_adsorbed and m_removed:

$E = (Qe * m) / (C0 * V - C * V) * 100$ Substitute the expression for Qe:

$E = ((k * C0) / (1 + k * C0)) * (m / (C0 * V - C * V)) * 100$

This equation provides the adsorption efficiency of the activated carbon in the air carbon filter using the Langmuir adsorption isotherm assumption.

V. FUTURE SCOPE

Future air carbon filters for vehicle emissions have a lot of space to grow and develop in order to better meet the difficulties of the air pollution. The potential areas of development are:

1) *Enhanced Adsorption Efficiency:* Enhancing the adsorption capacity and effectiveness of activated carbon in air carbon filters might be the subject of research and development initiatives. This may entail the investigation of novel materials, adjustments to the structure of activated carbon, or the creation of novel adsorbents with improved adsorption capabilities. The removal of contaminants from vehicle emissions, including VOCs and nitrogen oxides, can be improved by increasing the adsorption efficiency.
2) *Advanced Filtration Technologies:* Hybrid systems with complete pollutant removal capabilities can be made by integrating air carbon filters with other advanced filtration technologies. By combining air carbon filters with other technologies like electrostatic precipitators, catalytic converters, or selective catalytic reduction (SCR) systems, particulate matter, NOx, and other harmful pollutants from vehicle exhaust can be removed from the exhaust more effectively.
3) *Sustainable and Renewable Activated Carbon Sources:* The search for renewable and sustainable sources of activated carbon holds the key to the future of air carbon filters. At the moment, coal and petroleum-based materials are the main non-renewable sources of activated carbon. But new developments in biomass conversion technologies and the use of waste products, including agricultural byproducts or residues, can provide sustainable and environmentally acceptable sources of activated carbon, lowering the carbon footprint connected with its manufacturing.

VI. CONCLUSION

Air carbon filters provide an efficient and versatile means of combating air pollution and improving indoor air quality. Their ability to capture gaseous pollutants, versatility in different applications, superior odor control, and promotion of healthier living and working spaces make them a valuable tool for ensuring clean and fresh air in various environments.

VII. ACKNOWLEDGMENT

The authors of this paper would like to acknowledge the important role that activated carbon plays in air carbon filters, where it has proven to have outstanding adsorption abilities in removing and retaining a variety of contaminants from exhaust. The vast surface area and countless small pores in activated carbon's porous structure allow for the efficient adsorption of pollutants like nitrogen oxides (NOx), volatile organic compounds (VOCs), and odorous compounds produced by vehicle emissions. We would also like to thank our project guide Swati A. Joshi for supporting us and helping us understand the project deeply at every point.

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