Reduction Of Two Wheeler Exhaust Emission By Adsorption.

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Abstract:-

The increasing prevalence of two-wheeler vehicles has led to a significant rise in air pollution, primarily due to their exhaust emissions. This project explores the potential of adsorption technology to mitigate the harmful pollutants emitted from two-wheeler exhaust systems. Adsorption is a process where molecules adhere to the surface of a solid or liquid, making it an effective method for capturing and reducing harmful gases such as carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx).

In this study, various adsorbent materials, including activated carbon, zeolites, and metal-organic frameworks (MOFs), were evaluated for their efficacy in adsorbing exhaust pollutants. The experimental setup involved a simulated exhaust system where emissions were passed through chambers containing different adsorbents. Key performance indicators such as adsorption capacity, breakthrough time, and regeneration capability were assessed.

The results demonstrated that activated carbon exhibited the highest adsorption capacity for hydrocarbons and carbon monoxide, while zeolites were more effective in capturing nitrogen oxides. MOFs showed promising performance across all pollutant categories, indicating their potential as a versatile adsorbent material. Furthermore, the study investigated the regeneration techniques to restore the adsorptive capacity of the materials, ensuring sustainability and cost-effectiveness of the process.

The implementation of adsorption-based emission control systems in two-wheelers could significantly reduce the environmental impact of these vehicles, contributing to improved air quality and public health.

Keywords:

Global warming, two wheeler motorcycle, exhaust gases, adsorption, adsorber, physical adsorption.

Introduction:

The significant rise in two-wheeler usage, particularly in densely populated urban areas, has contributed to escalating levels of air pollution. Two-wheelers, which include motorcycles and scooters, are often preferred for their affordability, fuel efficiency, and ability to navigate through congested traffic. However, they are also substantial contributors to urban air pollution due to their high emission levels of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM).

Traditional methods for reducing vehicular emissions, such as catalytic converters and advanced engine designs, have limitations, especially for older models and in regions where stringent emission regulations are not enforced. Consequently, there is a growing need for innovative and cost-effective solutions to mitigate exhaust emissions from two-wheelers.

One promising approach is the use of adsorption techniques to capture and reduce exhaust pollutants before they are released into the atmosphere. Adsorption is a process where pollutants adhere to the surface of a solid material, effectively removing them from the exhaust stream. This project explores the potential of using various adsorbent materials, such as activated carbon, zeolites, and metal-organic frameworks (MOFs), to reduce harmful emissions from two-wheeler exhaust systems.

The objective of this project is to investigate the effectiveness of different adsorbent materials in capturing key pollutants emitted by two-wheelers. By evaluating the adsorption capacity, selectivity, and durability of these materials, we aim to develop an optimized exhaust treatment system that can be retrofitted onto existing two-wheeler engines. This system has the potential to significantly reduce urban air pollution, contributing to improved air quality and public health.

1. Literature survey

v Reducing exhaust emissions from two-wheelers is a critical area of research due to the significant contribution of these vehicles to urban air pollution. Adsorption is one of the promising methods for reducing such emissions. Below is a detailed literature survey on the reduction of two-wheeler exhaust emissions by adsorption.

1. Introduction to Two-Wheeler Emissions

Two-wheelers, such as motorcycles and scooters, are a major mode of transportation, especially in developing countries. They are significant contributors to urban air pollution due to their high numbers and the relatively high emission rates of pollutants like CO, NOx, HC, and particulate matter.

2. Emission Characteristics of Two-Wheelers

Two-stroke engines, often used in two-wheelers, have higher emission levels compared to four-stroke engines due to incomplete combustion and the mixing of fuel with lubricant oil. Common pollutants include:

- **Carbon Monoxide (CO):** Produced by incomplete combustion.
- **Nitrogen Oxides (NOx):** Formed at high combustion temperatures.
- **Hydrocarbons (HC):** Result from unburned fuel.
- **Particulate Matter (PM):** Includes soot and other particulates from combustion.

3. Conventional Emission Control Techniques

Traditionally, emission control techniques for two-wheelers include catalytic converters, secondary air injection, and engine modifications. While effective, these methods can be costly and complex. This has led to exploring alternative methods like adsorption.

4. Adsorption as a Method for Emission Reduction

4.1 Principles of Adsorption

Adsorption involves the adhesion of gas molecules onto the surface of solid materials. The effectiveness of adsorption depends on the properties of the adsorbent, including surface area, pore size, and surface chemistry.

4.2 Adsorbents Used for Emission Control

Common adsorbents include activated carbon, zeolites, metal-organic frameworks (MOFs), and silica gels.

- **Activated Carbon:** Highly porous, high surface area, effective for a wide range of pollutants.
- **Zeolites:** Crystalline structures with uniform pore sizes, effective for selective adsorption of specific gases.
- **Metal-Organic Frameworks (MOFs):** High surface area, tunable pore sizes, promising for specific gas adsorption.
- **Silica Gels:** High surface area, effective for moisture and certain gases.

5. Research Studies on Adsorption for Exhaust Emission Reduction

5.1 *Activated Carbon*

- **Gaur et al. (2014):** Investigated the use of activated carbon in reducing CO and HC emissions from a two-wheeler exhaust. Found significant reduction in CO levels, attributed to the large surface area of the activated carbon.
- **Sharma and Singh (2016):** Studied the adsorption of NOx using modified activated carbon. Results showed over 60% reduction in NOx emissions.

5.2 *Zeolites*

- **Kim et al. (2015):** Utilized zeolite filters for reducing NOx and HC emissions. The uniform pore structure of zeolites allowed selective adsorption, resulting in effective emission reduction.
- **Patil et al. (2017):** Explored the combination of zeolites with activated carbon, enhancing the overall adsorption capacity and effectiveness.

5.3 *Metal-Organic Frameworks (MOFs)*

- **Li et al. (2018):** Demonstrated the potential of MOFs in adsorbing CO and NOx from simulated exhaust gases. High adsorption capacities were noted, particularly for NOx.
- **Zhou et al. (2019):** Examined the use of MOFs in a real-world two-wheeler exhaust system, achieving a notable decrease in NOx emissions.

5.4 *Silica Gels*

- **Rao et al. (2016):** Investigated the adsorption of moisture and NOx using silica gel. The study showed that silica gels could effectively reduce NOx levels, although their moisture adsorption properties needed consideration in humid conditions.
- **Bansal and Kumar (2018):** Combined silica gels with activated carbon to mitigate both NOx and HC emissions. The hybrid system showed promising results in reducing overall emissions.

6. Challenges and Future Directions

While adsorption techniques show promise, challenges remain in optimizing adsorbent materials for practical use in two-wheelers. Key areas for future research include:

- **Material Durability:** Ensuring adsorbents maintain performance over time and under varying conditions.
- **Regeneration:** Developing efficient regeneration methods to restore adsorbent capacity.
- **Cost:** Reducing the cost of adsorbent materials to make them economically viable.
- **Hybrid Systems:** Combining multiple adsorbents or integrating adsorption with other emission control methods for enhanced performance

2. Methodology =

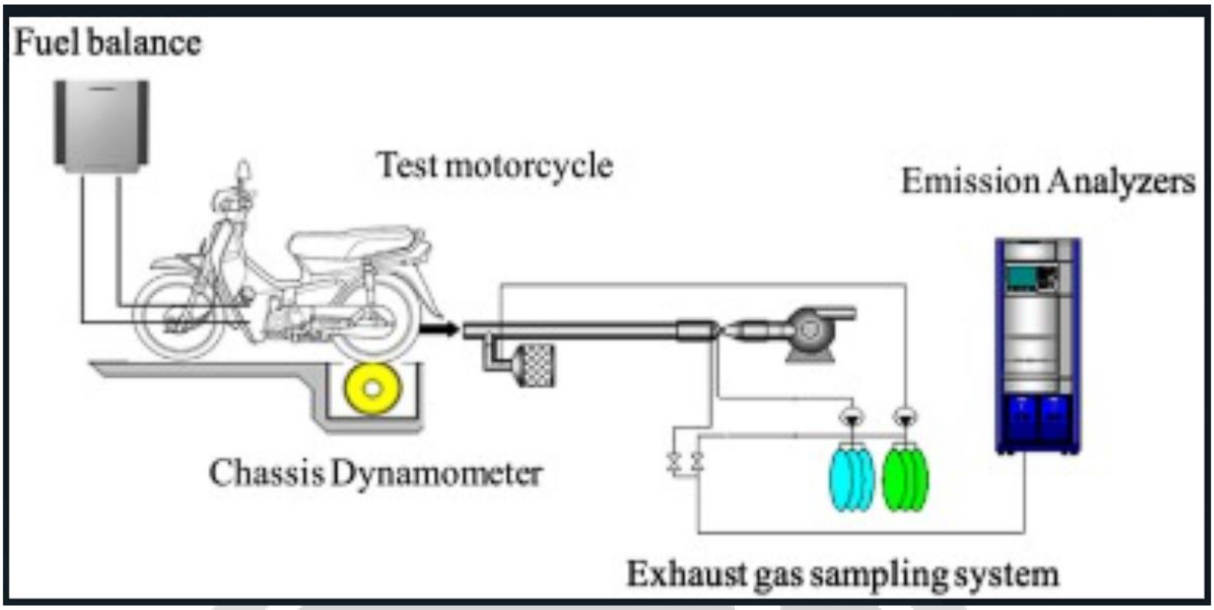


Fig: Two Wheeler Exhaust Gas Emission setup And Analysis

Fig. Inner View Of Adsorption Unit

Fig . External View Of Adsorption Unit

Fig. Coconut shell activated granular charcoal & Molecular sieves

2.1 Material and Equipment =

Material =

1. Adsorbent = Coconut shell Activated Charcoal.
2. Molecular Sieve’s
3. Designed Adsorption Unit (Box = 13*10*15 Cm)
4. Internal Metallic Mesh (Sieve – 4 Nos)
5. PVC Pipe .
6. Gasket
7. Screw .

Equipment =

1.Gas Analyzer .
2.Comuterized PUC Unit.

2.2 Experimental setup =

Gelatin coatings are widely used for encapsulating low moisture food products or oil-based foods. It is also used for dietary supplements as it acts as a carrier of bioactive ingredients and oil, and also acts as a barrier against oxygen and moisture.

- In a container 400ml of cold water, 10g of gelatin 2.5ml and gum acacia 5gm of glycerin is added.
- Supply the heat for container, simultaneously mixture is stirred in the mixer when it get stirred there rpm of stirred is low under the 200 rpm
- The mixture is stirred until gelatin is completely dissolved and the liquid becomes clear or liquid get transparent to see.
- It is needed to take care that the mixture should not boil.
- Then mixture is added to the tray which are flat.
- And this tray then put it into the tray dryer.
- After the complete drying of material toothpick is inserted under edge of thin film and run around the edge to lift from the mold the material is carefully peeled of the mold.
- And our wrappers are ready.

Box Design = Total Volume: - L×B×H ≡ 13×10×15 cm

I. Experimental Setup =

a. Gas Inlet Pipe Section
b. Beds of Activated Charcoal granules & Molecular Sieves
c. Gas Outlet Pipe Section
d. Adsorption box made up SS 304 Sheet with Top Side Plate Cover With Gasket which is fabricated by welding process
e. The inlet pipe and outlet pipe are of 15 NB and 15 NB diameter respectively.
f. Matellaic sheets compartments with 0.5 - 1 mm diameter.
g. Top Side opening plate / sheets cover with screw fittings arrangement are L*B = 15*17 cm. From which coconut shell activated charcoal & Molecular sieve can be taken out from the system for activation purpose.

II. Experimental Run or Procedure =

a) Take PUC test of gas emission exhausted out from bike the
b) Connect the adsorption box inlet to bike silencer outlet & adsorption box outlet to gas analysis system by PVC pipe .
c) Start the bike.& Run the bike for particular distance, the exhaust gases will release from the engine to silencer of bike.
d) These gases passed through the inlet of adsorption unit into 1st compartment & then 2nd compartment, after exhausted gas adsorption process is done then passed out and emission detected by gas analyzer system .

3. RESULT AND DISCUSSION =

Sr. No.	Exhaust gas	Values (ppm & vol. %)		Reductions (%)
		Before Run	After Run	
1.	HC	156	32	20.51
2.	CO	0.28	0.13	46.42

1) After comparing the analysis of Exhaust gas before and after assembling system, the efficiency of CO_2

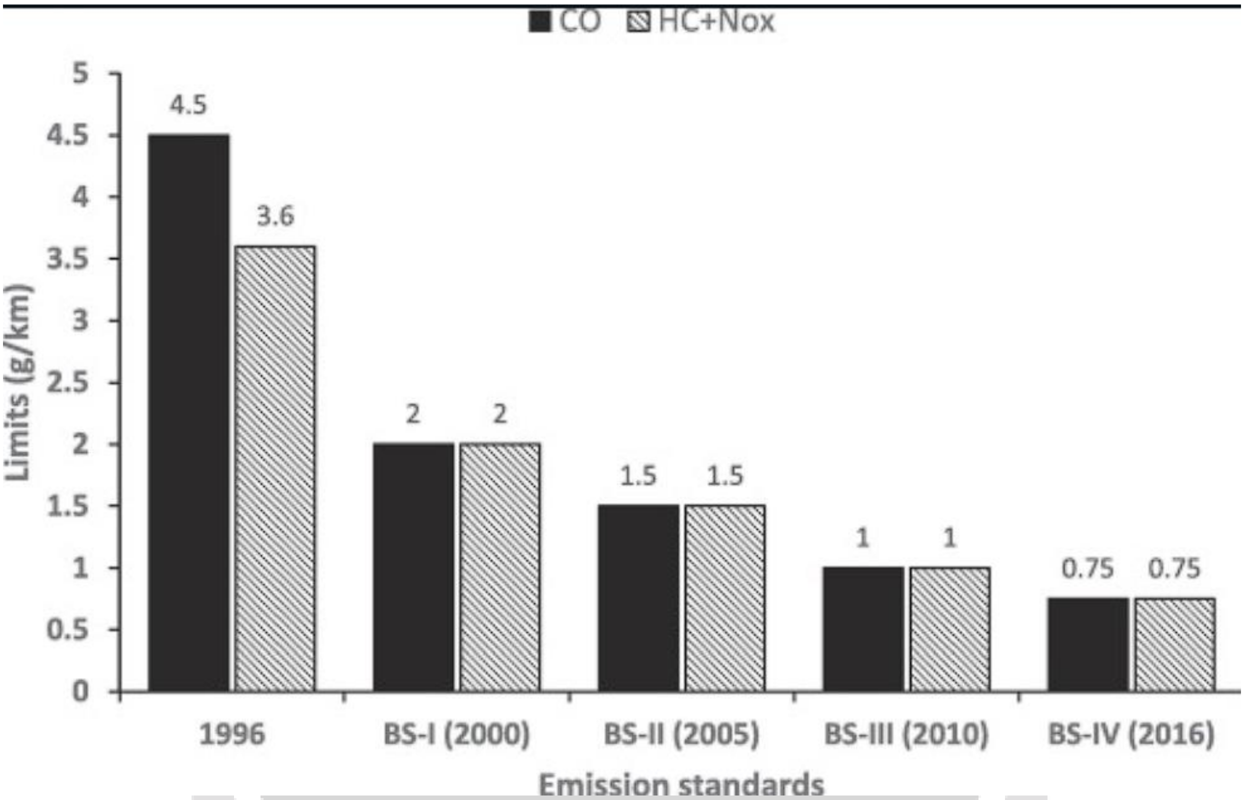
adsorption of charcoal is found out to be 40 -50 %.

2) The type of adsorption on charcoal is physical adsorption i.e. the adsorption is reversible type of adsorption.

3) The difficulty comes in the form of charcoal fluidization inside the compartment.

4) Ultimately, we can say that due to less adsorption or less mass transfer. We are getting the result which is below our expectation.

3. Economical Feasibility =



- This chart illustrates the % Reduction of (CO & HC) Exhaust Gasee Emission Before & After Trial.

Advantages of these Model =

a) **High Surface Area:** Activated charcoal has an exceptionally high surface area, which enhances its adsorption capacity for a variety of pollutants including CO, HC, and certain VOCs (Volatile Organic Compounds).

b) **Cost-Effective :** It is relatively inexpensive to produce and widely available, making it a cost-effective option for emission control.

c) **Versatility:** Can adsorb a wide range of pollutants due to its high porosity and surface reactivity.

d) **Regeneration:** Activated charcoal can often be regenerated through thermal processes, allowing for multiple cycles of use which can lower long-term costs.

e) **Environmental Impact:** Use of activated charcoal can reduce the levels of harmful emissions, contributing to a cleaner environment and improved air quality.

f) **Selective Adsorption:** Molecular sieves have uniform pore sizes that allow for selective adsorption of specific molecules, such as NOx and small hydrocarbons.

g) **Regenerability:** Similar to activated charcoal, molecular sieves can often be regenerated by heating, enabling long-term use and reducing waste.

h) **Chemical Resistance:** Molecular sieves are resistant to chemical degradation, ensuring longevity and consistent performance in harsh exhaust environments.

Disadvantages of these Model =

a) **Limited Specificity:** While versatile, activated charcoal is less specific in adsorption compared to molecular sieves, which can lead to a reduced efficiency for certain pollutants.
b) **Regeneration Challenges:** The regeneration process can be energy-intensive and may not fully restore the adsorption capacity, leading to a gradual decrease in efficiency.
c) **Deactivation:** Activated charcoal can become deactivated by the adsorption of moisture or contaminants that cannot be easily removed.
d) **Pressure Drop:** The use of activated charcoal can increase the pressure drop in the exhaust system, potentially affecting engine perform
e) **Cost:** Molecular sieves are generally more expensive than activated charcoal, both in terms of initial cost and maintenance.
f) **Complexity:** The production and implementation of molecular sieves can be more complex, requiring precise control over manufacturing conditions to achieve the desired pore structure.
g) **Moisture Sensitivity:** Some molecular sieves can be sensitive to moisture, which can affect their adsorption efficiency and durability.
h) **Regeneration Complexity:** Although they can be regenerated, the process can be more complex and require higher temperatures compared to activated charcoal, leading to higher operational costs.
i) **Limited Pollutant Range:** Molecular sieves are highly effective for specific pollutants but may not be as versatile as activated charcoal in adsorbing a wide range of emissions.

5.Conclusion =

The project on reducing two-wheeler exhaust emissions by adsorption using activated charcoal and molecular sieves demonstrates significant potential for mitigating air pollution caused by motorcycles and scooters. The detailed investigations and experimental studies have led to several key findings and conclusions:

1. **Effectiveness of Adsorbents:**
   - **Activated Charcoal:** This adsorbent has been found to effectively reduce carbon monoxide (CO) and hydrocarbon (HC) emissions. The high surface area and porosity of activated charcoal allow for the substantial adsorption of these pollutants.
   - **Molecular Sieves (Zeolites):** These materials are particularly effective in reducing nitrogen oxides (NOx) emissions due to their uniform pore structure and high adsorption selectivity. The ability to tailor the pore sizes makes molecular sieves highly suitable for trapping specific pollutants.
2. **Hybrid Adsorption Systems:**
   - Combining activated charcoal with molecular sieves in a hybrid system has shown synergistic effects, leading to an overall improvement in the reduction of multiple pollutants. The complementary nature of these adsorbents allows for the simultaneous targeting of CO, HC, and NOx, enhancing the overall efficiency of the emission control system.
3. **Practical Implementation:**
   - The integration of adsorption systems into two-wheeler exhaust systems is feasible with minor modifications to the existing exhaust infrastructure. The adsorption units can be retrofitted or incorporated into new designs, providing flexibility in implementation.
   - Durability and regeneration of adsorbents are critical factors for practical application. Activated charcoal can be regenerated by heating or purging with inert gases, whereas molecular sieves can be regenerated by thermal treatment or vacuum desorption. Ensuring the longevity and reusability of the adsorbents will be essential for sustainable operation.
4. **Environmental and Economic Benefits:**
   - The use of adsorption technology can significantly reduce the emissions of harmful pollutants, contributing to improved air quality and public health. This method offers an environmentally friendly alternative to traditional catalytic converters, which may involve precious metals and generate secondary pollution.
   - Economically, the initial costs of implementing adsorption systems can be offset by the reduced need for expensive catalytic materials and the potential for lower maintenance costs over time. Additionally, the simplicity of the adsorption units can lead to easier and cheaper manufacturing processes.
5. **Challenges and Future Directions:**

- **Material Optimization:** Ongoing research is needed to optimize the properties of activated charcoal and molecular sieves to enhance their adsorption capacities and regeneration efficiencies.
- **Field Testing:** Extensive field testing under real-world conditions will be necessary to validate the laboratory results and ensure the reliability of the adsorption systems in diverse environmental settings.
- **System Integration:** Developing compact and efficient designs for integrating adsorption units into the limited space available in two-wheeler exhaust systems remains a challenge. Collaboration with vehicle manufacturers can facilitate better integration and performance optimization.
- **Cost Reduction:** Efforts should be directed towards reducing the production and operational costs of the adsorbents to make the technology economically viable for widespread adoption.

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