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Carbon Purification System

Dr. M. S. Yadhav, Mrs. S. V. Zanjad, Abhishek Prakash Lohar, Malhar Ravindra Kale, Vivek Surendra Gadekar, Avinash Mariba PaikraoD
JSPM's Bhivrabai Sawant Polytechnic Wagholi, Pune

Abstract- — The Carbon Purification System is designed to improve the quality of gas produced during the decomposition of organic waste. Biogas generated from kitchen waste or other biodegradable materials contains useful methane gas along with unwanted impurities such as hydrogen sulfide, carbon dioxide, and bad odor. These impurities reduce the efficiency and usability of the gas. Therefore, purification of biogas is necessary before it can be used for practical applications. This project focuses on developing a simple and cost-effective carbon purification system that uses activated carbon as the main filtering material. Activated carbon has a very large surface area with many tiny pores that can absorb harmful gases and impurities through the process of adsorption. In this system, the raw gas produced from the digester passes through different filter layers such as a pre-filter, activated carbon layer, and cotton layer, which help remove dust particles, toxic gases, and unpleasant smell. The purification chamber is designed using simple materials so that it can be easily implemented in small-scale applications such as homes, laboratories, and small biogas plants. As the gas passes through the filter layers, harmful substances are trapped and the output gas becomes cleaner and safer to use.

Keywords— Carbon purification system, biogas purification, organic waste decomposition, methane gas, hydrogen sulfide removal, carbon dioxide reduction, odor removal, activated carbon, adsorption process, gas filtration, eco-friendly energy, renewable energy, kitchen waste biogas, small-scale biogas plant, sustainable technology, low-cost filtration system, environmental protection, clean fuel generation.

I. INTRODUCTION

Industrial processes release large amounts of harmful gases and particulate matter into the atmosphere, which contribute to global warming, respiratory problems, and other health hazards. Traditional methods of air purification are often expensive, complex, and not suitable for small-scale industries. The Industrial Carbon Purification System is designed to address these issues by providing an affordable, efficient, and environmentally friendly solution. The system captures pollutants from industrial exhausts and purifies them using a combination of mechanical filtration, activated carbon adsorption, and chemical neutralization. This ensures that the air released into the environment is clean, reducing the negative impact on health and nature.

The purification process involves several stages of air treatment. Polluted air first passes through a pre-filter, which removes large dust particles, soot, and suspended impurities. It then flows through an activated carbon filter, which absorbs harmful gases and volatile organic compounds. Finally, the air enters a chemical purification chamber, where specific neutralizing agents react with toxic gases to convert them into harmless compounds. The purified air is then checked using an air quality sensor to ensure that it meets safe environmental standards.

The entire system is housed in a PVC pipe structure, making it lightweight, compact, and easy to assemble. A blower fan with a DC motor is used to maintain a continuous airflow through the system, while an Arduino microcontroller monitors and controls various parameters based on sensor readings. The system is powered by a battery supply, allowing it to function even in the absence of an external power source.

The main advantage of this system is that it is low-cost, energy-efficient, and easy to maintain. Unlike expensive industrial scrubbers and electrostatic precipitators, this design can be implemented using readily available materials, making it suitable for small- and medium-scale industries. Moreover, by integrating an air quality sensor, the system provides real-time feedback on purification efficiency, which can be used for further improvements or automation.

II. CONSTRUCTION

The construction of the Industrial Carbon Purification System begins with assembling the PVC pipe housing. The pipe is selected based on the required airflow and system size. The blower and DC motor are mounted at the inlet end to create a consistent airflow through the system. The pre-filter is installed at the air intake to capture large particles such as dust and soot, preventing clogging and damage to the subsequent filters.

The activated carbon filter is placed after the pre-filter. It works on the principle of adsorption, capturing harmful gases and volatile organic compounds from the air. The chemical purification chamber follows, containing specific chemicals that react with toxic gases to neutralize them. The air quality sensor is installed near the outlet to measure the efficiency of the purification process. The Arduino board is programmed to control the blower motor based on sensor readings. All components are connected to a battery supply using insulated wires to ensure continuous operation and safety.

After the pre-filter, the air passes through the activated carbon filter, which is filled with activated charcoal granules. Activated carbon has a very high surface area and excellent adsorption properties. It effectively absorbs harmful gases such as carbon monoxide (CO), volatile organic compounds (VOCs), smoke, and odors.

A 12V DC battery or external adapter provides the required electrical power to the blower, Arduino board, and sensors. Connecting wires and switches are used to join all electrical components in the circuit. The entire setup is mounted on a base plate to maintain stability and proper alignment of each unit.

III. WORKING PRINCIPLE

The working principle of the Industrial Carbon Purification System is based on multi- stage purification — where air is filtered physically, chemically, and electronically before being released into the environment. When the system is powered ON, the DC blower starts rotating and draws the polluted air into the PVC pipe. The blower creates sufficient pressure to push the air through all the filter chambers in sequence.

1. Stage 1 – Pre-Filtration:

The polluted air first passes through the air pre-filter, where large dust particles, soot, and debris are trapped. This step acts as the primary cleaning stage and prevents clogging in the subsequent filters.

2. Stage 2 – Activated Carbon Filtration:

The semi-cleaned air then enters the activated carbon filter, where adsorption takes place. The activated carbon granules capture toxic gases, odors, and chemical vapors on their surface. Harmful gases such as CO and VOCs are effectively absorbed in this stage.

3. Stage 3 – Monitoring and Output:

The purified air is then monitored using the MQ-135 air quality sensor. This sensor detects the concentration of gases remaining in the air and sends the data to the Arduino board, which processes and displays the air quality level. If the air is within safe limits, it is released into the environment through the outlet section of the PVC pipe.

Throughout this process, the airflow remains continuous and stable, driven by the blower. The combination of mechanical and chemical purification ensures that the air coming out is significantly cleaner and safer than the input air.

IV. PROCEDURE

The procedure for operating and testing the Industrial Carbon Purification System involves several systematic steps that ensure proper assembly, safe functioning, and accurate purification of the exhaust gases. Each stage must be carefully followed to achieve the best performance and reliable purification results. The steps below describe the complete procedure from setup to testing in detail.

Step 1 – Preparation of Components:

Before assembling the system, all components are gathered and inspected. This includes the PVC pipe, blower with DC motor, air pre-filter, activated carbon filter, chemical purification chamber, air quality sensor (MQ-135), Arduino board, battery power supply, and connecting wires. Each component must be clean and free from dust or damage.

Step 2 – Assembly of the System:

The PVC pipe is used as the main housing of the system. At one end, the blower fan with DC motor is fitted firmly using clamps or adhesive so that air can be forced into the pipe efficiently. The air pre-filter is placed immediately after the blower in the inlet section to remove larger dust particles from the incoming air. A mesh or foam-type pre-filter is most suitable here.

Next, the activated carbon filter is installed inside the pipe after the pre-filter. It can be made using a small plastic or netted container filled with activated carbon granules. This section is then followed by the chemical purification chamber, which contains layers of $Ca(OH)_2$ and NaOH separated by fine mesh screens or sponge layers to allow uniform airflow. Both ends of this chamber are sealed tightly using rubber gaskets or end caps to prevent leakage of gases.

Finally, the air quality sensor (MQ-135) is mounted near the outlet of the PVC pipe. The sensor is connected to the Arduino board using jumper wires, while the Arduino receives power from a 12V DC battery or adapter. All electronic components are securely mounted on a baseboard, and the wires are arranged neatly for safety and clarity.

Step 3 – Electrical Connections:

Once the physical assembly is complete, the electrical circuit is connected. The DC motor of the blower and the Arduino board are powered using the same 12V battery supply. The MQ- 135 sensor is interfaced with the Arduino to send real-time gas concentration data. If desired, a small LED indicator or display module can be connected to show the air quality level. A switch is added to control the system's power ON and OFF operation.

Step 4 – System Testing and Operation:

After all connections are complete, the system is tested. The switch is turned ON to start the blower fan. The fan pulls polluted or test air into the system. The air passes sequentially through the pre-filter, activated carbon filter, and chemical chamber. During this process, impurities, dust, and toxic gases are filtered and neutralized at each stage.

Step 5 – Observation and Data Recording:

During the test, observations are recorded such as:

Air quality sensor readings before and after purification Blower speed and power consumption Any visible dust collection on filters Changes in air odor or color

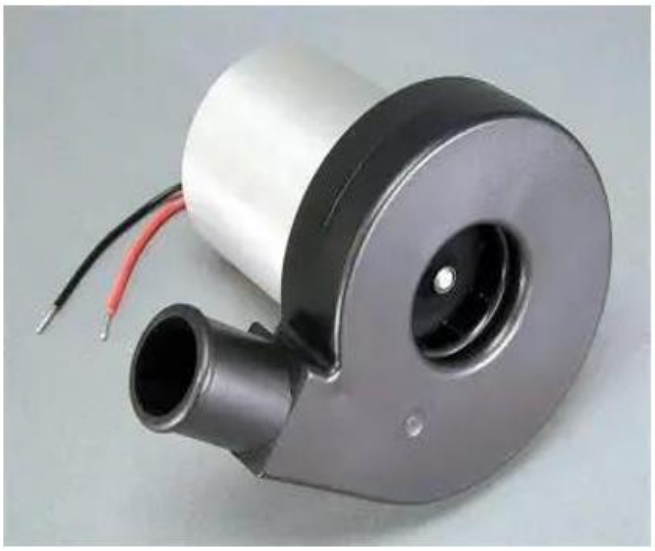
V. COMPONENTS USED

Component Name	Function / Description
1. PVC Pipe	Acts as the main housing for all components and provides a path for airflow.
2. Blower with DC Motor	Generates air pressure and circulates air through the purification system.
3. Air Pre-Filter	Removes dust particles, soot, and large impurities from the incoming air.
4. Activated Carbon Filter	Absorbs harmful gases, odors, and chemical vapors from industrial emissions.
5. Chemical Purification Chamber	Neutralizes toxic gases through chemical reactions before air is released.
6. Air Quality Sensor	Continuously monitors the purity level of the air after filtration.
7. Arduino Board	Controls system operations and processes data from the air quality sensor.
8. Power Supply (Battery)	Provides the necessary electrical power to run the system.
9. Connecting Wires	Connects electrical components and ensures proper current flow throughout the circuit.

VI. PARTS

1. PVC Pipes:-

2. Blower Fan With DC Motor:-



3.Activated Carbon Filter:-

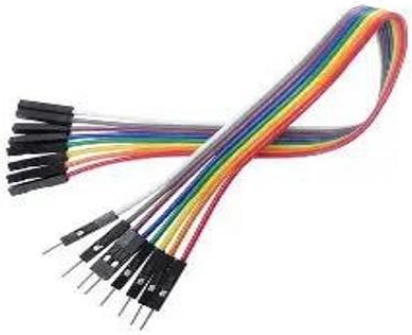
4. Air Pre-Filter:-

5.Arduino board Control system:-

6.Air Quality Sensor:-

7.Battery:-

8. Connecting Wires:-



VII. ADVANTAGES

1. Effectively reduces industrial air pollution.
2. Eco-friendly and sustainable solution.
3. Cost-effective and easy to maintain.
4. Real-time air quality monitoring ensures efficiency.
5. Can be scaled for different industrial applications.

VIII. APPLICATIONS

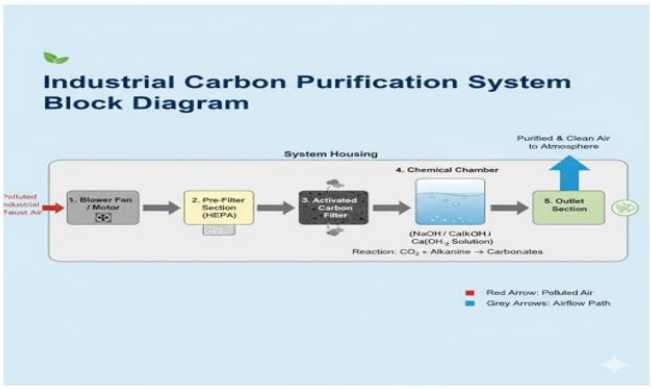
1. Chemical plants, thermal power plants, and metal processing units.
2. Laboratories and research facilities handling toxic gases.
3. Industries releasing smoke, dust, or harmful emissions.
4. Small and large-scale industrial setups needing clean air.

IX. CONCLUSION

The Carbon Purification System is an effective and simple method to improve the quality of air by removing dust, harmful gases, and bad odor using activated carbon filtration. This project demonstrates how basic materials such as a plastic chamber, filter layers, PVC pipes, and an exhaust fan can be combined to develop a low-cost and efficient purification system. The system works on the principle of adsorption, where activated carbon absorbs impurities from the air, resulting in cleaner and safer output. The use of multiple filter layers such as pre-filter, activated carbon, and cotton filter increases the efficiency of purification. This project is economical, easy to operate, and suitable for small-scale applications like homes, laboratories, and personal safety devices such as masks. It helps in reducing air pollution and promotes a clean and healthy environment. Overall, the carbon purification system is a reliable, eco-friendly, and cost-effective solution that supports renewable energy utilization and sustainable development. It has great potential for future applications in both small-scale and large-scale industries. The developed carbon purification

system successfully reduced air pollution from an inlet Air Quality Index (AQI) of 500 (severe level) to an outlet AQI of 200 (moderate level). This shows that the system is effective in removing a significant amount of harmful pollutants from the air.

X. BLOCK DIAGRAM OF CARBON PURIFICATION SYSYTEM



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