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Development of a device to capture particulate matter from vehicle exhaust

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ABSTRACT

The aim of the current study is to develop a device to capture particulate matter from air pollution, particularly from the exhaust of automobiles. Over the last few decades, India has grown tremendously. The growth has come with a tremendous disadvantage, Air Pollution. Air pollution occurs when harmful or excessive quantities of substances such as gases, particulates, and biological molecules are introduced into Earth's atmosphere. It causes diseases, allergies and even death of humans; it may also cause harm to other living organisms such as animals and crops, and may cause damage to the natural or built environment. Human activities and natural processes can generate air pollution. The study is upon developing a device to capture particulate matter and use them for the benefit of mankind. The device is expected to be a retrofit technology used to capture particulate matter which may be also called soot, which can then be processed to make ink. This ink is made of Carbon from the soot. The device can be fitted to diesel generators, small chimney stacks, or biogas burning chimneys. The device consists of sensors, filters, and a capture unit. The capture unit can consist of electrostatic filter, depth filter, and wall-flow filter.

Keywords: Particulate matter, vehicle exhaust, soot, wall-flow filter, electrostatic filter, depth filter, ink from soot.

1. INTRODUCTION

Air pollution is said to occur when harmful or excessive quantities of substances such as gases, particulates, and biological molecules are introduced into the atmosphere. It may cause diseases, allergies and also death of humans; it causes harm to other living organisms such as animals and food crops, it also damages the natural or built environment. Human activity or natural processes can both cause air pollution.

Air pollutant is a substance that has adverse effects on humans and the ecosystem. They can be solid particles, liquid droplets, or gases. Pollutants can be of natural or man-made origin. Pollutants can be classified as follows: Primary pollutants are produced from a process, such as ash from a volcanic eruption, carbon monoxide gas from motor vehicle exhaust, or sulfur dioxide released from factories.

Secondary pollutants are not emitted directly, they are formed in the air when primary pollutants react or interact. Ground level ozone is a prominent example.

1.1. Sources of air pollution

Various locations, activities or factors are responsible for releasing pollutants into the atmosphere. These sources can be classified into two major categories.

1.2. Anthropogenic (man-made) sources

These are mostly related to the burning of multiple types of fuel.

1. Stationary sources such as smoke stacks of fossil fuel power stations, manufacturing facilities and waste incinerators, furnaces and other types of fuel-burning heating devices.
2. Mobile sources such as motor vehicles, marine vessels, and aircraft.

3. Controlled burn practices in agriculture and forest management. Controlled or prescribed burning is a technique used in forest management or farming. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.
4. Fumes from paints, hair spray, varnish, aerosol sprays and other solvents.
5. Waste deposition in landfills that generate methane.
6. Military resources such as nuclear weapons, toxic gases, germ warfare and rocketry.

1.3. Natural sources

1. Dust from natural sources such as large areas of land with little or no vegetation
2. Methane emitted by the digestion of food by animals
3. Radon gas from radioactive decay within Earth's crust.
4. Smoke from wildfires
5. Vegetation in some regions emits environmentally significant amounts of VOC
6. Volcanic activity produces sulfur, chlorine, and ash particulates.

As the health hazards and effects of air pollution are evident, it makes it more important to come up with ways to reduce, control and prevent air pollution

2. OBJECTIVES

The objective is to develop a device that can capture particulate matter from the exhaust of automobiles. To confine and bind that captured particulate matter into high grade inks that everyone can use and express themselves with through art or writing.

3. DESIGN AND WORKING OF THE DEVICE

Fig.1: Model of the device

The device is a post tailpipe retrofit which consists of the following units:

3.1. Filters

This unit consists of physical filters to carry out primary filtration i.e., separation based on particle size. Larger particles are removed in the stage.

3.2. Sensors

Sensors are used to detect the filtration ability of the capture unit. It gives a signal if the filter(s) clogs and cannot function.

3.3. Capture Unit

The capture unit consists of the following filters:

3.3.1. Electrostatic filter

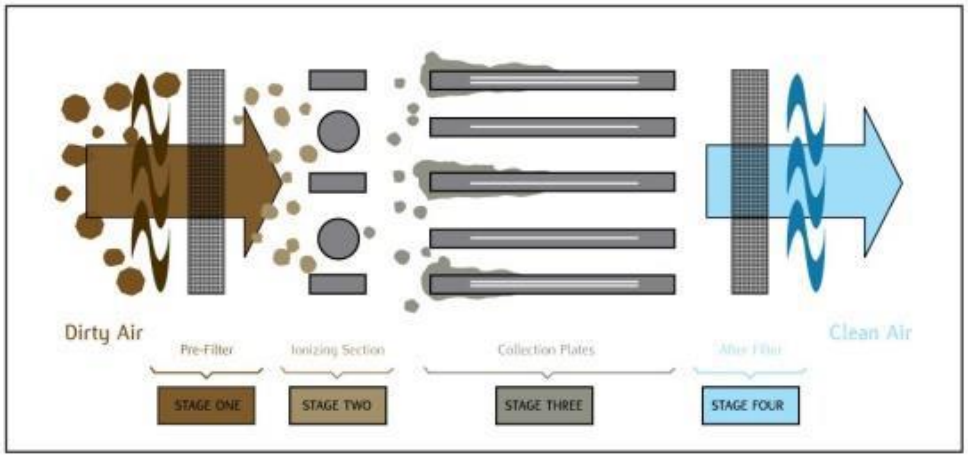

Fig. 2: Electrostatic filter

Electrostatic air filter is washable air filter which theoretically does not need to be replaced. These washable furnace filters work by having multiple layers of vented metal through which the air passes. As air passes through the first layer of filtration, air molecules are positively charged by the friction between air and the filter. The positively charged air molecules attach themselves to the next few layers as they pass through the rest of the filter.

3.3.2. Depth filter

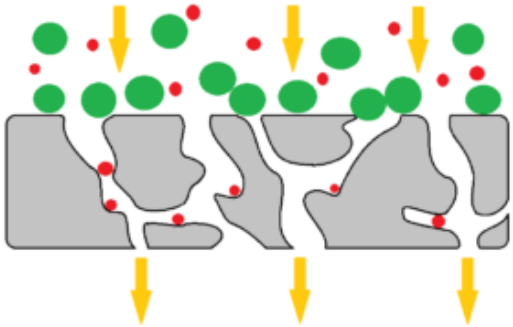

Fig. 3: Depth Filter

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Depth filters are those that use porous filtration medium to retain particles throughout the medium than just on the surface of the medium. These filters are generally used when the fluid to be filtered contains a high load of particles because, relative to other types of filters, depth filters can retain a large mass of particles before becoming clogged. Depth filtration is typified by multiple porous layers with depth which are used to capture solid contaminants from fluid phase. Due to the complex and channel-like nature of the filtration medium particles are retained throughout the medium within its structure, as opposed to on the surface. These filters pose the added advantage of being able to attain a high quantity of particles without compromising on the separation efficiency.

3.3.3. Wall-flow filter

This filter is also called Diesel Particulate Filter (DPF). A DPF is a filter designed to remove diesel particulate matter or soot from the exhausts of a diesel engine. Wall-flow diesel particulate filters generally remove 85% or more of the soot, under specific conditions it can also attain soot removal efficiencies approaching to 100%. Some filters are single-use intended for disposal and replacement once full of accumulated ash. The others are designed to burn off the accumulated particulate either by the use of a catalyst or by other means such as a fuel burner which heats the filter to soot combustion temperatures.

4. PARTICULATE MATTER

The particulate matter captured from this device is soot. Soot includes fine black particles, mainly composed of carbon produced by incomplete combustion of fossil fuels. The soot particles are extremely tiny in terms of diameter; this is smaller than dust or mold. Soot is about 1/30 the diameter of a human hair. It can travel deep into lungs, and can cause serious harm.

5. PURIFICATION OF CAPTURED SOOT

The captured particulate matter contains toxic impurities such as re-entrant dust, heavy metals, oils, VOCs etc. This is to be purified by chemical processes beginning with gravity based separation for high-mass particles, to comminution and catalyzed activation. Finally, the recovered soot is taken through a grinding process to bring to a consistent particle size, to be used an ink pigment. Services of waste management company can also be utilized to sort and recycle the waste from the purification steps.

6. CHOICE OF SOLVENT FOR INKS

Common solvents used in inks are variety of organic compounds such as hydrocarbons (aliphatic solvents like naphtha; paraffin hydrocarbons like pentane, hexane, heptane, isooctane, and mineral oil; and aromatic solvents like benzene, toluene, and xylene), alcohols (monohydric alcohols like methyl, ethyl, propyl, and isopropyl alcohols, and polyhydric alcohols like glycol and glycerol), ketones (such as acetone, methyl ethyl ketone, methyl isobutyl ketone, and cyclohexanone), esters (such as ethyl acetate, propyl acetate, butyl acetate, isobutyl acetate, and amyl acetate), and other organic substances such as ethers (like diethyl ether, isopropyl ether, and tetrahydrofuran). Hydrocarbons composed solely of hydrogen and carbon atoms are the simplest and least

expensive of the solvents, save for the aromatic hydrocarbons such as benzene and other chemicals having cyclic (or ring) molecular structures, which tend to be more expensive.

7. CONCLUSION

The purified captured particulate matter is processed to make ink. The ink is made of captured particulate matter from vehicle exhaust. The soot cannot be left as is as it contains carcinogenic particles. Hence, the soot should be purified and the purified soot can be converted to ink as it acts as an added advantage.

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