Design and Fabrication of an Air Purifier by Combining HEPA and Activated Carbon Filter

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ABSTRACT

The air purifier industry has seen a growth in terms of demand and sales lately. All credit goes to massive industrialization in developing countries such as India and China. As a result, a lot of research has been focused into the various methods of purifying air. The most harmful of the pollutants are PM 2.5 particulates and NOx emissions. The aim has been to bring down the costs without compromising on efficiency as efficient air purification is an expensive deal. This article presents a study of the current scenario of the problems of air pollution. Severity of the issues have been highlighted. A compilation of the most common and significant methods of purifying air such as those employing the use of HEPA filters, electrostatic smoke precipitators, activated carbon and UV light has been presented and their use in air purifiers manufactured by OEMs has been mentioned. Some of the most modern methods of purifying air such as those using transparent PAN filters, photochemical materials, soy proteins and silk Nano fibrils have been studied and reviewed. It has been found that these methods provide an attractive and economical pathway of filtering out PM 2.5 when compared to the conventional HEPA filters

Keywords: *Air Purifier, PM 2.5, NOx Emissions, Bio Materials*

INTRODUCTION

Air pollution has become one of the most significant and deadliest causes of deaths today. The World Health Organization (WHO) stated that around 6.5 million deaths were caused by air pollution in the year 2012 translating to 11.6% of total global deaths [1]. WHO states that air pollution is the cause of one-third of deaths caused due to stroke, lung cancer, and chronic respiratory diseases. Approximately, 92% of the world's population is exposed to air pollution levels that are beyond the permissible limits prescribed by WHO [2]. There are three basic strategies to tackle indoor air pollution [3]. The first is Source Control wherein, the source of pollutants is considered, and steps are taken to eliminate or decrease pollutants right from the sourceEliminate or decrease pollutants right from the source. If feasible enough and practically possible, this is the most effective method of reducing air pollutants. Ventilation is another method of reducing

indoor air pollution. The fundamental for attaining a good ventilation system is very simple. An efficient system of exchange of air between inside and outside of a closed space needs to be ensured. Infiltration refers to the induction of outside air into a closed space through openings, joints or cracks in walls. Infiltration falls under natural ventilation which on a broader spectrum refers to the inclusion of outside air into a room or building without the aid of any external promoter. The third method of reducing indoor air pollution is usage of air purification systems also known as air purifiers. Air purifiers have been in trend lately because of their high efficiency of purifying polluted air. There are various OEMs that manufacture air purifiers with different technologies and mechanisms of air purification. It can be stated here that an air purifier is not self-sufficient to tackle indoor air pollution but requires a good ventilation system in conjunction. The job of an air purifier is twofold reduction of pollutants, they being particulate matter (PM) and gaseous pollutants. The most common air purification media are being discussed here. Household air pollution is one of the areas that need immediate attention. There are different sources of indoor air pollution like tobacco smoking, fuel used for cooking, use of pesticides and chemical which causes disabilities among people. Household air pollution affects mostly the respiratory system and further leads to cancer. Apte and Salvi [4] helped in identifying different household air pollutants and their health implications and strategies to curb household air pollution. Indoor air quality (IAQ) is one of the major factors for the building owners and facility manager. IAQ has to be assessed properly before building any structure. Advanced techniques like moisture control

METHODOLOGY

HEPA FILTER

Vijayan et al. [9] studied the positive impact of mechanical air filters on indoor air pollution. Mechanical air filters refer to a meshed structure through which contaminated air is made to pass. The pore size of mesh is the most important factor for deciding the efficiency of mechanical filters. Contaminants having sizes greater than the mesh pore size are unable to pass and thus get separated leading to air purification. Such air filters are responsible for filtering out PM pollutants from indoor air. High Efficiency Particulate Air (HEPA) filters are the most used filtration media in today's air purifiers for filtering out PM. They have an efficiency of removing 99.97% of particulate matter of size less than 0.3 microns from contaminated air ensuring a flow rate anywhere between 150-400 cubic feet per minute depending on the clogging of their pores. HEPA filters appear in the form of pleated paper which is actually a very dense network of glass fibers. HEPA filters work on the principle of Brownian motion pertaining to which, there are three different mechanisms of trapping dust particles viz., impact, interception and diffusion. It is customary to use a pre-filter with HEPA filters in order to increase their life between subsequent replacements. Pre-filters are essentially a fiber mesh of comparatively larger pore sizes. Pre-filters are essential to trap the relatively larger particulates present in air so that they do not unnecessarily clog the HEPA pores

Figure 1 HEPA FILTER

ACTIVATED CARBON

Elements like activated carbon, zeolite, or potassium permanganate are added to airpurifier filters to increase efficiency to the filtering system. These elements work to absorb smoke, gases, chemicals, and odours that are present in the air. Activated carbon neutralizes odours and traps harmful chemicals and gases in its pores to provide relief from activities like secondhand smoke, off-gassing from plastics, and harmful fumes produced from renovations. An effective filtering system that is also equipped withchemical adsorption materials can produce cleaner and fresher-smelling air Activated carbon air filters remove pollutants from the air with a process known as adsorption. Note that this is different from absorption. In absorption, the substance you want to remove (let's say water) is absorbed into the structure of the absorbent (like a sponge), but it doesn't become a part of the absorbent on a molecular level. Therefore, when you absorb water with a sponge, the water does not become chemically bonded to the sponge. It just fills in the spaces inside it. Carbon filters on the other hand use ***ad-sorption***, *not* ***ab-sorption***. The key difference here is that during adsorption the pollutants stick to the outside of the carbon. Whereas with absorption, the pollutants are absorbed inside the structure itself–as with the sponge.

Carbon is a lattice of carbon atoms connected to each other. The activation process is so important because the increase in surface area gives gases a greater area to stick to. When a molecule of some gaseous substance comes through the carbon, it can stick to the surface of the bed, provided there is an open adsorption site

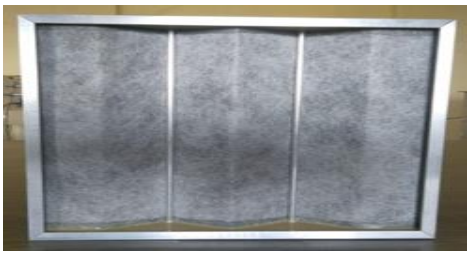


Figure 2 ACTIVATED CARBON

PROPOSED DESIGN

3000mm × 1000mm

Activated Carbon Filter

Size: - 305mm×305mm×50mm

CFM: - 1400

10 Micron

HEPA Filter

Size: 305mm× 305mm× 75mm,

Efficiency: 99.999% to 0.3u

Type: BOX TYPE

Result

Standard value CO_2 & CO concentration of indoor air.

Standard value of CO2	**421 ppm [10]**
Standard value of CO	**200 ppm [11]**

Air Quality Measurement of indoor air having different medium

Cigarette

Time	CO2 ppm	CO ppm	Remark
12:00:11 PM	2442	20.19	Intake
12:00:19 PM	906	5.05	Filtered
12:00:26 PM	4820	17.9	Intake
12:00:34 PM	920	5.08	Filtered
12:00:42 PM	1867	17.15	Intake
12:00:50 PM	920	4.92	Filtered
12:00:57 PM	6396	24.23	Intake
12:01:04 PM	935	5.34	Filtered
12:01:11 PM	3624	24.04	Intake
12:01:19 PM	1003	5.44	Filtered
12:01:27 PM	4879	19.3	Intake
12:01:34 PM	935	4.99	Filtered
12:01:41 PM	3142	20.85	Intake
12:01:48 PM	877	5.05	Filtered
12:01:56 PM	4088	21.55	Intake
12:02:04 PM	932	5.28	Filtered
12:02:12 PM	4338	29.77	Intake
12:02:20 PM	920	5.05	Filtered
12:02:28 PM	6993	13.36	Intake
12:02:36 PM	965	5.05	Filtered

Mortein coil

Time	CO2 ppm	CO ppm	Remark
12:10:38 PM	569	6.35	Intake
12:10:46 PM	375	3.01	Filtered
12:10:53 PM	705	5.94	Intake
12:11:00 PM	430	3.27	Filtered
12:11:08 PM	3652	6.29	Intake

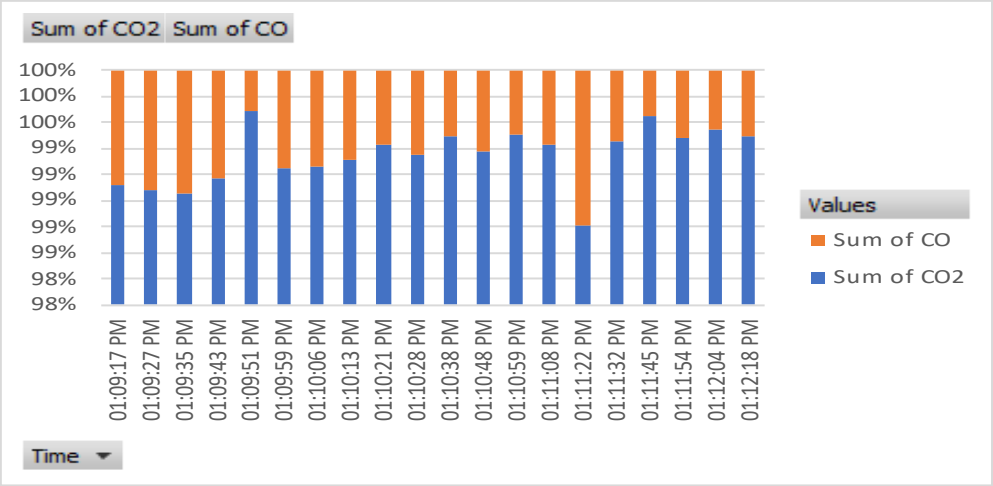
12:11:16 PM	518	3.34	Filtered
12:11:23 PM	852	5.85	Intake
12:11:35 PM	597	3.77	Filtered
12:11:42 PM	675	5.69	Intake
12:11:50 PM	744	3.98	Filtered
12:11:58 PM	341	6.29	Intake
12:12:08 PM	780	4.22	Filtered
12:12:16 PM	539	5.56	Intake
12:12:23 PM	846	4.09	Filtered
12:12:31 PM	373	5.5	Intake
12:12:38 PM	947	4.12	Filtered
12:12:46 PM	2701	7.47	Intake
12:12:53 PM	990	4.19	Filtered
12:13:01 PM	1770	10.54	Intake
12:13:12 PM	926	3.98	Filtered

Incense sticks

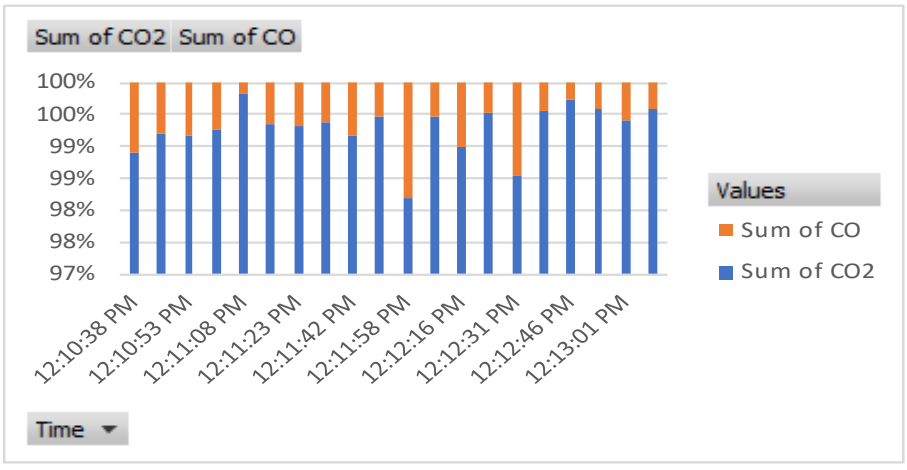
Time	CO2 ppm	CO ppm	Remark
01:09:17 PM	883	7.91	Intake
01:09:27 PM	535	4.95	Filtered
01:09:35 PM	2150	20.44	Intake
01:09:43 PM	700	5.91	Filtered
01:09:51 PM	4951	15.65	Intake
01:09:59 PM	790	5.98	Filtered
01:10:06 PM	2390	17.9	Intake
01:10:13 PM	874	6.07	Filtered
01:10:21 PM	4524	25.93	Intake
01:10:28 PM	923	6.07	Filtered
01:10:38 PM	4201	21.44	Intake
01:10:48 PM	1077	6.73	Filtered
01:10:59 PM	6441	31.79	Intake
01:11:08 PM	1229	7.04	Filtered

01:11:22 PM	2562	30.88	Intake
01:11:32 PM	1266	7.01	Filtered
01:11:45 PM	5929	21.12	Intake
01:11:54 PM	1356	7.1	Filtered
01:12:04 PM	5260	24.41	Intake
01:12:18 PM	1352	6.97	Filtered

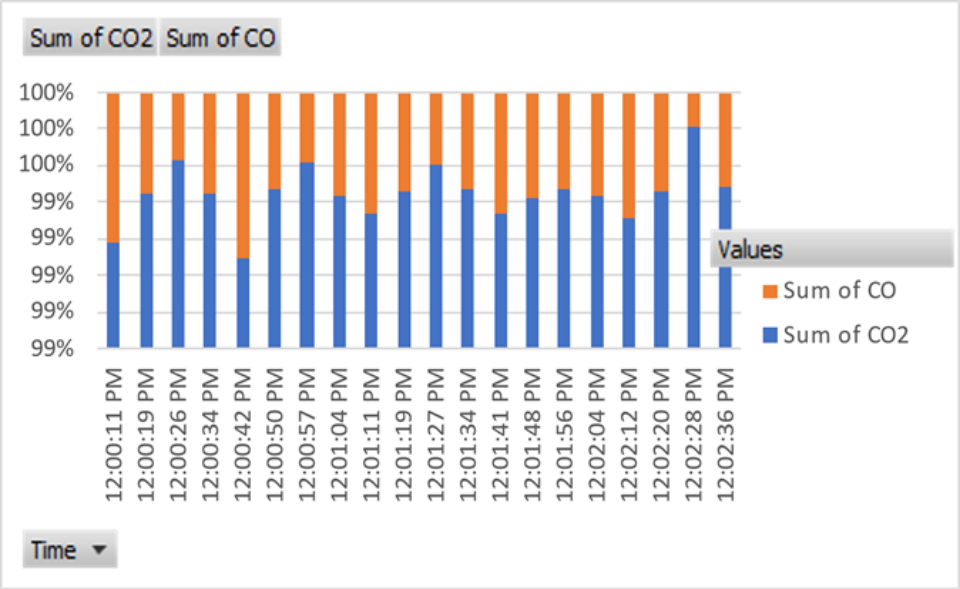
Data Graphs



(a) Graph of Cigarette



(b) Graph of Incense Sticks



(c) Graph of Mortein coil

CONCLUSION

The combination of High Efficiency Particulate Air (HEPA) and Activated Carbon (AC) filters in air purifier systems offers a highly effective solution for enhancing indoor air quality. By leveraging the strengths of both technologies, hybrid HEPA-AC air purifiers provide comprehensive pollutant removal, targeting both particulate matter and gaseous pollutants. HEPA filters excel at capturing airborne particles such as dust, allergens, and pathogens, while AC filters are effective in adsorbing gases, odors, and volatile organic compounds (VOCs).

•After filtration of these three pollutants environment (i.e. cigarette, incense sticks & Mortein coil) we found that maximum CO2 is in Cigarette, & we found maximum CO is in Incense Sticks.

•Hence, it is more dangerous to the environment.

•By removing a wide range of pollutants, including both particulate matter and gaseous contaminants, hybrid HEPA-AC air purifiers contribute to improved respiratory health, reduced allergies, and enhanced overall well-being for occupants.

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