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Development in Cigarette Smoke Filter for Passive Smokers

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Abstract - Cigarette smoking causes serious diseases through frequent and prolonged exposure to toxicants. Technologies are being developed to reduce smokers' toxicant exposure, including filter adsorbents, tobacco treatments and substitutes. This study examined the effect of modifications to filter ventilation, and active charcoal filter length and loading, as well as use of porous substances and chemical reactions, on the yields of toxicants in cigarette smoke. Earlier, an air-dilution mechanism, called split-tipping, was developed in which a band of porous paper in the Centre of the filter tipping functions to minimize the mainstream effects of smoke and to facilitate the diffusional loss of volatile toxicants. In our project we are mainly focusing on reducing the passive smoke stream effects by adopting simple means that will prove beneficial and facilitate in both design and manufacturing the filter unit. This will not only filter the air but also neutralize and reduce the harmful effects of toxic acidic constituents present in passive smoke. Certain smoking cabins can be provided for smokers and this filter can be used there particularly to isolate nonsmoking people from harmful effects of passive smoke.

Key Words: **Cigarette Smoke Filter, Charcoal Filter, Nicotine, Toxicity & Porosity, Passive Smoke, Neutralize.**

1.INTRODUCTION

Cigarette smoke contains more than 40000 compounds. Among these, Nicotine is well known to have serious systemic side effects in addition to being highly addictive. It adversely affects the heart, reproductive system, lung, kidney etc. Since the smoking addiction cannot be avoided completely, methods are being developed to reduce the harmful effects of smoke on non-smokers. Generally referred to as passive smoking. Effects of Passive smoking are neglected by the people but as reported by BBC news, it accounts for around 600,000 deaths per year, worldwide. Previous studies have been done in this field to reduce the effect of passive smoke but it failed to give the satisfactory results. There have been numerous attempts over years to reduce smokers' toxicant exposure, including filter absorbent, and substitution of tobacco constituents with alternative diluent materials. This study examined the effect of modifications to filter ventilation, and active charcoal filter length and loading, as well as use of porous substances and chemical reactions, on the yields of toxicants in cigarette smoke. Earlier an air-dilution mechanism, called split-tipping, was developed in which a band of porous paper placed in the Centre of the filter tipping functions to minimize the mainstream effects of smoke and to facilitate the diffusional loss of volatile toxicants.

This project and research focus on reducing the harmful effects of passive smoke by using some simple yet effective methods. Both theoretical and actual analysis have been carried out to study the percentage neutralization of passive smoke. It also encourages all public sectors to build and declare some areas as smoking zones. This will not only isolate the chain-smokers from non-smokers but also neutralize smoke from the zones, thereby giving out fresh air to atmosphere and overcoming all the fatalities caused, as mentioned above. This topic of 'cigarette smoke filter' was particularly selected in our interest as passive smoking is as harmful to human health as direct smoking.

Our main aim is to reduce pollution by using prefilters, activated charcoal filter in addition to the scrubber which is chemical based neutralized device which enhances the efficiency of whole filtration process and ANSYS CFD software has to be used for better analytical results.

2. EXISTING LITERATTURE

The document briefly characterizes the major categories of filtration and air-cleaning technologies, and their applications for removing contaminants from outdoor air brought into buildings and/or indoor air. The air-cleaning effects of plants and new air-cleaning technologies, for which there is very limited scientific and technical literature, are not considered.

2.1 Mechanical and Electronic Air Filter

Principles of Efficiency and Use: Mechanical filters use media with porous structures that contain fibers or stretched membrane material in a variety of fiber sizes, densities, and media extension configurations to remove particles from airstreams.

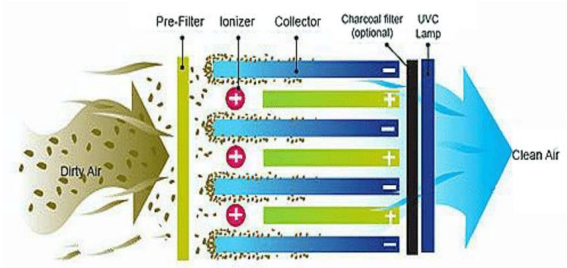

Fig -1: Electronic Air Filter

A portion of the particles in the air entering a filter attaches to the media and is removed from the air as it passes through the filter. Removal occurs primarily through particle impaction, interception and Brownian motion/diffusion, depending on particle size.

2.2 Sorbent Air Cleaners

Principles Efficiency, and Use: Sorbent air cleaners involve physical adsorption (physisorption) and chemisorption to remove gaseous contaminants from airstreams. Physisorption is adsorption of gaseous contaminants onto solid porous materials due to Van der Waals forces (nuclear attraction) and condensation in the small pores.

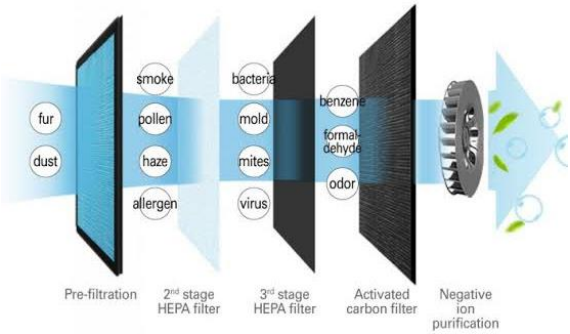

Fig -2: Sorbent Air Filter

This is a reversible process due to relatively weak forces: gases once adsorbed can later desorb back into the airstream. The most common adsorbent used is activated carbon.

2.3 Air cleaners using Photocatalytic Oxidation

Principles Efficiency and Use: Photocatalytic oxidation (PCO) is defined as a light mediated, redox reaction of gases and biological particles adsorbed on the surface of a solid pure or doped metal oxide semiconductor material or photocatalyst. Photocatalyst is TiO_2 (titanium dioxide), while zinc oxide (ZnO), Tungsten Trioxide (WO_3), Zirconium Dioxide (ZrO_3), Cadmium Sulfide (CdS), and Iron (III) (Fe (III)-doped TiO_2), among others, are also used

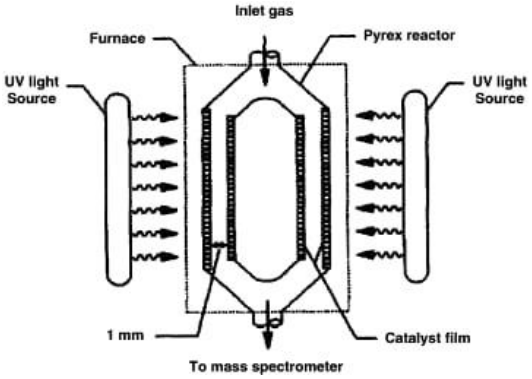

Fig-3: Photocatalytic Filter

Dopants (e.g., iron [Fe], Platinum [Pt], Silver [Ag]) can have a beneficial effect on the performance of the metal oxide photocatalyst.

2.4 Air Cleaners using Ultraviolet Germicidal Energy

Principles of Efficiency and Use: Ultraviolet (UV-C) disinfection (also called ultraviolet germicidal irradiation [UVGI]) is used to degrade organic material and inactivate microorganisms.

Fig-4: Ultraviolet Filter

The system is not a filter; thus, inactive particles remain in the airstream, which, in the case of dead fungal spores, may still cause a negative human response to their integral mycotoxins. The most effective wavelength range for inactivation of microorganisms is between 220 and 300 nm, with peak effectiveness near 265 nm.

2.2 Packaged air cleaners with Multiple Technology

Many air-cleaning devices use a combination of filters (i.e., particle air-cleaning technologies and gas-phase air-cleaning technologies). The devices are often stand-alone (portable), incorporate a fan, and are intended for

residential use. These devices are frequently called air purifiers or clean-air delivery (CAD) devices, but many other names are used as well. Many packaged air cleaners using multiple technologies are tested using the protocol of the Association of Home Appliance Manufacturers (AHAM) (AHAM 2013) to determine performance reported as the clean-air delivery rate (CADR) for specific contaminants (usually dust, tobacco smoke, and pollen)

3. NEED OF CIGARETTE SMOKE FILTER

India, being a densely populated region, have large number of active smokers. Since, Population density in India is around 464 people/m^2, the active smokers have significant effect on their neighboring people and even the environment. Hence, cigarette smoke filtration is a major challenge faced here.

Very less areas are declared as smoking zones due to overpopulation and hence smoke filtration is the only viable option in such regions.

Educating the people in slums and underdeveloped regions on the topic of effects of passive smoking is a tedious job. Hence, such filtration device needs to be directly installed in such regions and prohibition of smoking should be strictly prohibited outside the smoking zones.

This will not only prevent harm to human health but also reduce environmental pollution caused due to cigarette butts. These butts will be found in those particular smoking zones and will be easily disposed in mass quantities, instead of them lying roadside and leading to soil pollution.

There is a need to create public awareness about such issues. Declaring smoking zones and reduced deaths due to smoking, will surely make significant impact on people, who smoke in public.

Air pollution caused due to cigarette smoke is far greater than pollution caused from emissions of cars. Therefore, neutralizing and filtering this smoke will reduce air pollution by a significant amount.

4. METHODOLOGY

The proposed filter requires testing the deign first before manufacturing. Testing and manufacturing as well as other tasks were carried out in as follows:

- Reviewing the research literature for better understanding of smoke and air filtration.
- Documentation from the literature for references.
- Designing of the proposed model in 3D on design software- Solidworks.
- Checking the proposed filtration parameters virtually using Ansys.
- Selecting the appropriate material, charcoal layer thickness and components for the filter.
- Testing the filter for the desired output
- Manufacturing the body (shell) using material chosen as per research review.
- Final assembly of the filter and further experimental testing and optimization.

4.1 Components

4.1.1 Shell

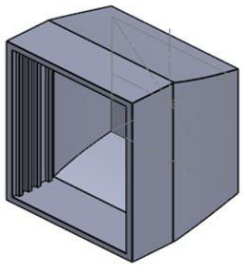

Fig-5: Shell

Shell accommodates the filter layers, fan and reducer assembly. It is made up of mild steel and is 2.5 times stronger than aluminum. Smoke is allowed to enter into the filter assembly through opening inlet of the shell.

4.1.2 Dust Filter

Fig-6: Dust Filter

Has 36x28x1 cm dimensions and absorbs some quantity of tar. Has porosity of 10 microns and allows the smoke to further pass to carbon filter layer

4.1.2 Charcoal Filter

Fig-7: Charcoal Filter

Has 36x28x5 cm dimensions and reduces the odor of chemicals in smoke. Neutralizes few of the chemicals and prevents the flow of VOCs to the scrubber.

4.1.4 Fan

Fig-8: Fan

3.5 inch, 12V DC, 1200 rpm fan capable of increasing the flow rate of smoke by providing induced draught. This increases the input smoke quantity to the scrubber and prevents the stagnation of smoke inside the shell.

4.1.5 Reducer

Fig-9: Reducer

A rectangular cross section piece whose area goes on decreasing towards the end. Fitted at the backside of the shell to accelerate the flow of smoke to the scrubber. Prevents flow losses and stagnation of smoke inside the shell assembly.

4.1.6 Scrubber

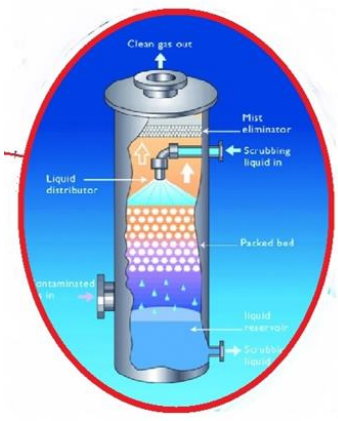

Fig-10: Scrubber

A scrubber is a waste gas treatment installation in which a gas stream is brought into intensive contact with a liquid, with the aim of allowing certain gaseous components to pass from the gas to the liquid. Scrubbers can be employed as an emission-limiting technique for many gaseous emissions. Scrubbing is also referred to as absorption. During scrubbing there is a transfer of components from the gas phase to the liquid phase. The level of gaseous components that can pass to the liquid phase is determined by the ability of these components to dissolve in the liquid.

4.2 Construction

The Fig-8 Shows the 3D model of the Filter which was created on Solidworks software. The model highlights the assembly of the components without ducts.

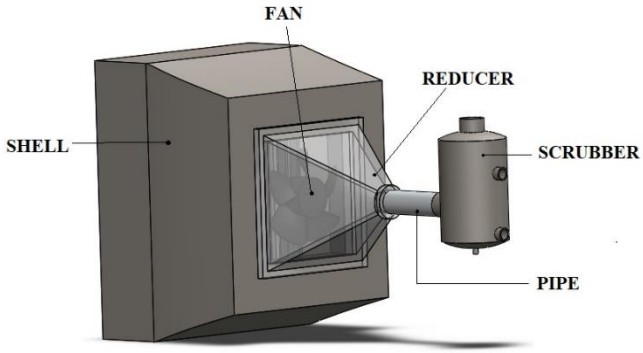

Fig-11: Smoking Filter Model

Shell accommodates the above-mentioned filter layers along with fan and reducer. Inlet of the smoke is from the backside of shell assembly. Additional pump required for scrubber is not shown in the figure as the modelling only includes the important working parameters. Pump and additional fan will be taken into consideration in the final physical model.

4.3 Working

The smoke filtration is carried out in two stages:

1. Air Filtration
2. Neutralization of Smoke

Stage:1 Air Filtration:

This process, similar to that of HEPA filter, takes place in the main shell body and is done with the help of three filter layers, as follows

a. Pre-filter: this layer removes the large dust particles which are in size of up to 10 microns.
b. Dust filter: this filter layer removes very small particles which are in the size of up to 1 micron.

c. Activated charcoal layer: this layer removes harmful chemicals up to 60%.
Above three layers remove the dust particles and partially neutralize the smoke. Further neutralization takes place in next stage.

Both pre-filter and dust filter are incorporated together in above mentioned (figure-2) filter layer i.e., it carries out the same function as that of the two.

Stage:2 Neutralization:

For neutralization of smoke wet scrubber arrangement is used. It contains caustic soda (H_2o+NaoH) and neutralizes the smoke to up to 95% clean air.

The working principle of the scrubber is somewhat same as that of cooling tower, except that the heat transfer is not the prominent objective here. The filtered air with the help of exhaust fan enters from the bottom of the shell into the scrubber and flows upwards. The constant draft from the fan makes it possible for the dense smoke to flow upwards. Aqueous solution of caustic soda is sprayed from top in continuous manner upon this smoke. Caustic soda and the smoke react with each other to neutralize the smoke. The chemical reactions are as follows; caustic soda is again recirculated with the help of small pump.

1. $CO + NaOH \rightarrow HCOONa$
2. $CO_2 + NaOH \rightarrow NaHCO_{3\,(aq)}$
3. $HCl + NaOH \rightarrow H_20 + NaCl$
4. $HF + NaOH \rightarrow H_2O + NaF \uparrow$
5. $O_2 + 4NaOH \rightarrow 2Na_2O_2 + 2H_20$
6. $2NO_2 + 2NaOH \rightarrow NaNO_2+NaNO_3+H_2O$
7. $SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

Reactions are shown only for the significant harmful constituents.

5. CONCLUSIONS

Due to the use of scrubber as an additional neutralization element, we can further neutralize the smoke and reduce its harmful effect up to 95% which gives pollutant free air. Installation of this device also promotes smoking zones in various sectors to separate the smokers from non-smokers, thereby decreasing the overall death rate due to smoke.

Continuous filtration and reuse of the caustic soda solution in scrubber reduces the cost of maintenance of the scrubber and increases the efficiency of the model. This model can also be installed in residential areas where smoke filtration or any other gas filtration is required. Along with caustic soda, other neutralizing liquids can also be used to obtain the remaining 5% purification. This will increase the number of stages in the filter but will enhance the output air quality to give richer and pollutant free air. This model can also find its application in industrial sectors where harmful gases are left of the chimneys. This setup not only works for cigarette smoke but also for other harmful gases provided we have another stage of filtration similar to scrubber arrangement, if needed, which neutralizes that respective gas.

6. REFERENCES

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