SMART AIR PURIFIER – A REVIEW

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Abstract— Air purifier is a device built to reduce the carbon dioxide content in the atmosphere. Over the years the pollution have been increasing rapidly, and due to rise in the Greenhouse gases. Global warming is also increasing in steady state. This device is an automated device which uses an absorbent to absorb carbon dioxide from atmosphere and to reduce the content of it to certain extent. It has an absorption chamber where carbon dioxide is absorbed and stored in cylinder for further use.

Index Terms— Air purification, absorbent, carbon dioxide, storage unit.

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1 INTRODUCTION

THE scientific consensus on climate changes related to global warming is that the average temperature of the earth has risen between 0.4 and 0.8°C over the past 100 years. Scientists from the intergovernmental panel on climate carrying out global warming research have recently predicted that average global temparatures could increase between 1.4°C and 5.8°C by the year 2100.

The purpose of this paper is to introduce a system which absorbs carbon dioxide from atmosphere and gives out less harmful air. The smart air purifier can also be called mechanical tree which follows the carbon dioxide absorption phenomenon.

In this paper potassium carbonate is used as the absorbent, hexagonal packed filters are implemented to filter the dust and thin metal sheets are employed in the place of absorber sheets. Objective of this paper being to build a mechanical unit to control the carbon dioxide atmospheric condition. New method of fluid filter utilization and its management through automation, also to have an effective storage of carbon dioxide from the atmosphere, to have an eco-friendly environment with reduced carbon dioxide and the stored carbon dioxide in other industrial application.

2 LITERATURES

Anusha Kothandaraman et. al (2010) that the use of potassium carbonate as solvent for CO_2 capture in IRCC system, resulted in energy consumption which was reduced by 22% by using potassium carbonate [1]. A K Chakra borty et. al (1986) investigated CO_2 absorption in aqueous solutions of hindered amines and reported the behavior of one particular amine, a-amino2-methyl-I-propanol (AMP), as a chemical solvent for CO_2 in aqueous solutions is efficient [2]. Fumihide Shiraishi et. al (2009) investigated toluene removal from indoor air using a miniaturized photocatalytic air purifier including a preceding adsorption/desorption unit and reported the experimental results obtained in the work clearly show that the miniaturized air purifier can reduce the toluene concentration in the 1 m^3 room to a value near zero in the first 10–15 min. This high performance is based on the adsorption of toluene by the continuous adsorption/desorption unit [3]. Jean Disdier et. al (2005) measured the effect of Photocatalytic Purifiers on Indoor Air Hydrocarbons and Carbonyl Pollutants and methodologies have been presented to assess the effects of photocatalytic air purifiers on indoor air quality [4].

Mathana Wongaree et. al (2016) investigated the photocatalytic performance of electrospun CNT/TiO_2 nanofibers in a simulated air purifier under visible light irradiation and CNT/TiO_2 nanofibers were successfully prepared from 50 % wt CNT/TiO_2 in PVP spinning solution by electrospinning. The photo decolorization of MB by 50-CNT/TiO_2 nanofibers was 58 % within 90 min under visible light irradiation [5]. Nicole Britigan et. al (2006) found out that Operation of an O_3-generating air purifier in a closed indoor environment results in an increase in the steady state O_3 concentration that is directly proportional to the O_3 emission rate of the air purifier [6]. P. Pichat et. al (2000) proposed purification/deodorization of indoor air and gaseous effluents by TiO_2 photo catalysis and The efficiency of a prototype to purify/deodorize air in an ordinary room was assessed through the use of adsorbent-coated fibers to collect pollutants in ambient air [7]. Seok Kim et al (2004) worked that the increase of absorber pressure and MEA solution flow rate causes the increase in increase of CO_2 absorption reaches 97% at 3 atm [8]. Senichi Masuda et. al (1993) proposed a new type of the integrated air purifier having three different functions-aerosol collection, deodorization, and disinfection in the living environment. Its construction, working principle, theory of its collection, and deodorizing performance are described, together with test results [9]. Xiaohui Huang et. al (2009) found out that the UV LED light source panel had a larger surface for irradiation than a mercury lamp. Thus, its sterilization efficiency was much better than that of traditional methods. The feasibility of UV LED/TiO_2 for photocatalysis was proved [10]. Recently Xiaoyang Shi et. al (2017) proposed a carbon dioxide absorption system driven by water quantity and reported a system containing nano porous & carbonate ions, which is capable to capture CO_2 from ambient air simply by controlling the amount of water in the system. It absorbed CO_2 from air when surrounding is dry, whereas desorbs when wet [11].

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3 METHODOLOGY

In this system the major part of the work is done by the chemical process and reactions of the absorbent. Here at first the air is sucked into the device through the help of air pump and is entered to the absorption chamber which consists of an absorber sheets, which absorbs the carbon dioxide present in the sucked air. In absorption chamber it consists of a sprayer which continuously sprays the absorbent liquid onto the absorber sheets.

There is also a recovery chamber present where reaction products are heated in a water heated bath and absorber sheets are submerged in water and heated to a certain level until the dissolved carbon dioxide reacts and forms gaseous carbon dioxide. This carbon dioxide is passed through a storage chamber where it is stored in cylinders and can be used for further purposes.

4 CONSTRUCTION AND PARTS OF SMART AIR PURIFIER (SAP)

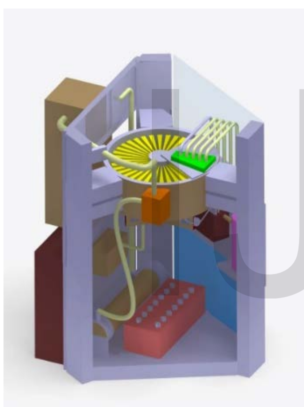

Fig. 1. Smart air purifier (SAP).

The position of different components coming in the SAP, is as shown. The equipment's are listed below. The dust filter on the SAP, goes above the absorption chamber in the Fig.1.

4.1. Three dusts filters

The dust filter, is the top most part & the pre-elementary part of the smart air purifier which is shown in Fig.2. The gas taken in which is $C0_2$ mixed air is checked for dust and other elements which cause problem and even damage the compressor unit. The dust filters are taken in order to maintain a smooth functioning of the compressor, this is by, and if one of the filter is heavily contaminated then the pressure generation to the required may be interrupted. The dust filters are separately connected to the compressor. The compressor operates one filter at a time. If one get filled with dust, the compressor unit shifts its inlet port to the second and so on. The shift from one filter to another actuates a secondary system to perform an automated work which is not shown in the Fig, which will clean the filters sequentially.

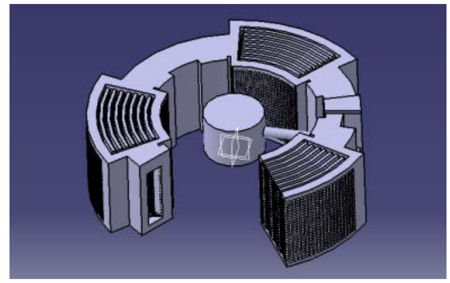

Fig. 2. The three dusts filters.

4.2 Compressor

The compressor used to get the gas pressure required for the absorption process. The absorption of CO_2 in K_2CO_3 (potassium carbonate) absorbent is found at good efficiency at 10 bar and greater. So the compressor is used for this purpose which is shown in Fig.3.

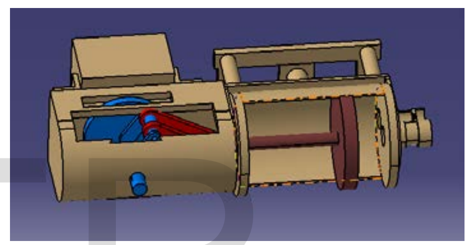

Fig. 3. Compressor.

4.3 The Absorption chamber

Before proceeding to our design, the following are the few designs previously done in the absorption model. The spray based model is the model which have the absorption at the spray drop level, the spray at high pressure is passed on to the incoming gas (polluted air) to absorb the CO_2. The only closing comment is that it isn't efficient absorption because of the absorbent used in their design and also less conversion of the polluted air to clean air. In the packed bed design the pressure required is very high about 60 bars, and the packing is very denser and requires greater handling. Bubbling design has less absorption capacity and is a slow process.

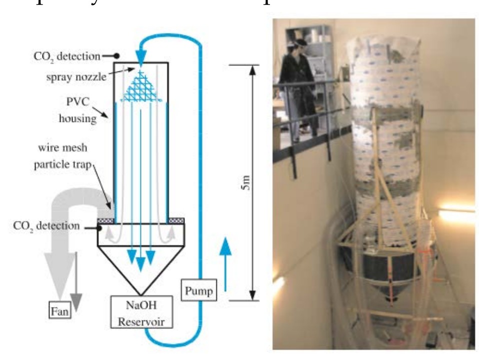

Fig. 4. Spray system.

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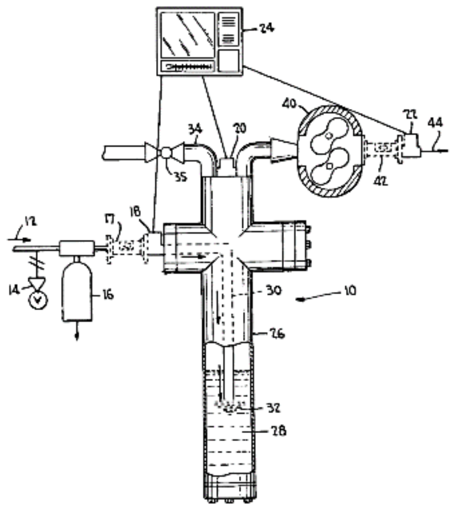


Fig. 5. Bubbling system.

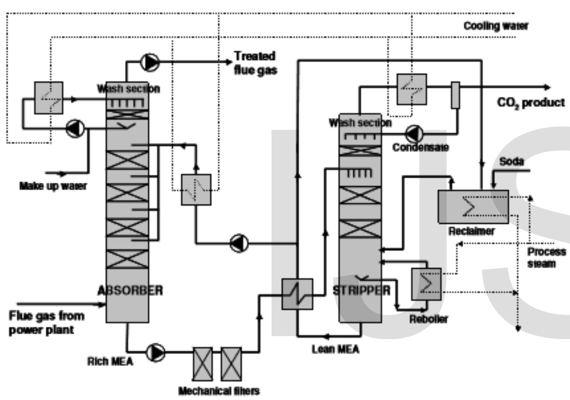


Fig. 6. Packed bed system.

The absorption system is the arrangement of the hexagonal packing filter, in circular pattern. Second, the compressor passes the gas at the required pressure. The gas in the confined space at high pressure gets absorbed in the sprayed absorber filters. Here, the first cycle completes. In the second cycle, as the absorption chamber will contain air with now reduced concentration Of CO_2, about 70% from 100% (The percentage Reduction can vary.), is pumped back to the secondary gas chamber.

While the gas being sent to the gas chamber, the system cleans the filters by water, & the gas reintroduced to the chamber filters. The concentration of CO_2 is 40%. In the third step, the CO_2 level is further reduced to lower level, to a required amount which will be then released to the atmosphere. When the system starts keeping the gas in the secondary chamber, and pumping the gas from it to the absorption chamber, there will not be any intake from the atmosphere to the device. After the three stages of reduction the system draws the polluted air from the atmosphere. If the absorption at the first stage is having good absorption efficiency then the system will not go for the further stages. The reduction of CO2 is constantly monitored, as the absorption by chemical in the scenario will not be constant, and changes with the amount of air + CO_2 mixture, also with the absorber filter usage.

Fig. 7. Absorption chamber

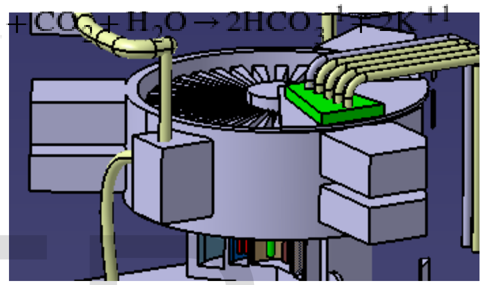
The chemical process undergoing in the absorption chamber is,

Where the potassium carbonate (absorbent) reacts with the CO_2 in the air, and converting into bicarbonates which confirms extraction of CO_2.

4.4 The Regeneration chamber:

In the regeneration system the chemical used in absorbing the CO_2 is regenerated for further absorption of the same instead of refuelling. The completion of the absorption stages allows

$$K_2CO_3 + CO_2 + H_2O \rightarrow 2HCO_3^{-1} + 2K^{+1} \quad (1)$$



the product of absorption to pass to the regeneration chamber through a solenoid valve.

The regeneration system consists of two glass chambers in concentric. The outer glass chamber is filled with water and consists of an electric heater. The inner glass chamber consists three pipes for fluid transfer. First, from the Fig.4 the green pipe allows the reaction product from absorption chamber to enter in it. Second allows for the regenerated gas to be stored. Third allows for the recirculation of the regenerated chemical i.e. K2CO3. The regenerated chemical is stored temporarily in the absorbent spray system. The two glass chambers are inside a metal cylinder to protect it.

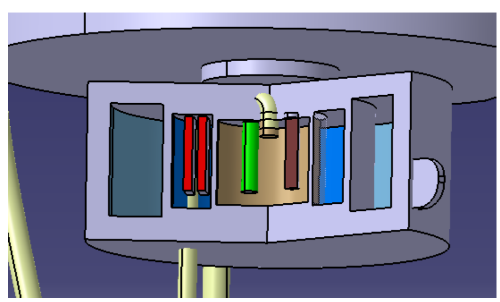


Fig. 8. Regeneration chamber.

4.5 The absorbent spray system:

In the absorbent spray system the chemical regenerated in temporarily stored. The requirement of the absorbent fluid can be seen at the spray system, if it is below the minimum amount, which can be refuelled.

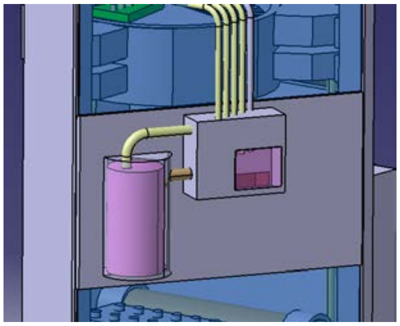


Fig. 9. Absorbent spray system.

4.6 The CO_2 storage.

It is the place where the system stores the extracted CO_2. It does is so by an air compressor.

Fig. 10. The CO_2 storage.

5 THE DESIGN CALCULATIONS OF THE AIR COMPRESSOR

The motor using will be of 5438-14340rpm.
Voltage (v): 12v or higher.
Current (i): relatively for 12v.
Torque (T): 5kg-cm and higher.
Diameter of the air pump cylinder (d): 11.5cm = 115mm.
Length of the cylinder (l): 16.5cm =165mm.

5.1 Suction stroke:

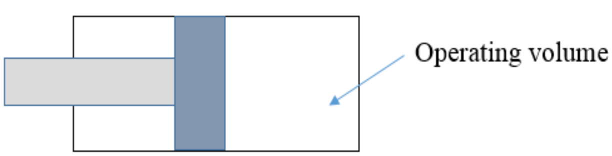
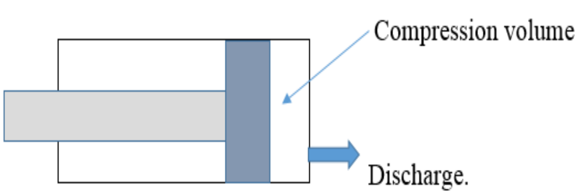


Fig. 11 Suction stroke of the piston.

Operating volume (V_{op}) = $(A*L)_{op}$
Operating length L_{op} = 10cm.
$V_{op} = 3.142*(0.115)^2 /4*0.165$
$=1.0388L$ or $1.0388*10^{-3}$ m^3.



5.2 Compression stroke:

Fig. 12 Compression stroke of the piston.

Compressed volume per stroke,

1 revolution = suction & pump.
=1.0388L

For compressing to 20 bar:

PV = nRT

And atmospheric pressure, P = 1bar
V = 2.3L
T = 26^0C or 30^0C.

And as R = $6.023x10^{-23}$ kg/mol K

$n = P_1V_1/RT_1$
as R is gas constant,
$P_1V_1/nT_1 = P_2V_2/nT_2$
As $V_1 = V_2$
$P_2 = P_1*n_2/n_1*T_2/T_1$

Here the atmospheric pressure is taken as 1bar,
- ⇨ P_2 = 1bar*(n_2/n_1)*(40+273)/(30+273)
- ⇨ P_2 =1.0330bar, if $n_2 = n_1$.

And, in this case, as it changes, after pump the n_2 will always be greater than n_1, Hence,
$n_2/n_1>1$

So, for different values of the ratio, n_2/n_1,
1. P_2= 20*1.0330=20bar.
2. P_2=30*1.0330=30.99bar.

6 CONCLUSION

Proposed arrangement used for smart air purifier has a lot of potential applications especially in populated and highly polluted areas. Where research on carbon capture is receiving ample attention.

It is a modern day technology smart purifier with a semi-automated system which requires less human interaction. It absorbs carbon dioxide from atmosphere up to certain extent, providing eco-friendly nature. This probably is a step for the cure of global warming. In this review paper, detailed information regarding smart air purifier for carbon capture using absorbent has been discussed. As potassium carbonate can absorb carbon dioxide from the atmosphere and the absorber sheets which can also be reused which makes this an automated system. A promising and efficient air cleaner which extracts carbondioxide from polluted atmosphere accounts for a significant decrease in global warming and respiratory diseases. Also the absorbed carbon and stored carbon dioxide finds its application in industries.

Acknowledgment

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