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Safety at industrial working place by separating Carbon Dioxide Gas

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Abstract

Environmental safety is a great issue for the betterment of human beings because of industrial revolution which changes the national economy and lifestyle by technological advancement. Because of energy demand, fossil fuels from industries are expected to be the main energy source in future days and thus the emission of CO_2 will be increased. CO_2 reduction from industries is a great issue nowadays as it is the main contributor of greenhouse gases which has a great impact on the environment like global warming. As the concentration of harmful gases in industry is very high which is emitted by workers and industry materials, it is required to maintain the safe percentage of CO_2, SO_2 and other gases in air of an industry and ensure safety from accidents like fire accidents. The harmful gases have also affected on the health of efficient workers and cause many diseases so that they can't provide the service for a sufficient time. This paper presents a system that will capture the harmful gases like CO_2, SO_2 from the polluted air of those industries and would use that CO_2 as a fire extinguishing agent for avoiding fire accidents and prevent the industries and the workers from fire attacks to ensure a safe working place and healthy environment for the workers. Every year industries have to go through many losses like machinery, buildings, compensations for the workers and most importantly valuable lives of efficient workers. This system will mitigate all the losses. This system will also work as an income source by selling captured CO_2 and SO_2.

Keywords: Industries, pollution, system, CO_2, fossil fuel, air, SO_2, fire accidents, diseases, system, loss

1. Introduction

Nowadays environmental disaster is a great problem by pollution causes by industrialization of 19th century. Environmental safety is a great issue for the betterment of human beings as industrialization has a great effect on air pollution and the major contributors are value-added industries like garments, textile, pharmaceuticals, fertilizer and Agro-based industries like paper, sugar, pulp and chemical industries [1]. Fossil fuels, coal, oil and natural gas used to burn by heavy industries. Thus, these industries emit a lot of CO_2 to the environment globally. Fossil fueled power plants are the largest contributor among them by emitting about 33-40 percent of the total CO_2 emission. The global warming used to happen because of the increasing concentrations of greenhouse gases (CHGs) such as CO_2 in the atmosphere. Thus, the temperature of the earth has been increased in recent past years. In recent years two third of greenhouse effect was caused by human activities [2].

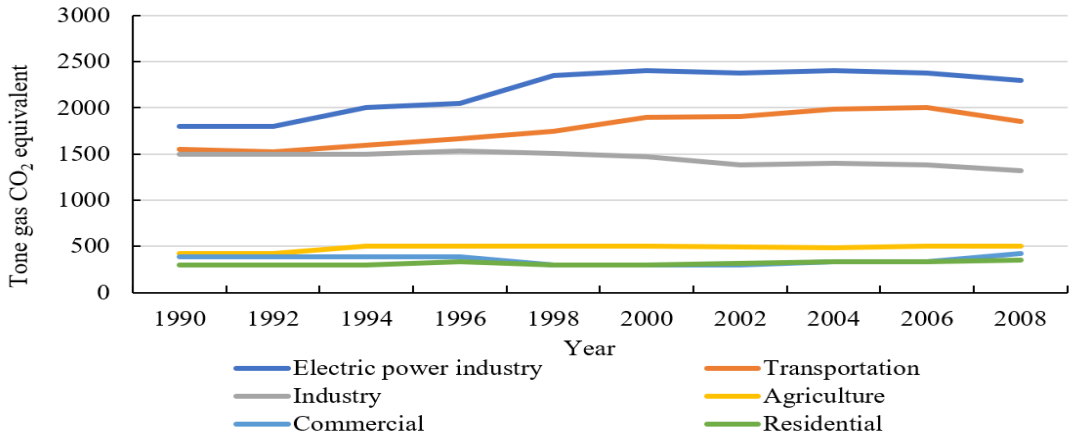


Fig. 1. U.S. GHG Emissions Allocated to Economic Sectors [2]

Figure 1, shows that in USA, power plant (55% of global emissions), transportation (23%) and industry have largest share in the emission of CO_2. There are some major industries for CO_2 emission such as Petrochemical and cement plants. Among them, cement industry contributes about 5% to global anthropogenic emissions of CO_2 [3-7]. In future days fossil fuels are expected to be the main energy source and thus the emission of CO_2 will be increased. CO_2 separation is greatly needed as CO_2 is the main energy source of greenhouse gases. From 1960 to 2010, the concentrations of CO_2 in the atmosphere has monotonically increased from 310 to 390 ppm [8]. CO_2 has a great effect on climate change among all greenhouse gases. Thus, many disasters occur like droughts, the increase in sea level, hurricanes, floods, and widespread melting of snow and ice [9]. All these disasters are a great threat to human life and ecological system of this earth. CO_2 is the primary anthropogenic greenhouse gas which is an account for 77% by the contribution of human activities to the greenhouse effect in recent years. Again, that CO_2 emission because of human activities is about 26 to 30 percent of all CO_2 emissions. The main reason for the anthropogenic emissions of CO_2 is the combustion of fossil fuels in industries. The concentration of CO_2 in flue gases depends on the fuel like coal (12-15 mol% CO_2) and natural gas (3-4 mol% CO_2). In the production of cement, there is 14-33 mol% CO_2, in oil refining 8-9 mol% CO_2 and in iron and steel 20-44% CO_2. From 2004 to 2011 global emission of CO_2 from energy uses were increased 26% (Figure 2) [2, 10-14].

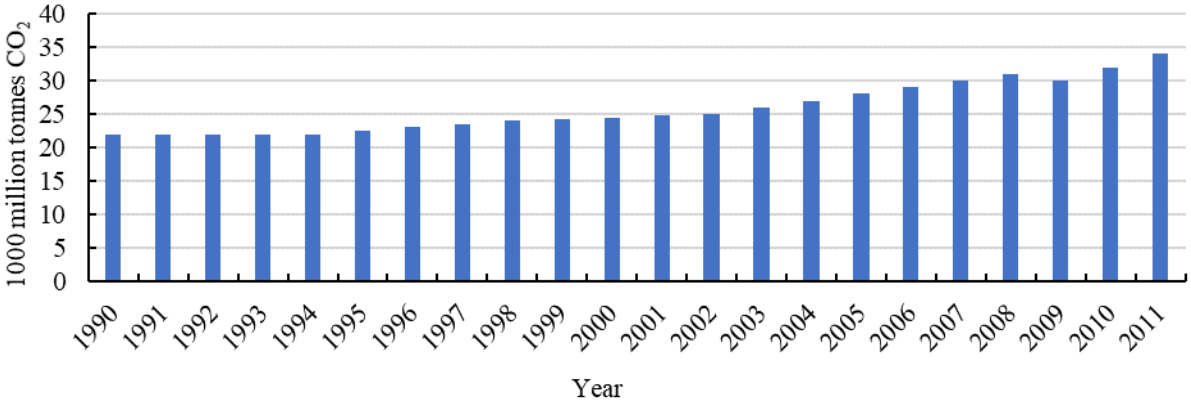


Fig. 2. Global CO_2 emissions from fossil fuel combustion and cement production [2]

CO_2 reduction is a great issue nowadays as it has a great impact on the environment like global warming. Besides, the concentration of CO_2 is too high in the industries and the environment of the industry is polluted as well. So, this is very much needed for the workers of the industry to have a convenient environment and working places. To keep the environment and working place healthy and safe for the workers in an industry it is required to maintain the safe percentage of CO_2, SO_2 and other gases in air of an industry or office which is emitted by workers and industry materials. On the other hand, in recent past year's fire accidents are common issues in industries and thus it makes a great loss for the industries by a lot of money and lives of the workers. Industrial accidents affect the livelihood of the workers and their families, and those livings near of the industry and endanger the safety of the workers. Due to industrial accident a lot of people lose their life and injured in every year [15]. According to the ILO, occupational accidents and work-related diseases cause over 2.3 million fatalities annually, of which over 350,000 are caused by occupational accidents. Thus, many people suffer a lot and the entrepreneurs and economies count a great loss is around 4 percent of the world's gross domestic product (GDP), or about US $2.8 trillion, is lost annually in direct and indirect costs [16]. In European countries manmade industrial disasters frequently happens, resulting in adoption of minimum requirements for safety and health protection at the workplace to prevent accidents and occupational diseases in Member States of the European Union (EU) [16,17]. The environment and air of the industries are very much polluted with harmful gases like CO_2, SO_2, etc. They also effect on the health of efficient workers and cause many diseases so they can't provide the service for a sufficient time. Vertigo, sneezing, cough, headache, burning sensation of the eyes, tiredness, nausea etc. used to happen by the immediate effect of smoke inhalation. Bronchitis and asthma happen because of its long-term effect. Lead affects the circulatory, nervous and reproductive systems as well as affects kidney and liver including liver cancer or cirrhosis. Carbon monoxide is a poisonous gas which hampers the mental development and growth of an expected baby. Pneumonia and bronchitis are caused by nitrogen oxides [1].

This paper presents a proposed system to ensure a healthy environment by maintaining the safe percentage of air elements in the environment for the workers by capturing harmful gases and reduce global warming. The presenting system will prevent the industries and workers from fire attacks to ensure a safe working place and reduce the loss of money since a lot of money is used to invest behind a lot of workers to make them efficient by

giving them proper training. If they can't work for so many years due to the illness of these gases and accidents then it will be a great loss. Another function of this system is to preserve an excess amount of carbon dioxide and sulfur dioxide and then sell it for different industrial purposes.

2. Methodology

We have designed our proposed system in SOLIDWORKS for the reduction of harmful gases of the industry and ensuring safety by removing fire accident. And besides this system can be an income source of the industry.

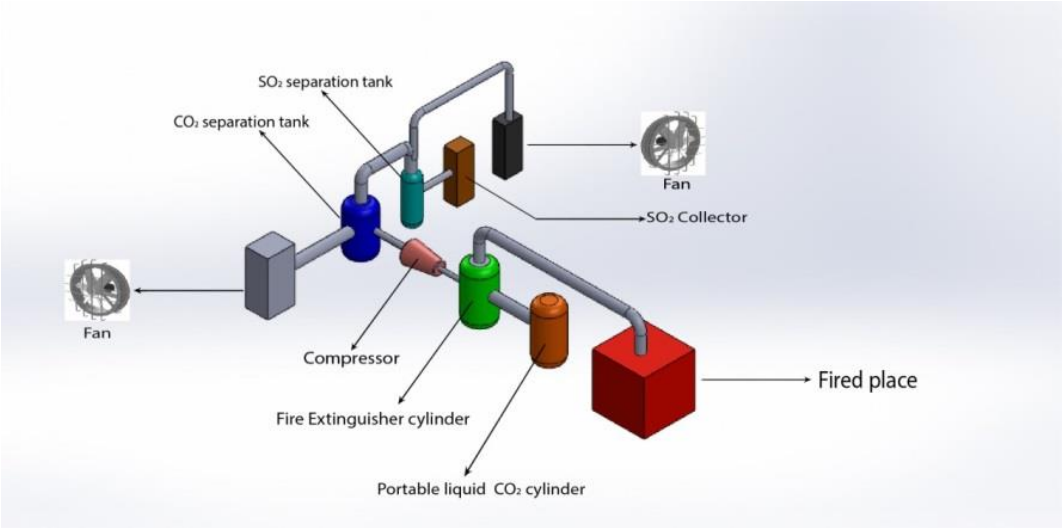
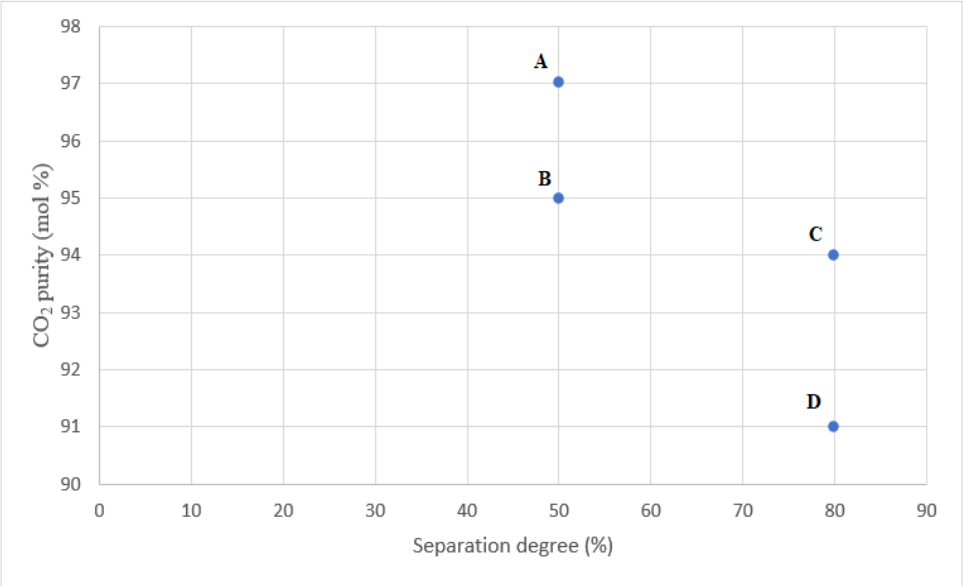


Fig. 3. Proposed Designed System

At first fans will be at the top of the room as hot air remain at the upper side of room. Then these fans will collect the air and release it to the system. Then in CO_2 separation tank CO_2 will be separated from the air according to the following processes of CO_2 separation. After that the remaining air will pass to the SO_2 separation tank and it will separate SO_2 from the air according to the following process of SO_2 Separation. Then the remaining gas will pass to the environment. SO_2 will be collected in the cylinders and then it will be used in different purposes. Again, after separating CO_2 from the air it will be passed to the compressor to get liquid CO_2. The compressor will compress the gaseous CO_2 at 100 bar pressure and produce liquid CO_2. It will be reserved in fire extinguishing cylinder as a fire extinguishing agent. When the fire extinguisher cylinder will be filled up, then the extra liquid CO_2 will be reserved in portable liquid CO_2 cylinder. The industry will use the extra liquid CO_2 from the portable cylinder according to their own choices and even they can sell as well. Now the industries will use the liquid CO_2 from the fire extinguishing cylinder as a fire extinguishing agent. In the industries there will be an automatic system that will detect the temperature and the type of fire in the fired place by using fire sensor. Then it will release the liquid CO_2 automatically as a fire extinguishing agent from the fire extinguishing cylinder.

3. Results and discussion

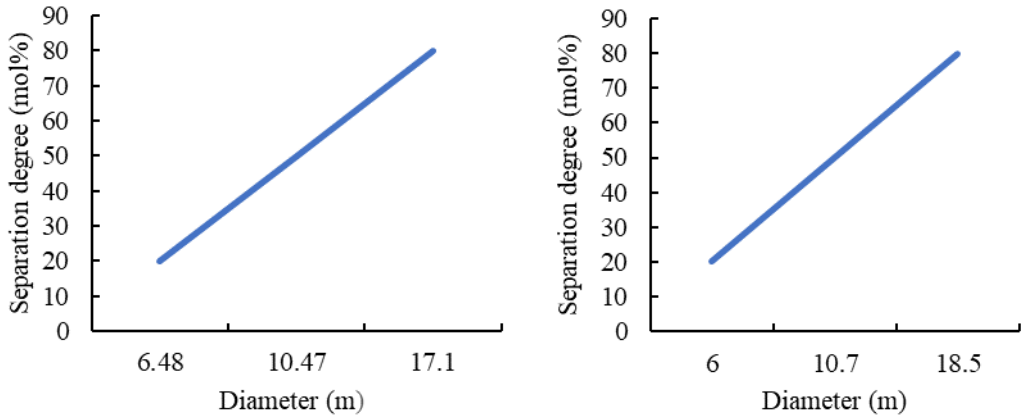
For separating CO_2, we are proposing membrane separation process which is the most effective method for Carbon dioxide capture and sequestration (CCS) in different industries. Some parameters like selectivity, permeability and area which are very important and decisive for membranes as capture target is high degree of CO_2 separation and high CO_2 purity. On the other hand, some operating conditions like pressure ratio and CO_2 molar fraction in feed gas influence the CO_2 purity and degree of CO_2 separation. In membrane separation process some important issues are important like , (1) Degree of CO_2 separation increases with the decrease in CO_2 purity; (2) high pressure ratio helps to have high CO_2 purity; (3) large membrane area is needed for a high degree of CO_2 separation; (4) more specific energy is required for increasing the degree of CO_2 separation [18]. In an industrial power plant of 1000 MW under the operation condition of 30 mbar we have seen that with the increase of the separation the CO_2 purity decreases in Figure 4.



Membrane area, A= 49×10^6 m^2, B= 17×10^6, C= 51×10^6 m^2 , D=49×10^6 m^2

Fig. 4. CO_2 purity (mol%) vs Separation degree (%) of single-stage membrane [14]

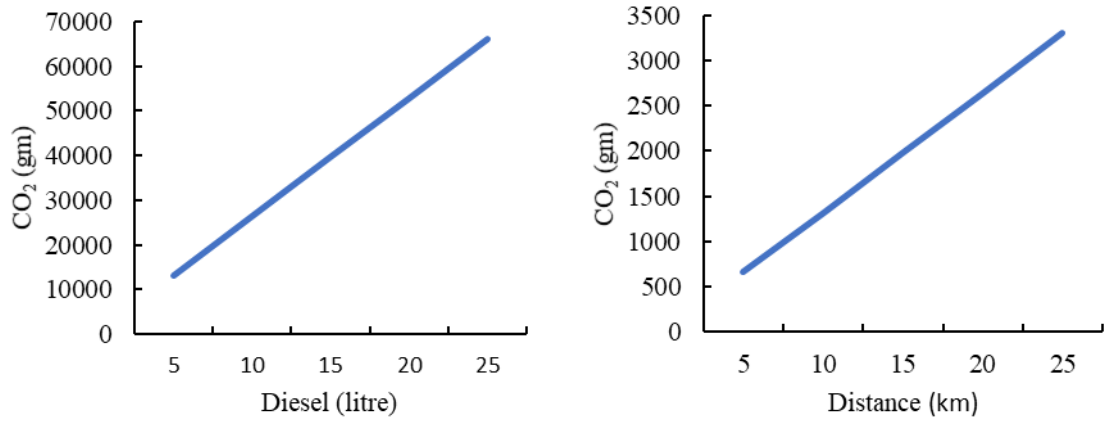
Again, for another power plant the diameter of the membrane increases with the increase in separation degree. In figure 5, the Relation between the diameter and the separation degree of CO_2 is shown for the process selectivities of 25 and 55 respectively with CO_2 purity requirements of 80 and 90 mol% respectively and the operating conditions: feed CO_2 molar fraction 14 mol%, feed flow 100 m3 h−1, permeate vacuum 30 mbar and 55 mbar, respectively.



(a) For 80% CO_2 purity (mol%) (b) For 90% CO_2 purity (mol%)

Fig. 5. Separation degree (%) vs diameter (m) of single-stage membrane [14]

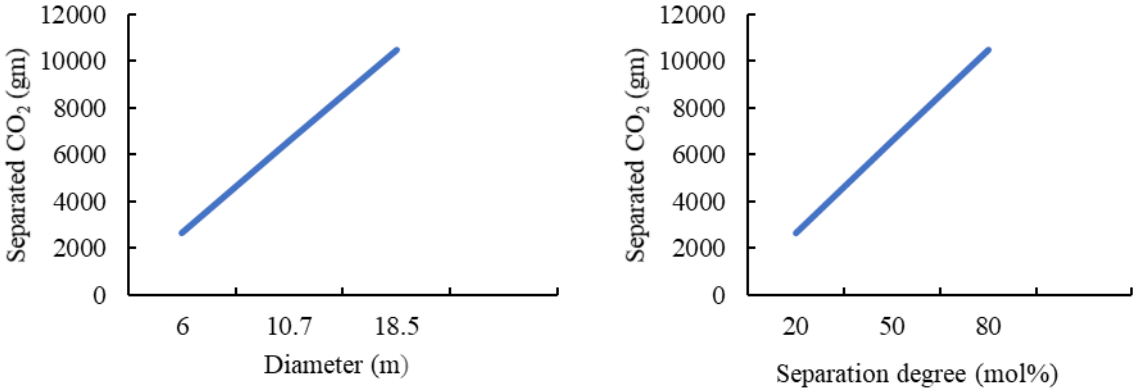
We can separate CO_2 from big industries by applying this process. But we can apply this process in small industries such as four-wheeler vehicles also. Exhaust gas recirculation system is a technology for reducing the emission of CO_2 from the vehicle. We can also replace this system in place of EGR also. A four-wheeler vehicle by burning 1 litre of diesel produces 2640 gm of CO_2. Thus, by burning 5, 10, 15, 20 and 25 litres of diesel it produces 13200, 26400, 39600, 52800 and 66000 gm of CO_2, respectively. Again, a four-wheeler vehicle moves 20 km per litre of diesel and produces 2640 gm of CO_2. When the vehicle moves 1 km it produces = 132 gm of CO2. Thus, by travelling 5, 10, 15, 20 and 25 km the vehicle produces 660, 1320, 1980, 2640, and 3300 gm of CO_2, respectively.



(a) (b)

Fig. 6. (a) CO_2 emission from diesel of a four wheeler vehicle (b) CO_2 emission from by different distances of a four-wheeler vehicle.

Let, a four-wheeler diesel engine vehicle after burning 5 litre of diesel produces 13200 gm of CO_2. Let, for separating CO_2 the vehicle has the membrane having with 90% CO_2 purity (mol%). Thus, 6 m diameter membrane having with 20% separation degree separates, $13200\times\frac{20}{100}$ = 2640 gm of CO_2. Again, 10.70 m diameter membrane having with 50% separation degree separates, $13200\times\frac{50}{100}$ = 6600 gm of CO_2. Again, 18.50 m diameter membrane having with 80% separation degree separates, $13200\times\frac{80}{100}$ = 10500 gm of CO_2. So, out of 13200 gm of CO_2 different diameter membranes having with different separation degree separates different amount of CO_2 in figure 7.



(a) (b)

Fig. 7. (a) Separated CO_2 (gm) vs diameter (m) (b) Separated CO_2 (gm) vs separation degree (mol%)

If we want to have the 100% separation degree that is to separate full amount of 13200 gm of CO_2 emitted from 5 litre of diesel then we need to increase the diameter of the membrane. When membranes have 80% separation degree, for separating 10500 gm of CO_2 it requires membrane of 18.50 m diameter. For separating 13200 gm of CO_2 it requires membrane of $\frac{18.50\times13200}{10500}$ = 23.25 m diameter. Thus, for increasing separation degree from 80% to 100% the diameter needs to be increased from 18.50 to 23.25 m. On the other hand, flue gas contains large amounts of sulfur dioxide (SO_2) where wet flue gas desulfurization based on limestone is the most promising and effective method for separating SO_2 from flue gases. It has some disadvantages like high operating cost, potential to cause secondary pollution and greater water requirement [19]. Figure 8, shows the SO_2 separation efficiency (%) with respect to time of 2000 ppm,2500 ppm and 3000 ppm of SO_2 in outlet flue gas.

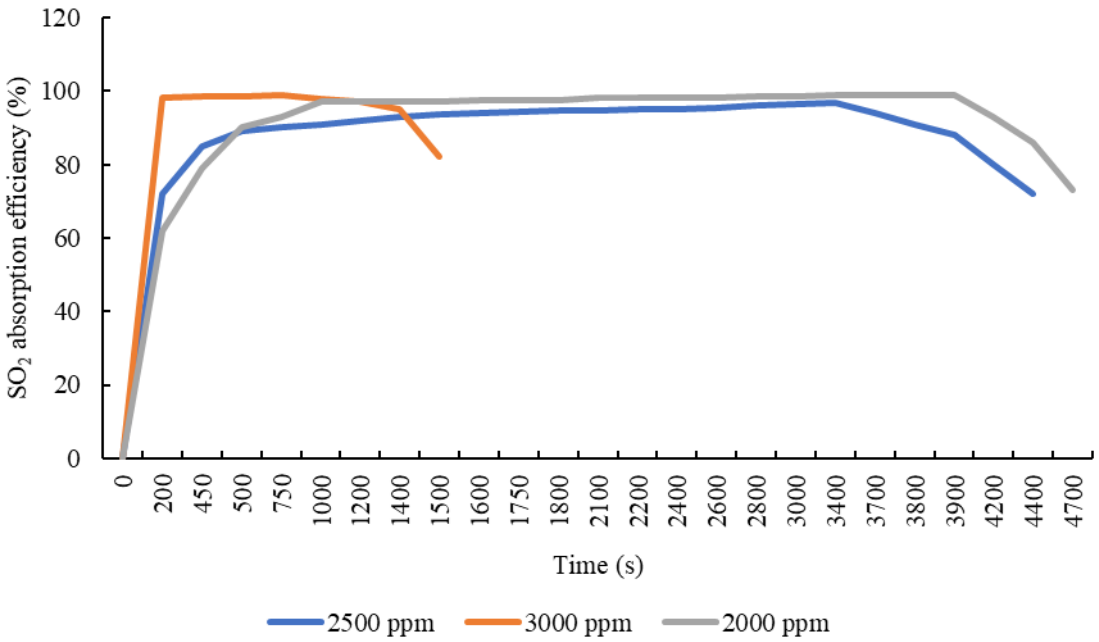


Fig. 8. SO_2 absorption efficiency (%) vs time (s) (gas flow,0.12m3/h; absorption solution, 100 mL;O2, 5 vol%; 298K) [19]

In coal-fired power plants and industries which burn fossil fuels release a great deal of CO_2 and SO_2. The percentages of these gases are too much high. So, the workers working there at high risk daily. Due to the emission of these gases day by day the workers are getting themselves sick and lose their working capabilities. Industries lose their experienced workers and can't get expected output from the workers. Every year industry owners have to spend a lot of money for the compensation of the workers. If use this system to those power plants and industries, it will absorb an excess amount of CO_2 and SO_2 from the air and make the workplace healthy and safe for the workers and this process will also reduce the extra cost due to the sickness of workers.

4. Conclusions

Global warming and rise of sea level are very important issues now. On the other hand, fire accidents, health problems of skilled workers because of polluted air in industries are also common. This system will capture the harmful gases like CO_2, SO_2 from the polluted air of those industries and would use that CO_2 as a fire extinguishing agent. Capturing SO_2 would be beneficial to the health of workers. This system can easily avoid fire accidents and can save our valuable lives of workers with ensuring a healthy workplace for them. This system will also reduce carbon emission, global warming and rise of sea level at a high rate in big industries which are big issues for the recent years all over the world. CO_2 emission will be lessened at the industry level so that we need not think about separating CO_2 from environment any more. Annual Budget for disaster for every country will be reduced so that every country can use those money in other development sectors. The industries can earn money by selling CO_2 and SO_2 as product and thus the cost of CO_2 and SO_2 will be reduced.

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