Industrial Scrubbers and Air pollution Control

Omar Ayman, STEM high School for Boys

Abstract

Air pollution appears as a more straightforward problem which is facing the whole world, where it affects the ecosystem; it harms animals in general and humans in particular. As a result, scrubbers were used in industries to remove harmful chemicals and acids from polluted gas [1]. Scrubber is a waste gas treatment installation as it uses liquid to remove particulate substance or gases from an industrial use or flue gas stream [2]. In other words, scrubber is an air pollution device control, where an atomized liquid, typically water, drags particles and pollutant gases in order to successfully wash them out of the gas stream. Scrubbers can be used as an emission-limiting technique for many gaseous emissions. The two types of scrubbers, which are wet and dry scrubbers, mainly approach the same aim: achieving air pollution reduction.

I. Introduction

Every problem has its own solution and every situation must be analyzed wisely to reach a proper solution. Air pollution occurs when harmful gases enter into the atmosphere and make it difficult for plants, animals and humans to survive. Scrubbers met the technical performance standards and was used in the last decades to control the pollutant gases that emit from industries and cause air pollution. Scrubbers mainly work on transporting the components from the gas phase to the liquid phase. It was noticed that the level of gaseous particles that can reach the liquid phase is determined by the ability of these gaseous particles to dissolve in the liquid. There are distinct types of scrubbers: Wet and dry scrubbers. Wet scrubber's process forces the polluted components to pass through a wet limestone slurry which traps sulfur particles. In contrast, dry scrubbers do not utilize any liquid to absorb inlet particles. Scrubbers prove that they are an ideal solution for industries' emissions, but they also have some disadvantages. Apparently, corrosion is one of the biggest problems of the scrubber's system. Corrosion takes place in microscopic cells whenever conditions are suitable, reacts with oxygen and hydroxyl ions, and then it leads the metal to corrode.

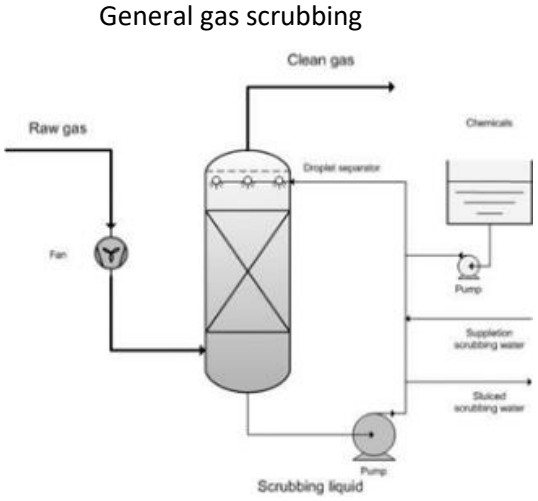

Figure #6: The structure of the gas scrubber

However, it was found that stainless steel that is used in scrubbers can cause distinct types of corrosion.

II. Mechanism

During this process, components are transferred from a gas to a liquid phase. The level of gaseous components that can permit to the liquid phase is determined by the ability of these components to dissolve in the liquid as shown in figure #1. As a result, Henry's Law was used as it is applicable to low concentrations and components with a partial pressure less than 1atm. The partial

pressure was calculated using the equation shown in figure #2 [3], where:

p = partial pressure
x = mole fraction
H = Henry constant

$$p = H \cdot x$$

Figure #2: Henry's Law

The importance of scrubbers lies in its ability to remove contaminants and chemicals from the process. However, scrubbers have two different mechanisms to rely on. The first mechanism involves particles wetting. This can be achieved by using the scrubbing liquid. The efficiency gets higher with smaller droplets. The smaller the droplets, the bigger the surface area for the weight of the liquid; as a result, this gives a greater chance for the particles to get wetting [4]. The second mechanism is basically the removal of the modified (wetted) particles to the collecting surface. Then, the separation of wetted particles from the carrying gas stream occurs in the inertial collector. Increasing the gas velocity or even the liquid droplets velocity in Venturi Scrubbers - a type of wet scrubbers - will ultimately increase the number of collisions per unit time. Thus, the efficiency will be increased to a greater extent. This makes venturi scrubbers operate at a very high gas and liquid velocities with an extreme pressure drop.

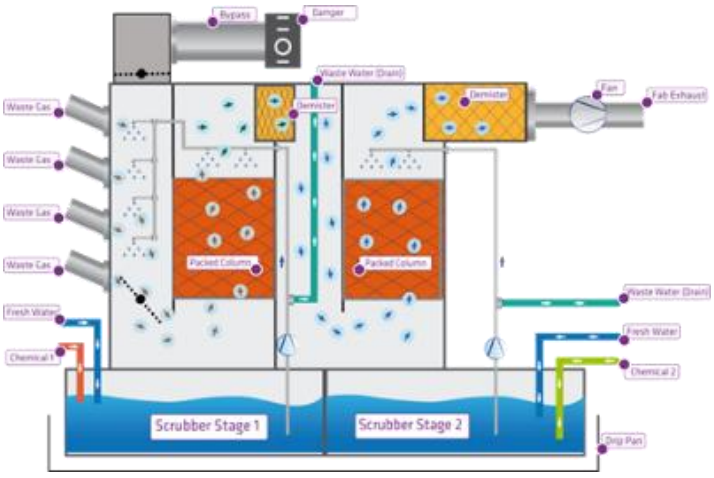

Figure #3: The operating system of wet scrubbers.

III. Types of Scrubbers

There are two main types of scrubbers: Wet scrubbers and dry scrubbers. Their main use is protecting the environment by removing harmful chemicals and acids from polluted gases. Furthermore, there are multiple types of scrubbers that aim to support the process, including wet and dry scrubbers [5]. Concisely, with high efficiency and well-maintained industrial scrubbers, a facility can complete production and keep the environment and its workers protected. There are two main types of wet scrubbers: Venturi and Packed Tower scrubbers. The operating system of wet scrubbers differs from the other types of industrial scrubbers as demonstrated in figure #3, because of the liquid-gas association that increases the moisture level of the gas that is being excluded from the scrubber. The increased moisture in the gas will create a visible cloud exiting the scrubber. A venturi scrubber is a type of wet scrubbers and it designed to effectively use the energy from the entered gas stream to spray the liquid being used in order to purify the gas stream [6]. This type of devices is a part of the air pollution controls, and this together referred to as wet scrubbers.

IV. Advantages and Disadvantages

Advantages of Scrubbers can be determined by describing their uses, which are removing the contaminants from an industrial use or flue gas stream with high efficiency. Scrubbers is an ideal solution for industries' emissions, but they also have some disadvantages that are discussed below:

Advantages

1- One of the effective advantages of using scrubbers is the positive environmental impact. Actually, the removal of harmful substances from exhaust gas is important as it prevents a large number of pollutants from escaping into the air.

2- Developments in wet scrubbers have allowed it to increase the efficiency in pollutant removal. One of the major developments has been to take full advantage of the total surface of the liquid with which the polluted gas associates, as more surface area means that more of the particles can be singled out of the gas.

3- Dry scrubbers produce relatively little wastes. Actually, most of these materials that are sprayed into the exhaust are burned off in the heat of the stream or caught in a filter.

4- The use of dry scrubbers is not expensive as there is no linked cost with removing, transferring, and storing waste water from wet scrubbers

5- The design of the dry scrubber allows it to remove sulfur dioxide with high efficiency that can reach 98%.

Disadvantages

1- The residual waste powder that used in scrubbing must be disposed of because it is a risky material. This waste must be handled by specialists because of its chemical makeup.

2- Using scrubbers causes a high potential for corrosion problems which will cause a significant deterioration of natural and historic monuments along with increasing the risk of terrible equipment failures [7].

3- Scrubbers have a high potential to cause corrosion; as the selected materials of construction for scrubber system can be low corrosion resistant metals. As highly corrosion resistant metals can be expensive, choosing between the higher performing metals and the cost may have some consequences that lead to an economic analysis and demonstrate mainly what is gained from the both scenarios.

V. Corrosion

Corrosion has been one of the biggest problems that scrubbers cause. When metal reacts with another substance such as oxygen, it corrodes. Furthermore, it can also happen when metals are put under stress. Thus, it cracks.

Stainless steel that is used in scrubbers can cause diverse types of corrosion depending upon the nature of the agent. Corrosion actually takes place in microscopic cells wherever conditions are suitable. The typical conditions for corrosion are imperfections in metal surfaces, metal exposed to electrolytic solutions, and obviously, the presence of chemicals in solution that can react with the oxygen and hydroxyl ions.

VI. Conclusion

As a matter of fact, the effects of air pollution are alarming. They are known to create several respiratory and heart conditions along with cancer and other threats to the human body.
Scrubbers have two main types: Wet and dry scrubbers. Those two types of scrubbers approach achieving air pollution reduction through different mechanisms. Using scrubbers to remove harmful chemicals and acids from polluted air made it much easier to reduce air pollution. Scrubbers appear as an ideal solution for industries' emissions. However, it causes corrosion which is one of the biggest problems of the scrubbers as in most cases, they use stainless steel.

VII. References

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