

AMELIORATED SOX SCRUBBER

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Abstract: The emission of oxides of Sulphur from marine diesel engine, in power plants and in many small scale and large scale industries is causing serious threat to environment which need to be controlled, as exhaust passes over the catalyst the harmful pollutants get converted into harmless gases by promoting chemical reactions. Exhaust gas is emitted as a result of combustion of heavy fuel, coal and other fuels. Internal combustion engine generate undesirable emissions during the combustion process. The main exhaust pollutants are HC, CO, NO_x, CO₂, particulate matter, volatile organic compounds, SO_x etc. NO_x and SO_x are of special concern as threats to vegetation, the environment and human health. The particle level in exhaust gas concerns about the Sulphur content in fuel has introduced oil. IMO and the European united have introduced a restriction of Sulphur of no more than 0.50% m/m on and after 1st January 2020 outside an ECA.

Keywords: Exhaust pollutants, IMO sulphur cap, Harmless gasses

1. Introduction

Sulphur dioxide (SO₂) belongs to the family of sulphur oxide (SO_x) gases. These gases are formed when fuel containing sulphur (mainly coal and oil) is burned (e.g., for electricity generation) and during metal smelting and other industrial processes. High concentrations of SO₂ are associated with multiple health and environmental effects. The highest concentrations of SO₂ have been recorded in the vicinity of large industrial facilities. Although relatively few people live in areas where SO₂ concentrations exceed the National Ambient Air Quality Standards (NAAQS), SO₂ emissions are an important environmental issue because they are a major precursor to ambient PM_{2.5} concentrations. Health effects associated with SO₂ depend on the exposure concentrations and durations, and on the susceptibility of exposed populations. Asthmatics are much more susceptible to SO₂ exposure than people who do not have asthma. Effects associated with longer-term exposures to high concentrations of SO₂, in conjunction with high levels of PM, include respiratory illness, alterations in the lungs defences, and aggravation of existing heart or lung disease. The most susceptible populations under these conditions include individuals with cardiovascular disease or chronic lung disease, children, and older adults. Many other environmental concerns are associated with high concentrations of SO₂. For example, airborne SO₂, along with NO_x, contributes to acidic deposition. SO₂ exposure also can harm vegetation by increasing foliar injury, decreasing plant growth and yield, and decreasing the number and variety of plant species in a given community. Finally, SO₂ can accelerate the corrosion of materials (e.g., concrete, limestone) that are used in buildings, statues, and monuments that are part of the nation's cultural heritage.

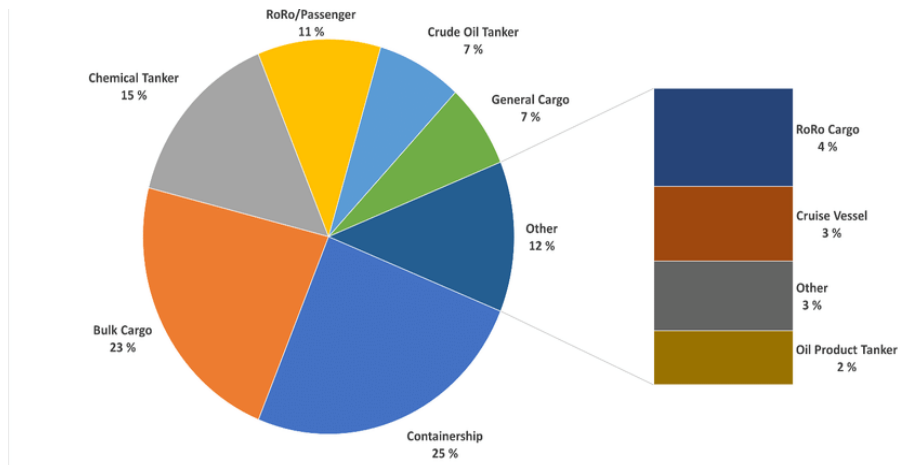


FIGURE 1. Global Emission Statistics From Different Types Of Ships

2. Main work

The abatement of sulphur dioxide contained in flue gases is of significant industrial concern. At present, the flue gas desulfurization (FGD) is still the main technical means to control sulphur dioxide pollution. Although various processes have been proposed for flue gas desulfurization, the wet-type scrubbing is still the dominant process. The wet type processes include methods using alkaline solutions of sodium, calcium and magnesium compounds as absorbent. The sodium method above all is excellent in reactivity between the absorbent and SO₂, but the sodium compounds used are relatively expensive. For this reason, the calcium method using relatively cheap calcium compounds such as calcium carbonate is most widely employed as a flue gas desulfurization system for large boilers in power plants. However, when sodium compounds are used in a closed-loop system (with regeneration of solutions), it is estimated that the costs will be comparable or lower than those of calcium-based processes. The research group has developed a new type of desulfurization technology - Desulfurization process of low-state membrane electrolysis applied to sodium alkali recycling solution. An aqueous Na₂SO₃ solution is used as absorbent in a closed-loop process. The technology enables low-cost, stable operation and resource recovery. As SO₂ absorption by sodium alkali is a key in the process, the study on SO₂ absorption has become an important basis for universal application of the technology. Based on the simulation experiments in the laboratory, the in-depth research of sodium alkali FGD process has been conducted in a packing column. The experimental data can provide the reliable design basis for industrial applications of the process.

2.1 Types of scrubbing system

There are basically two types of scrubbing system dry scrubbing system and wet scrubbing system. Both remove the particulate matter but the process undergone is different.

Dry scrubbing systems are used to remove acid gases such as SO₂ and HCL from waste gas streams. These systems apply a powder sorbent material, either calcium- or sodium based alkaline reagent, to react with the acid gases in the flue gas and produce a solid salt that can be removed in a particulate control device such as a bag filter or ESP. These scrubbers do not require a stack steam plume or wastewater handling/disposal. In dry scrubbing systems or dry sorbent injection systems, the dry-powder sorbent material is injected directly into the ductwork or reaction chamber, whereas in semi dry scrubbing systems or spray dryer absorbers (SDAs), the sorbent material is first mixed with water and then injected into a spray-drying vessel where all the liquid is totally evaporated by cooling the

gas stream while the sorbent reacts with the acid gases to form solid salts that are removed by the particulate control device. The removal efficiency of the scrubbing system can generally be improved by the use of a reaction tower

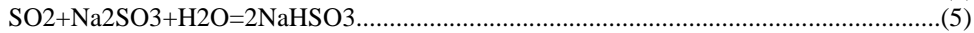
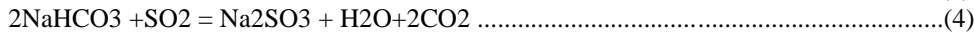
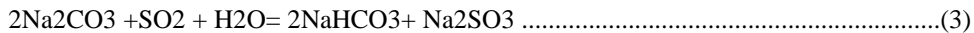
Wet scrubbing systems are devices that utilize a suitable liquid (water or alkaline solution) to remove particulate and gaseous pollutants (such as SO₂). A wet scrubbing system may consist of ductwork and a fan system, saturation chamber, scrubbing vessel, mist eliminator, pumping and possible recycle system, spent scrubbing liquid treatment or reuses system, and exhaust stack. Wet scrubbers generate wastewater stream that must be treated or reused in the plant. Since the gas stream is saturated with liquid and a steam plume is created, a mist eliminator or entrainment separator is also often an integral part of any wet scrubbing system to remove or recycle the scrubbing liquid in addition to providing additional pollutant removal.

2.1.1 Reaction mechanism of sodium alkali FGD

In the sodium alkali FGD process, NaOH or Na₂CO₃ is used as the initial absorbent, which lead to the formation of sodium sulphite and sodium hydrogen sulphite, depending on the pH-value of absorption solution. The main absorption reactions are as follows.



When the absorbent is Na₂CO₃:



2.1.2 Problem Statement

In conventional type scrubber only water is used which is not effective in scrubbing maximum amount of SOX content. In other type calcium carbonate is used as scrubbing medium, but the disadvantage of this type is that it forms gypsum as bi product which will block the system pipe lines and which is not effective. Hence in this project sodium hydroxide is used as a scrubbing medium which is effective in absorbing maximum SOX content, for this we have designed and fabricated scrubber unit and testing is carried out to ensure the reduction of SOX emission in the exhaust gas.

2.2 Objectives

- 1.To design the model of scrubber.
- 2.To fabricate the scrubber unit based on design.
- 3.To test the performance of scrubber.

2.3 Design and fabrication

Scrubber systems are a diverse group of air pollution control devices that can be used to remove some particulates and gases from industrial exhaust streams. Traditionally, the term "scrubber" has referred to pollution control devices that use liquid to wash unwanted pollutants from a gas stream scrubber are cleanings installations in which the gas flow is brought in intensive contact with a fluid which as aim to remove gaseous components from the gas to the fluid. Scrubber can be applied as

emission control technique at various gaseous emissions. There are two types of scrubbers, wet and dry scrubber. Wet scrubbing works via the contact of target compounds with the scrubbing solution.

2.3.1 Design of scrubber tower

The scrubber is completely made up of mild steel. Initially the rough design was sketched and then each part of the scrubber column was designed in CAMD and using that the mild sheet of 2mm thickness was cut using a laser cutting machine and rolled to the structure of the scrubber. Then each part was welded according to setup. The nozzles were fitted inside the column. Then pipelines were connected between pumps and nozzles in the scrubber and suction of the pump is connected to NaOH tank. The furnace oil from the tank is passed to the furnace and which was controlled by a ball valve to control the flow. The flow of NaOH solution from tank to the nozzle was controlled by recirculating ball valve. The exhaust gas from the furnace is passed to the scrubber column inlet through metal pipes connected between them

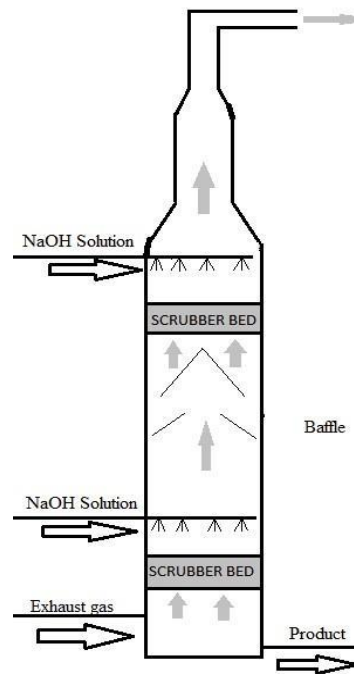


FIGURE 2. Cross Section Of Scrubber Tower

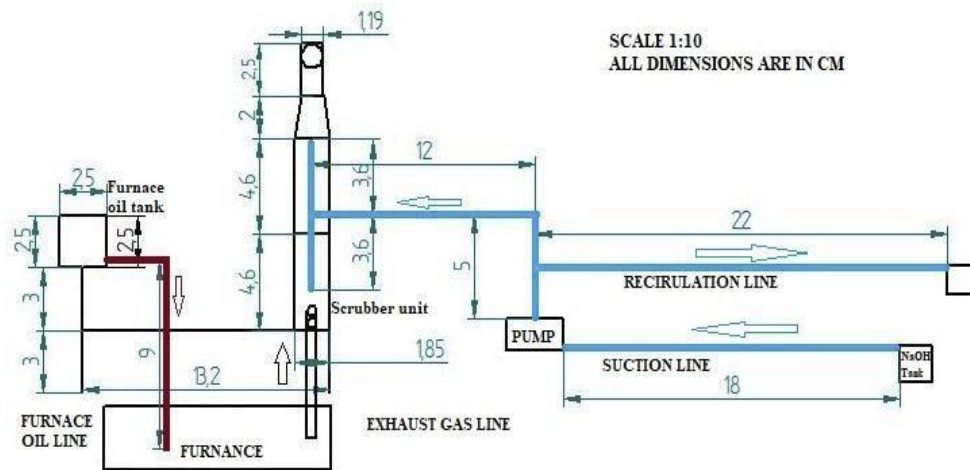


FIGURE 3. Working Model Design

2.4 Tests and results

The setup for the testing of the project is done as shown in Fig 5.1, the testing is done for two variations of flow rates, one for 3.4L/min and another for 2L/min. The furnace is lit and a constant supply of furnace oil of 125 cm³ /min is supplied, then initially the sulphur content is sensed and noted then two tests for a period of 5min each is done and values of sulphur content is noted and also during the test the concentration of NaOH solution is maintained at 0.5mol/L. The testing was done by One Earth enviro labs, a NABL accredited lab, using a flue gas analyser.

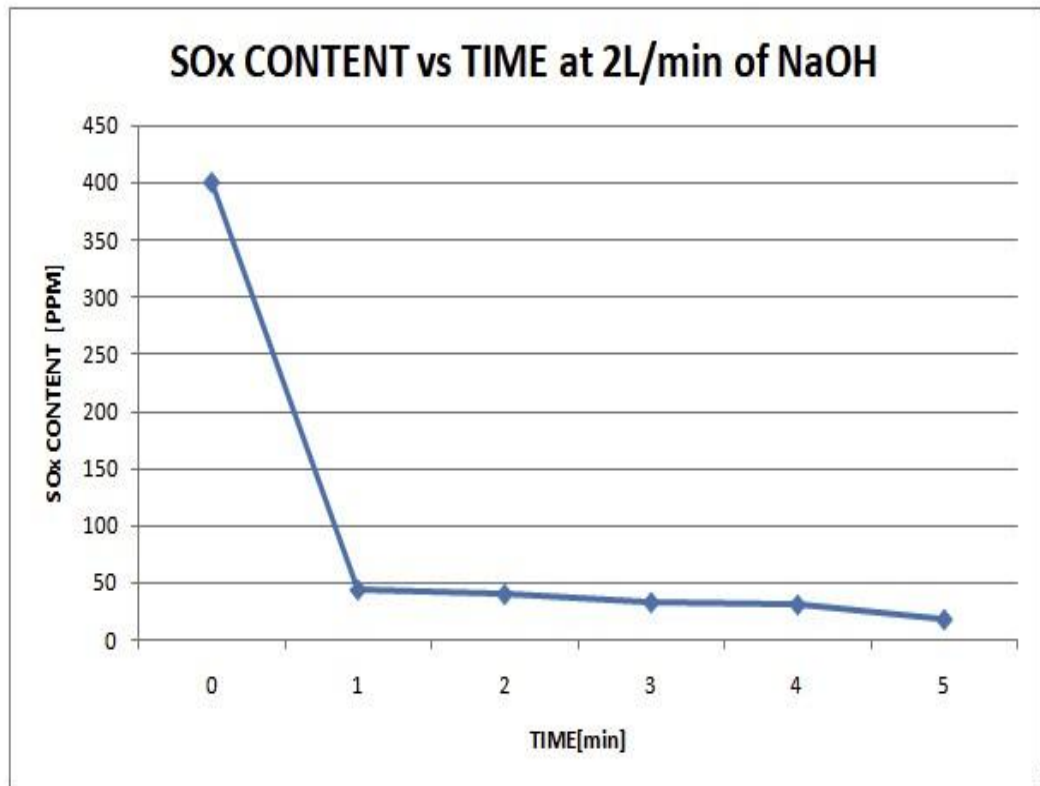


FIGURE 4. Tests And Results

Calculations

Furnace oil flow rate maintained when NaOH flow rate was 3.4L/min

Initial level= $25 \times 25 \times 8.7 = 5437.5 \text{ cm}^3$

Final level= $25 \times 25 \times 7.7 = 4812.5 \text{ cm}^3$

Furnace oil consumed = Initial level – final level

= $5437.5 - 4812.5 \text{ cm}^3$

= $625 \text{ cm}^3 = 125 \text{ cm}^3 / \text{min}$

Furnace oil flow rate maintained when NaOH flow rate was 2L/min

Initial level= $25 \times 25 \times 7.7$

= 4812.5 cm^3

Final level= $25 \times 25 \times 6.7$

= 4187.5 cm^3

Furnace oil consumed = Initial level – final level = $4812.5 - 4187.5 \text{ cm}^3 = 625 \text{ cm}^3 = 125 \text{ cm}^3 / \text{min}$

% Efficiency of scrubbing when NaOH flow is 3.4 L/min

% Efficiency = $[\text{CSOx scrubbed} / \text{CSOx initially present}] \times 100$

CSOx scrubbed = $470 - 23 = 447 \text{ ppm}$

CSOx initially present = 470 ppm

% Efficiency = $[447 / 470] \times 100 = 95\%$

% Efficiency of scrubbing when NaOH flow is 2 L/min

% Efficiency = [CSOx scrubbed / CSOx initially present] X100

CSOx scrubbed = 400-18 = 382ppm

CSOx initially present = 400ppm

% Efficiency = [382/400] X 100 = 95%

2.5 Pictures of the model



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FIGURE 5. Fully Assembled Working Model

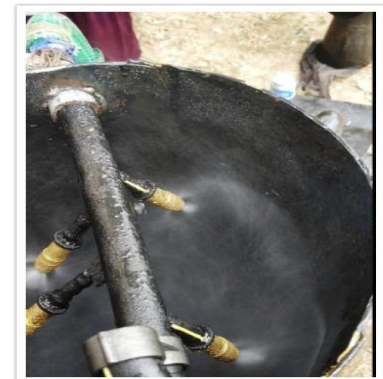


FIGURE 6. Top Part Of The Funnel And Arrangement Of Nozzle In The Scrubber Unit



FIGURE 7: Scrubber Shell

3. Conclusions:

This scrubber system can reduce the SO_x emission into the atmosphere by around 95%. Here the NaOH concentration is maintained at 0.5 mol/L, and the NaOH flow rate and furnace oil flow rate is maintained constant for particular trial and we have seen that there was reduction in oxides of sulphur by about 95% in both the trials of the test. This system with additional modification and as per requirement can be installed in ships, small scale industries and in coal power plants, thus can reduce the pollution of the environment by oxides of sulphur. As per (Marine environment protection committee) MEPC 73 guidance from Jan 1 2020 all ships must comply with the regulation of emitting only 0.50% sulphur into atmosphere, hence by necessary modification this scrubber can fulfil that requirement.

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