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ALTERNATIVE ANALYSIS OF SODIUM/CALCIUM HYDROXIDE WITH GRAPHENE IN SCRUBBER TOWER

Jeyasurya S[1], Kabilan J[2], A C Mariappan [3], G Peter Packiaraj[4]

[1,2]Final year B.E Marine Cadets, PSNCET, Tirunelveli, Tamilnadu
[3,4]Assistant Professor, Department of Marine Engineering, PSNCET ,Tirunelveli ,Tamilnadu

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ABSTRACT:

➢ *This study explores the synergistic effects of integrating graphene with sodium/calcium hydroxide in scrubber towers for efficient CO2 capture and SO2 removal. A novel theoretical model and experimental analysis reveal that graphene-based sorbents exhibit superior performance compared to conventional sodium/calcium hydroxide systems.The implementation of exhaust cleaning scrubber systems onboard ships represents a critical strategy for reducing air pollution and complying with increasingly emissions regulations. This thesis explored exhaust cleaning scrubber technology, focusing on its different types of designs, operation, and impact within the maritime industry. Using books, websites and online publications, the process itself proved to be eye-opening.Concerning the environment, exhaust scrubber systems offer benefits and Drawbacks. Sulphur emissions have decreased, which is a positive. However, Waste wash water discharge contaminate seawater if not well monitored. Therefore, the purpose of this thesis was to educate interested parties such as Shipowners, operators, regulators, and policymakers about the advantages And difficulties associated with implementing scrubber technology aboard Ships, the various exhaust gas scrubber system designs, the impacts they Have on the environment and all the laws that prohibit the discharge of wash Water as well as the IMO regulations.*

Keywords:

International Maritime Organization, MARPOL, Exhaust scrubber, Open loop, Close loop, Water discharge, Sox reduction.

1.INTRODUCTION:

➢ The maritime sector is important for global trade as it connects economies and Makes it effortless to travel between continents. However, the industry's Reliance on fossil fuel for propulsion, environmental impact concerns were Raised particularly regarding greenhouse gas emissions and air pollution. As The environmental awareness and regulatory demands escalates, ship Operators and ship owners are forced to search for productive ways to improve Sustainability and reduce emissions in maritime transportation industry. Installation of exhaust cleaning scrubber system on board ships is a sole Solution. Scrubber system reduce the pollutant emissions such as nitrogen Oxides (NOx), Sulphur dioxide (SO2) and particulate matter (PM) which are Part of the exhaust gas that the ship engine releases after combustion. Exhaust Cleaning scrubber system offers effective ways to meet the emission Regulations meanwhile reducing the environmental impact of maritime trading Operations by cleaning the exhaust gases before they are released into the Atmosphere This thesis explores various views of exhaust cleaning scrubber system Onboard ships, aiming to provide in-depth understanding of their operation, Local laws of certain ports regarding the use of scrubbers, installation, design, And consequences within the marine industry. This thesis aims to discuss Crucial questions about scrubber technology and its adaptation into shipboard Operations by using regulatory frameworks, real world case studies and Existing literature.The introduction of Maritime Organization's (IMO 2020), sulphur emission Regulation has motivated ship owners to be interested in exhaust cleaning Scrubber system enabling them to comply with the regulations, even though the system comes with operational limitations, environmental effects, and complex technology that this thesis will discuss in further detail. Shipowners must adjust and be attentive to challenges and opportunities that This system presents and that will contribute to more sustainable manner and A future cleaner maritime transportation operation. This thesis aims to provide Useful information into the role of the scrubber system by analyzing the facts From industry reports and academic research done in the past.

2.PRINCIPLE:

➢ A scrubber tower, also known as a wet scrubber or air scrubber, is an air pollution control device designed to remove pollutants, gases, and particulate matter from industrial exhaust streams. Here's how it works:

➢ The scrubber tower uses a liquid, usually water or a chemical solution, to scrub the pollutants from the exhaust gases. The process involves physical and chemical interactions between the liquid and the pollutants.

3.WORKING PROCESS:

[1] Exhaust gases enter the scrubber tower and mix with the scrubbing liquid.

[2] Pollutants are transferred from the gas phase to the liquid phase.

[3] Chemical reactions may occur between the pollutants and the scrubbing liquid.

[4] The liquid droplets containing pollutants are separated from the cleaned gas

[5] The cleaned gas is discharged through the outlet.

4.COMPONENTS:

Inlet:
Exhaust gases enter the scrubber tower.

Spray nozzles or distributors:
Distribute the scrubbing liquid evenly.

Contact zone:
Exhaust gases interact with the scrubbing liquid.

Entrainment separator:
Separates the liquid droplets from the cleaned gas.

Outlet:
Cleaned gas is discharged.

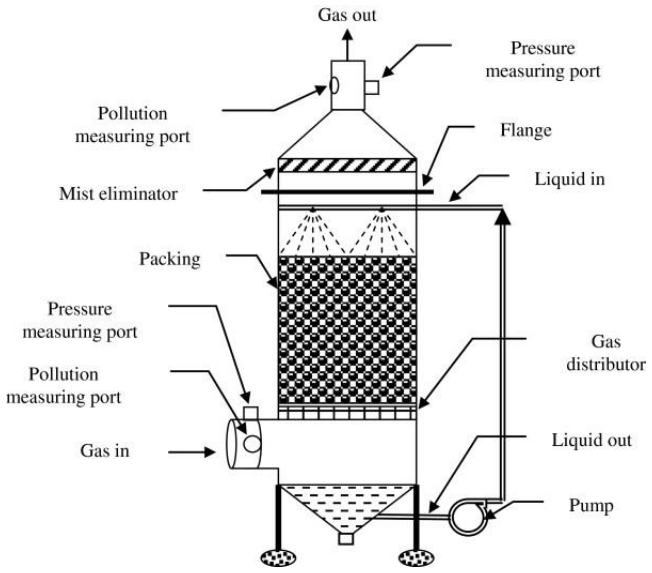

Fig:1.1 scrubber tower

5.Overview:

➢ Scrubber system is viewed as a necessary equipment for vessel operation, it Is critical that the operators and engineers involved become fully familiar with The installed system. Although scrubbers are quite new installation in maritime Applications, the technology has been widely acknowledged on land. It is Proven that the system has extremely lowered the emissions of sulphur oxides And thus it has been used for decades on land-based fuel oil burning or coal Facilities. The air quality is improved by the exhaust gas filtration, as the scrubber system Cools down the exhaust gases by removing solid particles, and gases mist. However, shipping sector pollutes air and water affecting the environment and Marine life. Ships with open loop system contaminate the sea by discharging Wash water overboard. Wash water has high acid and warmth comparatively To the surrounding sea water due to the exhaust gases that are being cooled By seawater circulation and that change affects the aquatic life. Metals such
As nickel, lead, and copper are as well present in the wash water. Due to air Pollution, some international, local, and regional regulations are presented in This thesis because they have an influence on scrubber performance Monitoring and operation. We will also investigate the recommended Guidelines that the IMO has provided for the certification and operation of Scrubber units.

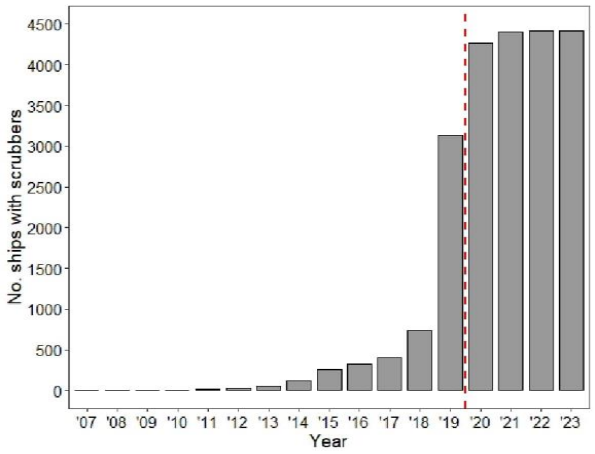

Fig: 1.2 scrubber tower graph

6.GENERAL KNOWLEDGE OF EXHAUST SCRUBBER :

➢ Varieties of exhaust scrubber system There are two types of industrial scrubbers, dry and wet. Knowing the Difference between wet and dry scrubbers is important. Although dry scrubbers Generally cannot remove pollutants to the

same extent as wet scrubbers, they Are an excellent choice for applications in facilities without the need of Infrastructure to handle produced wastewater.

6.1 Dry scrubber system:

- Dry scrubber system is an

air pollution control device used to extract pollutants From industrial exhaust gases, this system is also called a dry sorbent system. As an alternative to liquid, sodium bicarbonate or lime are examples of dry Sorbents that are injected into the gas stream in a dry scrubber. The removal Of pollutants from exhaust gases is not done by liquid. However, by passing The gas through the sorbent dust to maximize binding, acid is removed from Gas. They do this by using a dry reaction material known as sorbent, such as
Alkaline slurry. They are used in many industries to comply with environmental Regulations and are especially useful for reducing acid gases .

- The sorbent particles are

finely grinded in order to increase the surface area As well as the removal efficiency. When the sorbent particles are finely grinded, They make it easier to spread uniformly through the gas stream. The dry Sorbent meets the contaminants in the gas stream. Pollutants are absorbed Into the sorbent particles or adsorbed onto the surface of the sorbent, Depending on the type of sorbent and pollutants in use. The combination of the Sorbent and pollutants creates fewer toxic compounds during the chemical Reaction. For example, when sulphur dioxide and lime react, they produce Calcium soleplate. The cleaned gas is released into the atmosphere with lower pollutants. (There are two types of particulate control devices that are used to capture dirty Sorbent particles, the bughouse and the electrostatic precipitation. The Bughouse filter has filter sleeves or fabric bags that traps the particulate matter As the gas flows through the bags while the electrostatic precipitator collects The dirty sorbent particles from the gas stream by using electrostatic forces. Particles are charged as they pass through the ionization zone and then the Charged particles are attracted to the oppositely charged collection electrode Where they can be removed from. Relying on the system design, the sorbent Might be recycled after capturing pollutants or disposed of as waste. Sorbent Recycling can reduce operating costs. Constant monitoring of the dry Scrubber's performance is important to ensure effectiveness, parameters like Sorbent injection rates and gas flow rates are monitored and adjusted as Necessary.

7.BLOCK DIAGRAM:

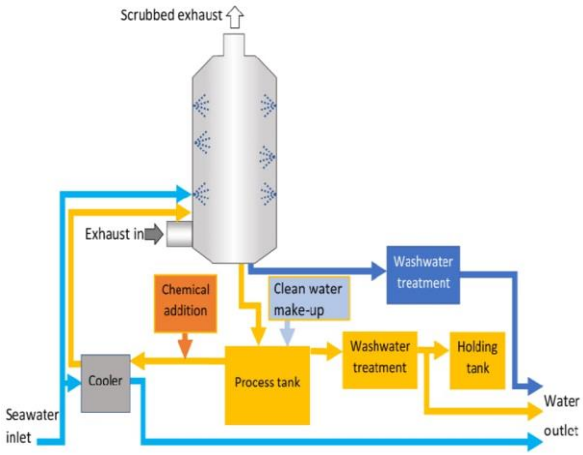

Fig : 1.3 Block diagram of Scrubber tower

Simplified diagram of a hybrid scrubber system. Light and dark blue lines represent the open loop mode, and the yellow lines show the closed loop mode. Modified from EGCSA

Characteristics of Marine Scrubbers

Characteristic / Element	Wet Scrubbers	Dry Scrubbers
Scrubbing Liquid	Seawater or fresh water is used to remove sulfur	Water or fluid is not used to remove sulfur. Pellets of hydrated lime is used instead.
Temperature	Temperature not as high as dry scrubbers	Higher temperature than the wet scrubbers (burns off soot)
Power	Consumes more power than the dry scrubbers	Consumes less power (do not require circulation pumps)
Disposal/Storage	Disposed over board after being treated (into the sea) Does not require storage	Discharge at ports / Requires storage
Weight	Lighter than dry scrubber	Heavier than wet scrubbers
Other Classification / Types	Closed-loop or open-loop scrubbers	Lime granulate scrubbers

8.ADVANTAGES:

Using graphene instead of sodium hydroxide (NaOH) and calcium hydroxide ($Ca(OH)_2$) has several potential advantages:

Improved efficiency:

- Graphene has high thermal

conductivity, which can enhance heat transfer and reduce energy consumption.

Increased safety:

- Graphene is non corrosive and non-toxic, unlike NaOH and $Ca(OH)_2$, which are highly caustic and hazardous.

Reduced environmental impact

- Graphene is a more sustainable option, as it can be produced from carbon-based materials and has a lower environmental footprint.

Enhanced durability:

- Graphene is highly resistant to degradation and corrosion, extending its lifespan and reducing maintenance needs.

Multi-functional applications:

- Graphene can be used in various applications, such as energy storage, composites, and electronics, making it a versatile material.

Cost-effective:

- Graphene has the potential to be more cost-effective than NaOH and $Ca(OH)_2$ in the long run, despite its current higher production costs.

Improved performance:

- Graphene based systems can offer improved performance, such as faster reaction rates and higher efficiency, due to its unique properties.

9.CONCLUSION :

- The use of scrubbers has a great potential in the substantial social and environmental benefits as they can reduce the SOx emissions by at least 95% and PM (Particulate Matter) by at least 60%. Scrubbers can also reduce the NOx emissions, although there is no consensus as to by how much. Although the significant drop in non GHG related emissions, the widespread use of ship scrubbers can benefit populations (e.g., by avoiding some diseases) and the environment (e.g., by avoiding acid rain). On the other hand, scrubbers can also help reduce Greenhouse Gases (GHG) emissions to some extent. However, there is some concern regarding the sulphates being discharged into the sea as they can change the acidity of water. The changes could have an impact on sea water biodiversity, especially among fish species. Research on this particular aspect has been limited so far. Furthermore, element of concern is the scrubber's end of life management and the production of the scrubber system itself which might be energy intensive.

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11.BIOGRAPHY:

I am pursuing B.E final year Marine Engineering cadet at PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu.

I am pursuing B.E final year Marine Engineering cadet at PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu.

Project Guide cum Assistant Professor PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu. Also having 15 years' experience in Oil and Gas industries. Specialization in NDT and worked varies Gulf Countries.

Project Guide cum Assistant Professor PSN College of Engineering & Technology, Tirunelveli, Tamil Nadu. MEO Class-IV Marine Engineer and worked varies Countries.