DESIGN OF AIR POLLUTION CONTROL DEVICES IN CEMENT INDUSTRY

Design of Environmental Engineering System

Submitted by

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LIST OF ABBREVIATIONS

PM	PARTICULATE MATTER
WHO	WORLD HEALTH ORGANIZATION
SO_2	SULFUR DIOXIDE
NO_2	NITROGEN DIOXIDE
CO	CARBON MONOXIDE
CO_2	CARBON DIOXIDE

ABSTRACT

Air pollution, resulting from human activities like industrial operations and transportation, poses significant threats to human health, ecosystems, and the environment. The cement industry, while essential for infrastructure development, is a major contributor to atmospheric pollution, emitting pollutants such as particulate matter (PM), sulfur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO2), and dust. These emissions have adverse effects on global warming, ozone depletion, acid rain, biodiversity loss, and crop productivity. In urban areas, vehicles and industries contribute significantly to air pollution, with the cement industry being one of the 17 most pollution-emitting industries. Consequently, this project addresses the challenge of designing efficient Air Pollution Control Units to mitigate SO2, NOx, and PM emissions from the cement industry. The integrated approach employs cyclone separators, electrostatic precipitators, bag house filters, and wet scrubbers, aiming to achieve compliance with environmental regulations and promote sustainable cement production for a cleaner and healthier future. The successful implementation of this integrated approach holds the potential to contribute significantly to cleaner air and improved public health. By reducing the environmental footprint of the cement industry, this project aspires to create a greener and healthier future for communities living in proximity to cement plants, and for the global environment as a whole. Through this concerted effort, we strive to pave the way for sustainable cement manufacturing and a more promising outlook for generations to come.

Keywords: Pollution, Cement Industry, Sustainable, Footprint, Environmental Regulations

INTRODUCTION

Air pollution is the presence of harmful substances and pollutants in the Earth's atmosphere, caused by human activities like industry and transportation. These pollutants, such as solid particles, liquid droplets, and gases, can have negative impacts on human health, ecosystems, and the environment. The primary sources which pollute the atmosphere are automobiles and industries. As per the study, the pollution contribution of vehicles is about 60%, and industries are about 20-30% in urban areas (Bhat and Mehraj, 2013). These pollutants include particulate matter (PM), sulfur dioxide, oxides of nitrogen, carbon monoxide, ozone, etc. As per the World Health Organization (WHO) database, air pollution is responsible for about 25% of deaths across the world (Amal et al. 2018).

Cement is a very fine powder of grey or white color, used as a binding material for the production of concrete or mortar. The construction of modern structures cannot be imagined without the use of concrete and mortar. It is, then, evident that cement production and its manufacturing industries play a crucial role in the development and economic growth of a country. Besides all the benefits of cement industries to a country, it also faces many challenges due to environmental concerns and sustainability issues (Potgieter, 2012). According to the Central Pollution Control Board of India, the cement industry is one of the 17 most pollution-emitting industries. It disgorges major pollutants like particulate matter, SO_x, NO_x, CO_2, CO, and dust (Sharma, 2012). The carbon dioxide generated through the cement industry contributes to about 5-7% of greenhouse gases (Potgieter 2012).

The emissions from the industry have a profound effect on our Health and on Environment as a result of which is global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity, etc. (Pariyar et al. 2013).

The complete manufacturing process of cement and the pollutant generated from each manufacturing process and unit of cement shown in Figure 1.

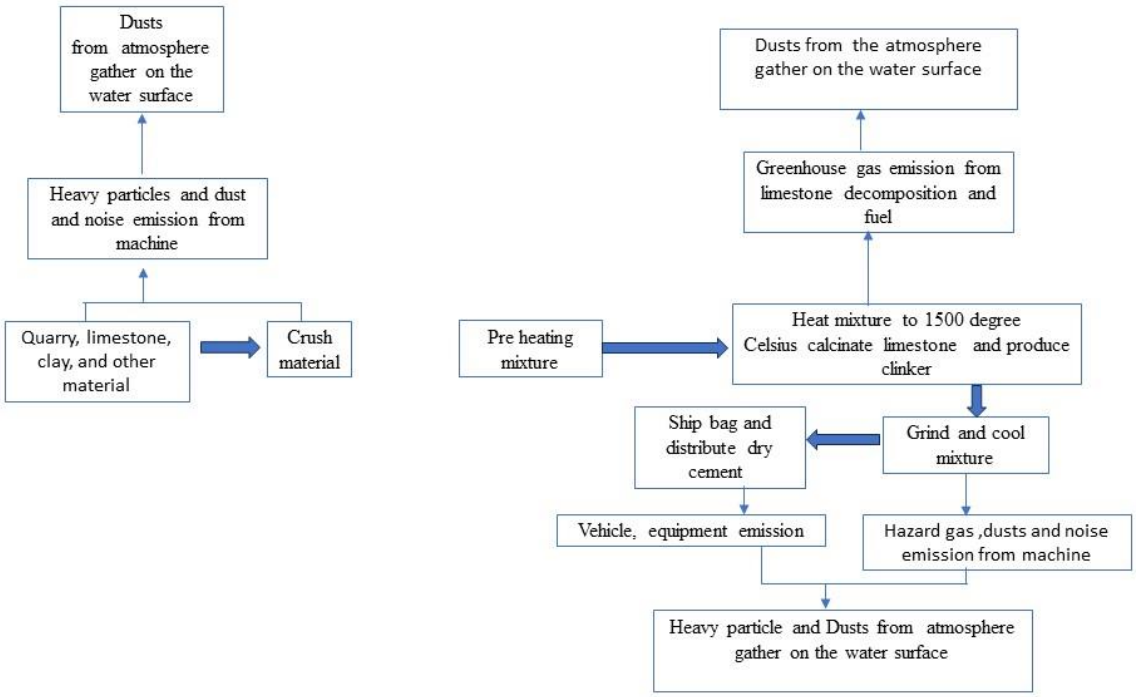

Figure 1: Manufacturing process of cement and the pollutant generated from each manufacturing process and manufacturing unit of cement

ECONOMICAL ASPECT OF THE CEMENT INDUSTRY

India is the second-largest country in production and consumption of cement after China, having a total installed capacity of approximately 465 MT. Dominated by around 30 prominent players, this industry comprises about 210 large cement-producing plants and 365 small ones.

In the financial year 2020, this giant construction industry had a turnover of ₹64,000 crores. Clearly, it enjoys a reputation for being among the best in the world.

One of the oldest and most significant industries, it has contributed as high as 0.10% to the GDP. Producing a metric ton of cement generates job opportunities for around 14 lakh people.

SCOPE OF THE PRESENT STUDY

The Indian cement industry is one of the most significant contributors to air pollution and for that, there are various air pollution control methods we see in this industry. The cement industry contributes to around 7% of global carbon emissions. Particulate matter (PM) emissions from cement plants are very high, and cement is understood to be the most severe pollutant in the world.

The pollutants commonly emitted by cement plants are dust or particulate matter, NO_x, SO_x, carbon oxides, and methane, among others. Cement being the major contributor to air pollution, an approximate number of 4,90,000 annual deaths may be attributed to emissions from the cement industry. Further, emissions from cement factories pose a threat to the life of surrounding flora and fauna.

So, this paper mainly focused on the Air Pollution Control Devices for Particulate Matter, SO_x, and NO_x generated from the Cement Manufacturing Industry. In this study, Cement Industry were visited for a complete study of recent technology used in the Manufacturing Process of Cement, the different raw materials, ground-level observation of different types of pollutant generated from different manufacturing process and manufacturing units, and the different air pollution control devices used in cement manufacturing industry.

Therefore, to assess the design of air pollution devices in the cement industry, we have taken up this study. The present study would be beneficial in the following ways:

- Identification of air pollutants: The study will identify the different types of air pollutants emitted by cement plants, such as particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, and volatile organic compounds.
- Review of existing air pollution control technologies: The study will review the various air pollution control technologies currently used in the cement industry, such as cyclone separator electrostatic precipitators, bag filters, and wet scrubbers.
- Assessment of emission standards and regulations: The study will analyze the local and international emission standards and regulations applicable to the cement industry. This will help in designing air pollution devices that comply with the required emission limits.

- Techno-Economic Analysis:
    - In-depth analysis of the techno-economic aspects of implementing different air pollution control technologies in the cement industry.
    - Evaluation of capital and operating costs, energy consumption, maintenance requirements, and the overall cost-effectiveness of various technologies.
    - Comparison of the benefits and drawbacks of different technologies to determine the optimal solution.
- Design and Optimization of Air Pollution Devices:
    - Development of design guidelines for air pollution control devices in the cement industry based on the previous assessments.
    - Optimization of design parameters such as size, efficiency, pressure drop, and energy consumption.
    - Consideration of factors like space constraints, available resources, and specific requirements of different cement plants.

TREATMENT FLOW CHART

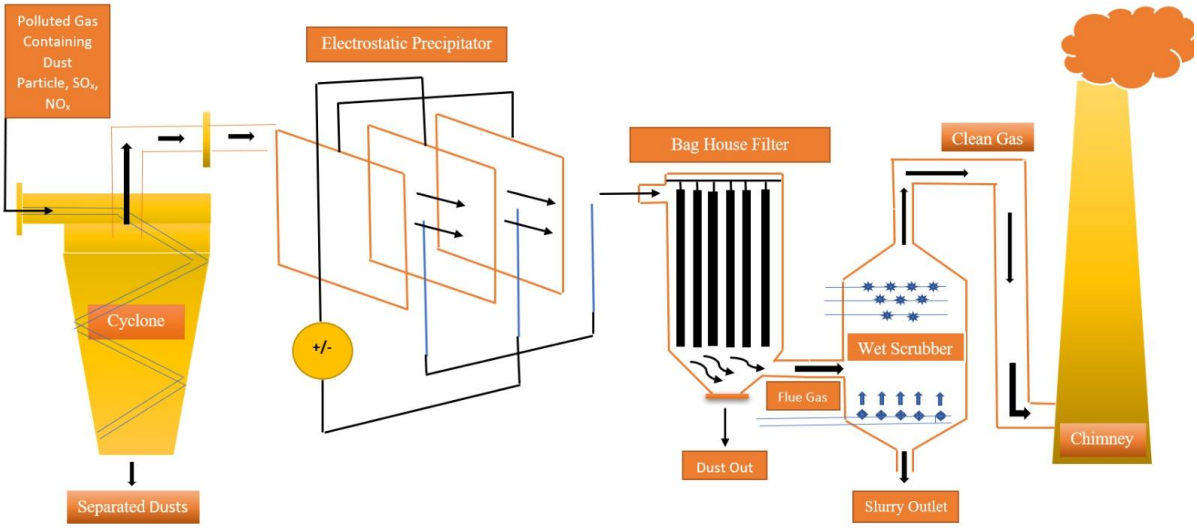

Figure 2: Pollution Control Devices used in Cement Industry

PROBLEM STATEMENT

The cement industry heavily relies on fossil fuels, such as coal, petroleum coke, and natural gas, to provide the high temperatures required for the production process. Burning these fuels emits a considerable amount of CO_2, particulate matter, nitrogen oxides (NO_x), and sulfur dioxide (SO_2). The cumulative effect of these emissions contributes to air pollution, which can have serious health implications, including respiratory issues, cardiovascular diseases, and worsened air quality. It also contributes to climate change due to the release of greenhouse gases.

A Comprehensive Approach to Efficiently Capture and Reduce Particulate Matter, NO_x, SO_x, and CO_2 Emissions while Ensuring Cost-Effectiveness and Compliance with Environmental Standards

SOURCE OF AIR POLLUTANTS GENERATED FROM THE CEMENT MANUFACTURING INDUSTRY

Manufacturing cement is a detailed process, involving several steps. Fugitive emissions are released in each of these processes, as detailed in the infographic below.

1. Mining - As the raw material for cement is mined from limestone quarries, a variety of processes such as drilling, blasting, crushing, transporting, and stockpiling are involved, which result in the emissions of particulate matter and carbon dioxide.
2. Raw Material Preparing - The raw material is mixed and ground to consistency in processes that are either dry, wet, or semi-dry. In the processes of both grinding and further transporting to the kilns, fugitive emissions of particulate matter happen.
3. Kiln Processing - This process involves combusting in the kiln. The raw material is heated and clinkers, or hard, spherical nodules are produced as a result. Kiln processing involves the following stages: drying or preheating, calcining, and clinker cooling. Calcination is a process of burning the raw mix at high temperatures so that clinkers are formed. Air blowers later cool these clinkers before being transported to the cement mill. Emissions at this stage are mainly in the form of gases such as carbon dioxide, SOx, NOx, carbon monoxide, and hydrocarbons. These are released both from the mixture that is being burned and treated, and the fuel used for burning.
4. Cement Milling - This is the final stage of producing cement, where the clinkers are ground into a fine powder. Certain chemicals are added in order to set the cement. This stage is also called finish milling. The emissions released during this stage include particulate matter, SO_x, and NO_x.
5. Cement Packaging - This involves the dispatch and conveyance of cement. Particulate matter emissions happen significantly in this stage, during the loading, transport, unloading, and storage of cement from the warehouse to construction sites.

JUSTIFICATION OF ALL AIR POLLUTION CONTROL DEVICES USED IN CEMENT INDUSTRY

Cyclone Separator: Cyclone separators are widely used in the cement industry to control particulate emissions. They offer high removal efficiency for coarse dust particles, which are generated throughout the cement production process. In addition to their effectiveness, cyclones are a cost-effective solution with low maintenance requirements. They can withstand high temperatures and have a small footprint, making them suitable for integration into cement plants. Cyclone separators have a proven track record and contribute to energy savings by preventing fouling of downstream equipment. Overall, their use in the cement industry helps reduce environmental and health risks while promoting sustainable and responsible operations.

Electrostatic Precipitators: In the cement industry, using both cyclone separators and electrostatic precipitators (ESPs) is an effective way to control particulate emissions. Cyclones are good at removing larger particles, while ESPs excel at capturing fine dust. By combining both technologies, cement plants can achieve comprehensive and efficient particulate matter control. This approach ensures compliance with emission standards, protects downstream equipment, reduces energy consumption, and requires minimal maintenance. Overall, it is a justified and reliable pollution control solution for the cement industry.

Wet Scrubbers: Wet scrubbers offer an effective solution for air pollution control in the cement industry by removing harmful gases like SO_2, NO_x, and CO_2. They have high removal efficiency, can handle multiple pollutants simultaneously, and provide versatility in varying gas volumes and concentrations. Wet scrubbers can also capture fine particulate matter and withstand high temperatures. By using wet scrubbers, cement plants can comply with emission regulations, reduce greenhouse gas emissions, and improve community relations, promoting sustainable and responsible operations.

WORK DISTRIBUTION AND TIME FRAME PROPOSAL

Task Distribution for Phase 1 (13 September 2023)		**Task Distribution for Phase 2 (15 November 2023)**	
Task	**Members**	**Task**	**Members**
Design of Cyclone Separator	Nishant Behera	Design of Wet Scrubbers	Adil Nawab
Design Electrostatic Precipitators	Adil Nawab	Design of Chimney	Nishant Behera
Financial Scope of the above two Air Pollution Control Devices	Navinkumar Mulchand Gupta	Design of Bag House, Financial Scope of the above two Air Pollution Control Devices	Navinkumar Mulchand Gupta

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