International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 06 | June - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Use of AFR In Cement Manufacturing Process - A Case Study of Dalmia Cement Bharat Limited Rajgangpur

Prem Sahoo[1], Abhijit Mangaraj[2], Sanam Sarita Tripathy[3]

[1]M.Tech in Environmental Engineering GIFT Autonomous College
[2]M.Tech in Environmental Engineering GIFT Autonomous College
[3]Assiastant professor in Civil Engineering Department, GIFT Autonomous College

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Abstract - The cement industry is one of the largest contributors to global CO_2 emissions, primarily due to its energy-intensive production processes and reliance on fossil fuels. As sustainability concerns intensify, the integration of Alternative Fuels and Raw Materials (AFR) has emerged as a viable strategy to reduce environmental impact, lower production costs, and promote circular economy principles. AFR encompasses a wide range of materials, including waste- derived fuels, biomass, used tires, plastics, and industrial by-products such as fly ash and slag, which can partially replace conventional fossil fuels in cement kilns.

Extensive research indicates that incorporating AFR can significantly lower CO_2 emissions by reducing the clinker factor and substituting non-renewable resources. Additionally, the co-processing of industrial and municipal waste in cement kilns provides an effective waste management solution while conserving natural resources. Despite these advantages, challenges such as fuel variability, emissions control, material handling complexities, and regulatory compliance must be addressed to optimize AFR utilization. Advanced technological solutions, stringent monitoring systems, and policy frameworks are essential for ensuring the safe and efficient adoption of AFR in cement manufacturing.

India, the second-largest cement producer globally, is responsible for approximately 7% of the country's total CO_2 emissions. The Indian cement industry currently operates at an average Thermal Substitution Rate (TSR) of 2.5%, indicating significant potential for increasing AFR utilization. To achieve the targeted 5% TSR by 2020 and 20% TSR by 2030, an estimated 7,000 tonnes and 25,000 tonnes of alternative fuels must be co-processed per million tonnes of cement produced, respectively.

To facilitate this transition, Indian cement manufacturers are investing in pre-processing infrastructure, advanced kiln technologies, and policy-driven initiatives to enhance AFR adoption. This thesis provides a comprehensive review of recent advancements, global best practices, case studies, and future prospects for integrating AFR in cement manufacturing. It explores innovative strategies for increasing TSR, overcoming operational challenges, and ensuring regulatory compliance while maintaining product quality and process efficiency. The findings highlight the crucial role of AFR in driving the cement industry toward a low-carbon, resource-efficient, and environmentally sustainable future.

Key Words: *Alternative Fuels and Raw Materials (AFR), Thermal Substitution Rate (TSR), Green House Gas (GHG) emissions, municipal and industrial waste, and industrial by-products.*

1.INTRODUCTION

In order to meet the increasing demands of the global population, every industry must become prudent in adopting innovative practices to utilize, reprocess, and recover resources, conserve energy, and manage waste. The cement industry is no exception in this regard. The production of cement requires a substantial amount of resources and energy, resulting in significant carbon dioxide emissions. Numerous industries are actively engaged in an industrial ecosystem where the byproducts from one industry serve as inputs for another. It is feasible to recover and utilize many industrial byproducts and supplementary materials in the manufacturing of final products; some of these can partially replace the fuel needed to transform raw materials into finished goods. The use of byproducts or waste as fuel will reduce the demand for fossil fuels, thereby diminishing the associated environmental impacts of production, transportation, and combustion of these fuels, as is practiced in hazardous waste management. This approach also alleviates pressure on local solid waste landfills and waste incineration, minimizing their environmental repercussions, which include groundwater contamination, methane emissions, and harmful ash residues.

1.1 Scope and Objectives:

The main scope of this work is to test the hazardous waste samples generated from Pharma industry to assess their suitability for their usage as AFR, by adopting the Co-processing method.

The major objectives of the present study are:

- To assess the potential for energy conservation in industrial production via the co-processing of hazardous waste from pharmaceutical industries.
- To determine and measure the extent of waste utilization as alternative fuel resources (AFR) in cement kilns.
- To examine the quality of clinker, raw meal, and emission levels, as well as to analyze methods for reducing greenhouse gas emissions.
- To suggest feasible environmental conservation strategies aimed at conserving energy and raw materials through the co-processing of hazardous waste.

3. Materials

3.1 Sustainability Initiatives:

The developing countries and the countries that are undergoing transition are facing problems related to their waste management. In several countries, discharged of waste water to public sewers and burning of hazardous waste and solid waste within the company premises, illegally dumping the waste at low laying areas are not succeed in meeting the fundamental necessities of scientific waste disposal. Due to this there will be contamination of land, ground water and air which leads to the deterioration of basic living condition and there by affecting the entire population. Due to this pollution or contamination, the poisonous materials entering to the ecosystem and finally entering to the food chain of living organisms. Due to the industrial pollution and their emissions the Greenhouse gases emitting to the atmosphere and causing global warming. Hence, the efficient use of fossil fuels, lethal residues and the contamination of water and soil resources are at the front position of environmental concerns and public deliberations. Cost saving initiatives in the business, competition in the global market and productivity are the main concerns of almost all businesses.

The proven and possible solution to the waste management is co-processing of waste in a suitable industry like cement. In the cement industry the rotary kiln can offer an environmentally sound and economically efficient treatment for several of wastes generated in the society. These wastes can be used as Alternative Fuels and Raw Materials (AFR) in cement a kiln, which in tern reduces the environment pollution. This method of co-processing of waste in cement kiln will help out in achieving the targets set in Agenda 21 of the ―Earth Summit‖ in Rio de Janeiro (1992) and the Johannesburg Declaration on Sustainable Development (2002).

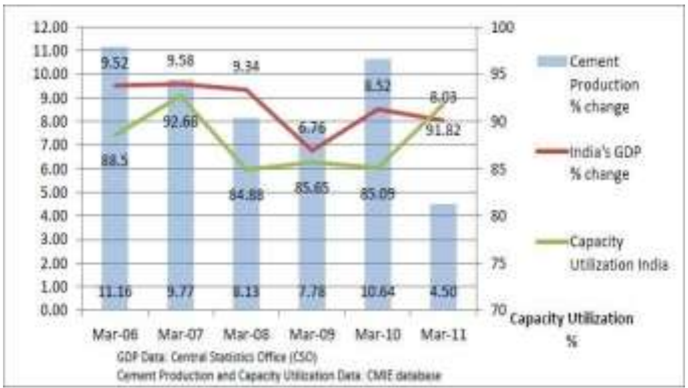

Fig. 1 Comparison of Cement production and its Utilisation – Indian Scenario

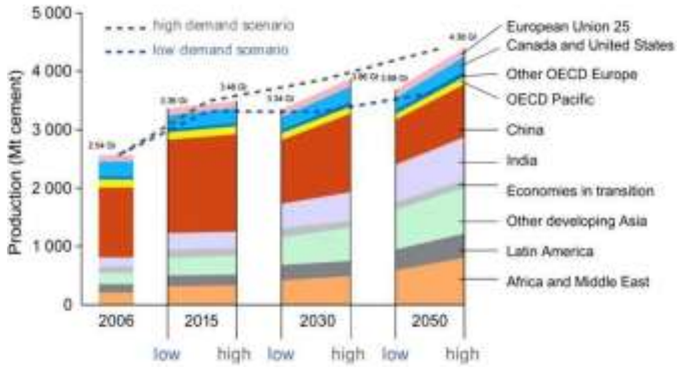

Figure 2 Annual World Cement Production

In addition to the energy use and CO_2 emissions challenges facing the cement industry, the problem of increasing waste generation is facing countries around the world. This problem is particularly significant in developing countries where major urbanization is taking place. Municipalities and governments in many countries face problems finding safe and environmentally sensitive means to dispose of growing amounts of municipal solid waste (MSW) and sewage sludge. Finally, the ashes from waste co-processing are be integrated into the clinker which can result in saving the virgin raw materials.

Cement Production Process in Brief:

Mining process: The key raw material Limestone is mined from the quarries by using compressed air drilling machines and then blasting with explosives materials in the mines. After wards, the mined limestone is being transported through dumpers or through ropeways to the production site. Gradually the surface mining is gaining popularity because of its eco friendliness.

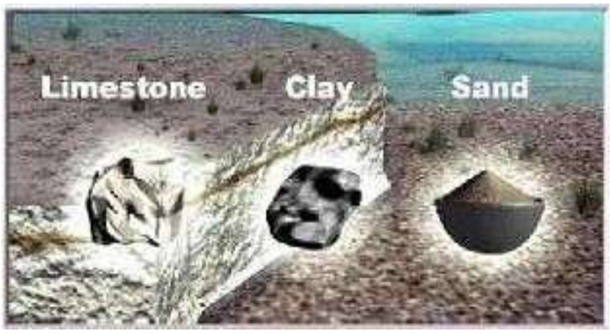

Fig.3 Mining the key raw materials**.**

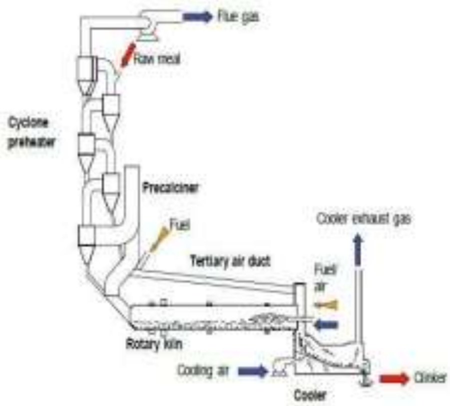

Fig.4 Pyro processing

Fig 5 Locations showing Cement, Steel and Thermal Power Plant of India (Co-processing Guide lines, 2010)

4. RESULTS AND DISCUSSION

Characteristics of Raw Materials:

The raw materials necessary for cement production must provide the oxides needed for clinker in the approximate ratios indicated in Table 4.1, with calcium oxide (CaO) being the primary requirement. Practically, this implies that naturally occurring calcareous deposits, such as limestone, marl, or chalk, which are primarily composed of calcium carbonate ($CaCO_3$), are essential. Clay or shale usually supplies the remaining components.

To address minor deficiencies in one or more oxides present in the primary raw materials, 'corrective' constituents such as iron ore, bauxite, or sand may be incorporated to modify the chemical composition of the raw mix in accordance with the process and product specifications (Taylor, 1997; Karstensen, 2007b). Generally, the majority, though not all, of the raw materials are extracted from locations close to or within a few miles of the cement plant.

Properties of Raw Meal and Kiln Coal:

Raw Meal Analysis:

One Representative sample of Raw meal was analyzed for Heavy Metal Content and TOC.

Sr.No	Parameter	(mg/Kg)
1	Antimony	<5
2	Arsenic	<1
3	Cadmium	<1
4	Chromium	3.93
5	Cobalt	7.41
6	Copper	<1
7	Lead	<1
8	Manganese	329.59
9	Nickel	11.52
10	Thallium	<1
11	Vanadium	<1
12	Mercury	<1
13	Zinc	<1
14	TOC (%)	7.04

Table 1 Heavy Metal Concentrations & TOC of Raw Meal

Coal Analysis:

One Representative sample of Coal was analyzed for Heavy Metal Content and TOC The results obtained are shown in Table 4.3.

Sr.No	Parameter	(mg/kg)
1	Antimony	<5
2	Arsenic	<1
3	Cadmium	<1
4	Chromium	32.14
5	Cobalt	5.69
6	Copper	<1
7	Lead	<1
8	Manganese	76.05
9	Nickel	8.96
10	Thallium	<1
11	Vanadium	9.19
12	Mercury	<1
13	Zinc	<1
14	TOC (%)	52.17

Table 2 Heavy Metal Concentrations & TOC of Coal

	CPCB Norm	Pre Co-processing	Co-processing	Post Co-processing
PM mg/ Nm3	50	46	48	45
CO mg/ Nm3	100	92	98	91
NOx mg/ Nm3	400	396	385	390
SO2 mg/ Nm3	200	17.68	18.12	20.48

5. CONCLUSIONS

The aim of this study was to conduct a co-processing trial to illustrate that the cement kiln can effectively co-process hazardous wastes in a manner that is both irreversible and environmentally sound, meaning there is no impact on emissions when traditional fuel is partially substituted with hazardous waste. The co-processing of waste to replace virgin resources in energy-intensive sectors such as cement manufacturing has been shown to be a significant component of sustainable development. In a developing nation like India, there exists substantial potential for waste generation that can be harnessed in cement kilns. The quality of clinker and the strength of cement were not compromised by the identified waste co-processing, and the ambient air quality complied with the National Ambient Air Quality Standards set forth by the Ministry of Environment & Forests, India. The scientific management of waste through co-processing not only provides a practical solution to the challenges of waste disposal but also conserves considerable landfill space and a large quantity of coal, leading to a significant reduction in greenhouse gas emissions.

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