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CEMENT PLANT ENVIRONMENT IMPROVEMENT WITH HELP OF LOSSES CONTROL

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Abstract: This research is carried out to investigate the influences of different losses control techniques in a modern cement plant. The literature research indicates the different losses and possible improvement areas in different manufacturing processes performed to obtain perfect quality cement. The customer satisfaction and requirements are used to decide the final product or cement quality. The final output is now analyzed with environment pollution. Each possible improvement is required to financially analyze for payback period for new investment. The process different variables, improvement practical applicability and limitation, new technology and cost, availability of resources will be deciding the final impact. To optimize cement manufacturing processes, different processes and parameters are optimized to obtain desirable results.

***Index Terms* – Green gas emission, Process optimization, Modern Technology, Energy Efficiency.**

I. INTRODUCTION

India ranks second in cement production in the world after China. Cement manufacturing is an extremely energy-intensive method of processing throughout the word. Consumption and manufacturing of cement are not only connected to the constructing area, but influences the overall monetary and growth of nation. Cement is also considered as the major contributor to air pollution, and causes approximate number of 4, 90,000 annual deaths due to emissions [7]. The gasoline emissions emitted are NOx, SOx, carbon oxides and methane and particulate matter or dust. The cement enterprise needs raw material, fuel and chemical components, which generate emissions and have a negative impact on the environment. The cement total production volume in India in 2019 was337.32 MT as compared to 174.3 MT in 2007-08, as shown in **figure-1**. Cement industry is expected to reach 550-600, Million Tons Per Annum (MTPA) by the year 2025[3]. Indian cement industry enjoys a reputation as one of best industry in the world [8].

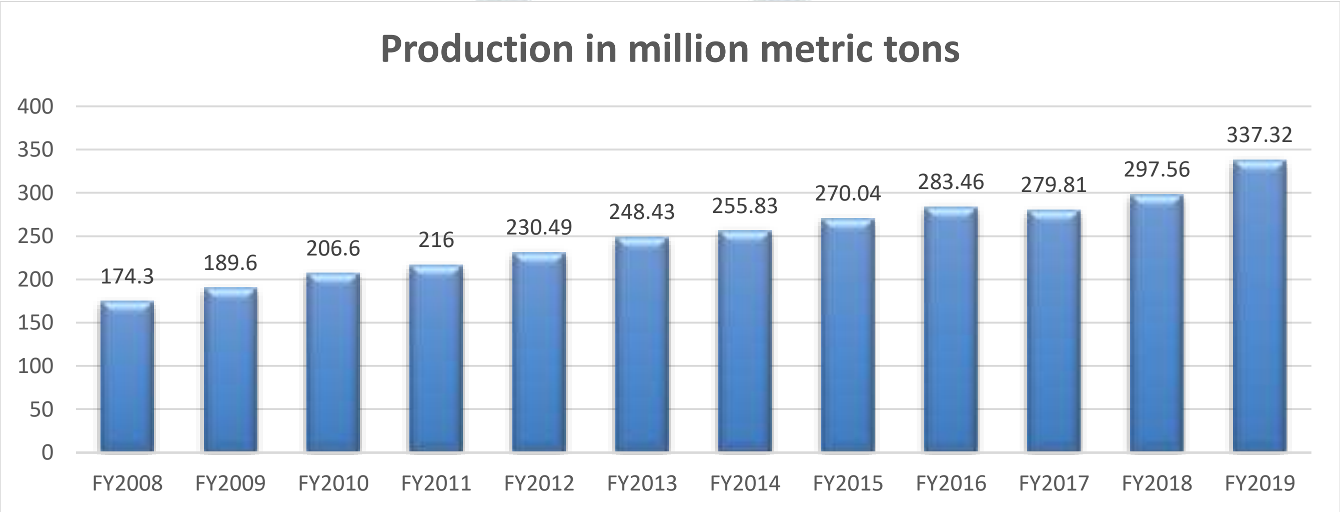
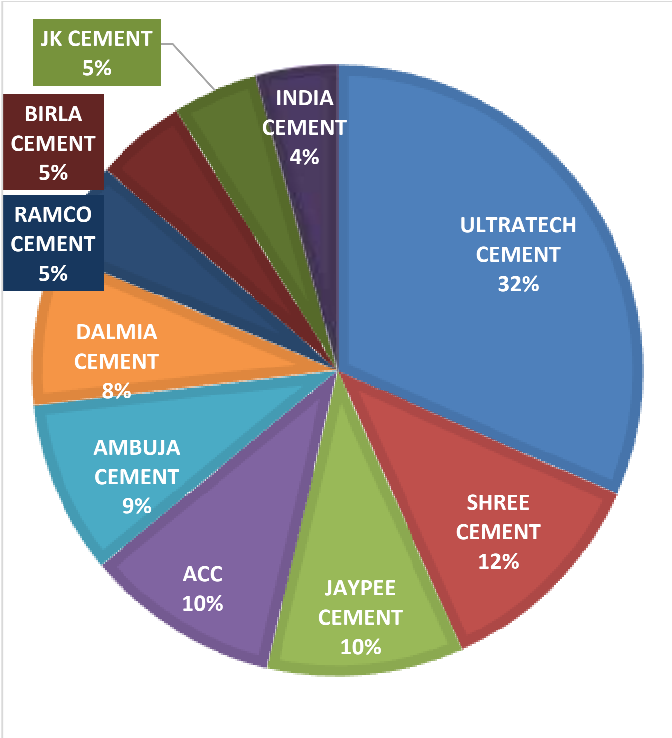


Figure-1 Indian cement production in million (MT) [11]

For a metric ton of cement production, around 14 lakh job opportunities are obtained [4].The Indian cement industry comprises around 210 large cement producing plants and 365 small ones. The industry continues to enjoy robust market demand through the pandemic situation, as India continues to be the second largest global consumer of cement. In the financial year 2020, the Indian cement industry had a turnover of 64,000 crore. **Figure-2** shows the contribution of different cement plants. **Figure-3:** Indicates the total Carbon dioxide atmospheric emission by different fuel and community uses.



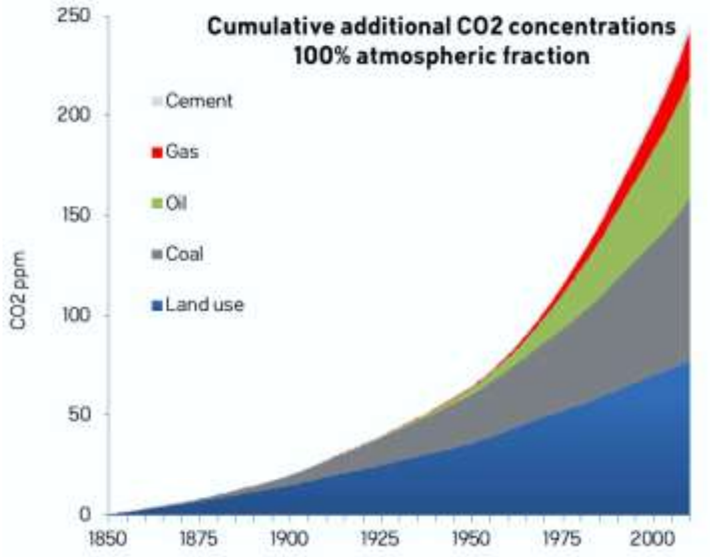


Figure-2: Cement manufacturing by different Indian plant [5] Figure-3: Carbon dioxide atmospheric emission by uses

The different housing schemes, urbanization, and government policies to renew and refurbish roads and other infrastructure, both production and consumption of cement remain high in India in compare to world other countries.

The cement industry is one of the most significant contributors to air pollution [2]. Particulate matter (PM) emissions from cement plants are very high, and cement is understood to be the most severe pollutant in the world [1]. The kinds of pollution emitted by the cement industry needed how these emissions can be effectively dealt with. The effects of the cement industry's pollution on life can be very severe. Below are some of the findings on its impact on humans and human-made systems:

1. The tests conducted on workers in cement industries in Bengal and Tamilnadu have shown that 1/5th of the worker population is affected by diseases such as bronchitis, asthma and obstructive respiratory disease [4].

2. In Sri Lanka, which has ecological and geographical proximity with India, found that over 14% of the people living close to cement factories are afflicted with respiratory disorders [5].

3. In an interesting study conducted in the US, the economic benefits of reduced PM emissions from the American cement industry were estimated to range between 0.76 and 3.97 million USD annually [6].

The specific heat consumption in Indian cement plant is around 82 KWh/ ton of cement competitive than best consumption of 65 KWh/ ton of cement. The Indian cement plant energy performance is good in compare to rest of world including China, Spain USA etc. **Figure-4** indicates cement consumption in different areas and sectors**.** One of the major challenges faced by the cement industry is unaccounted or 'fugitive' emissions.

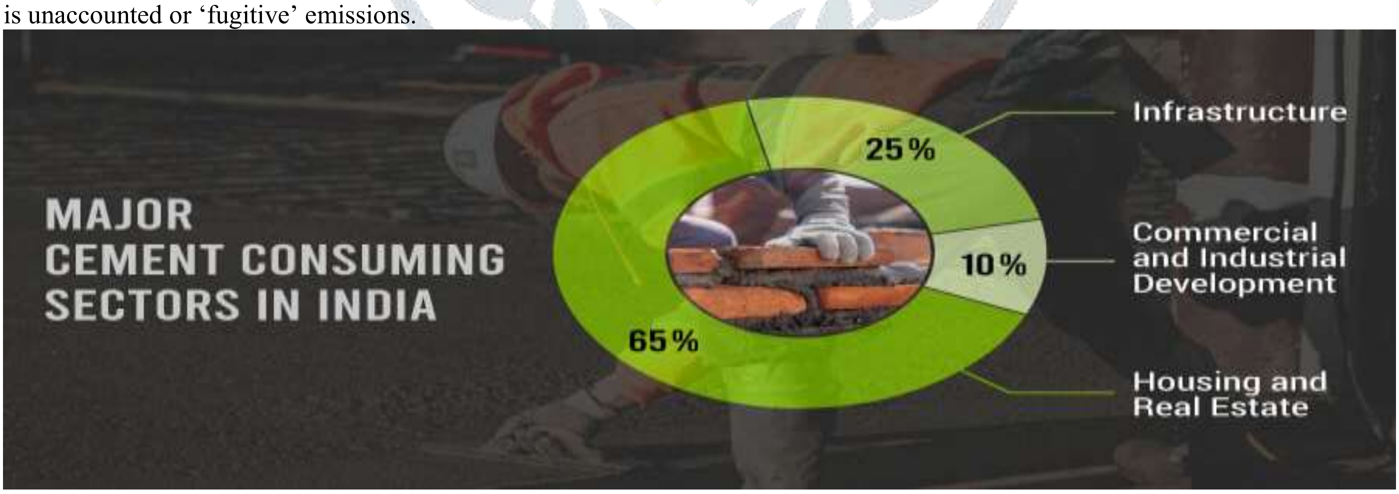


Figure-4 Consumption of Indian cement after production [5]

II. CEMENT MANUFACTURING

In order to obtained best quality cement the different sequence of operations from mining to packing are performed. Pre Calciner is the device in which calcination process is take place before entering in the kiln to reduce the power and fuel consumption. After the calcination process cement clinker is formed but the temperature is very high around 1400℃ so we have to cool down the hot clinker [1]. After cooling the temperature of the clinker is 200℃ and goes into further storage. **Figure-5:** indicates the cement manufacturing processes. Clinker' comes out of the kiln in small pieces. After cooling, these clinkers are goes to grind and after add raw materials to create Portland cement. Fugitive emissions are released in each of these processes, as detailed in below.

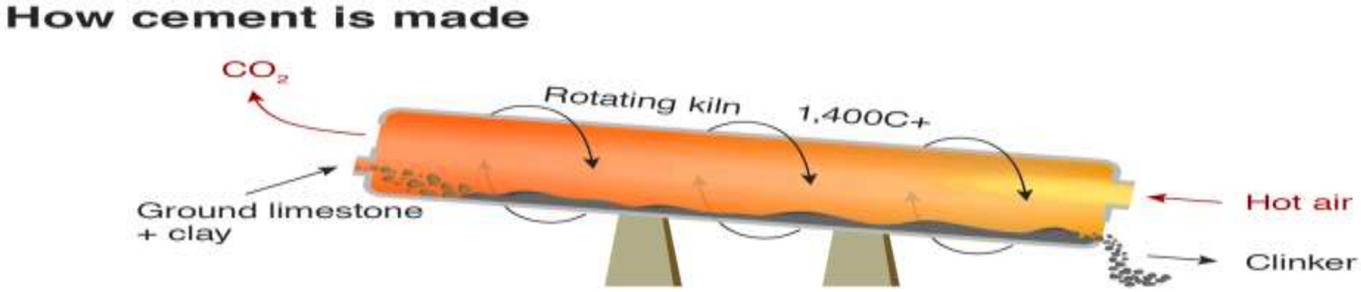


Figure-5: Cement manufacturing processes [7]

Mining - Different processes such as drilling, blasting, crushing, transporting and stockpiling are involved for the raw material of cement from mining of limestone, which result in the emissions of particulate matter and carbon dioxide.

Raw Material Preparing - Raw material is mixed and ground by different 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 developed.

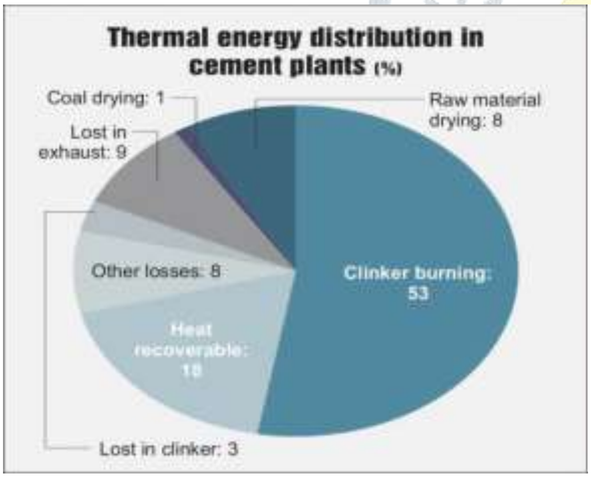
Kiln Processing - This process involves combusting in the kiln. The raw material is heated and clinkers or hard, spherical nodules are produced. Kiln processing involves the stages: drying or preheating, calcining, and clinker cooling. Calcination is a process of burning the raw mix at high temperature so that clinkers are formed. These clinkers are later cooled by air blowers 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 treated, and the fuel used for burning.

Cement Milling – In this final stage of producing cement, 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 include particulate matter, SOx and NOx.

Cement Packaging – It includes the dispatch and conveyance of cement. Particulate matter emissions happen significantly in this stage, during the loading, transport, unloading and storage of cement.

III. CEMENT MANUFACTURING AND POLLUTION

Cement is the second primary source of pollution, account for about 7% of global CO_2 emissions [10]. The emissions regulations become increasingly strict; so the cement producers become more effective to reducing pollution emissions. Emissions compliance is highly needed in cement plant to reducing emissions of gases and particulate matter. Due to the changing targets, it's not always necessary to procure new equipment and technology to reduce emissions. In some plants, process or raw material changes and optimization is sufficient. For example, modifying the operating parameters of the kiln system or changing the raw material mix. The appropriate technological solution for the specific emissions challenges faced is always required. The use of fuels in cement production is becoming more important with respect to implications on emissions. The emissions of carbon dioxide come from, oxidation of fossil fuels, deforestation and other land-use changes, and carbonate decomposition. Cement causes the largest source of emissions from the decomposition of carbonates. The process thermal energy distribution is shown in **figure-6** as below. Cement manufacturing is top most in different energy intensive processes in term of cost and energy consumption both as in **figure-7**.



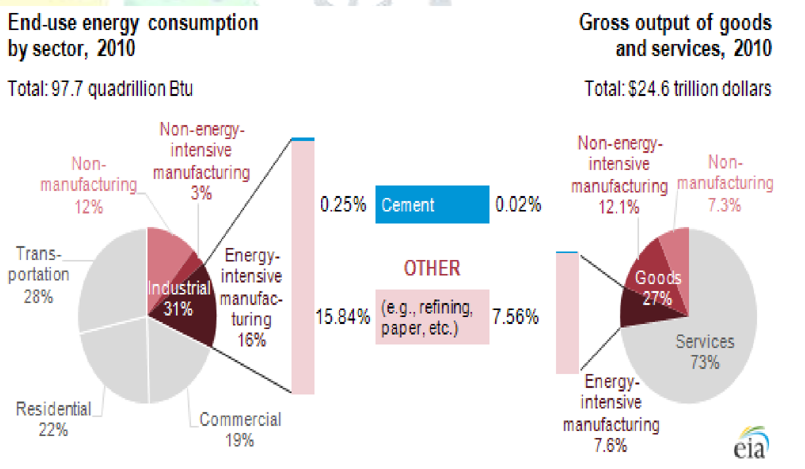


Figure-6: Cement process energy distribution [3]. **Figure-7: Energy consumption distribution in different end-uses [4]**

Regular emissions from known sources are accounted for and hence easier to track and control. Fugitive emissions, on the other hand, are difficult to track since their source is unknown. Hence, they contribute to ambient air pollution in an untraceable way. The problem of fugitive emissions occurs during every stage of the cement manufacturing process, and poses a huge challenge for sustainable development. **Figure-8:** Indicates total carbon dioxide atmospheric emission by different countries and its percentage.

Conventionally, cement industry pollution control equipment includes electrostatic precipitators, bag-houses, pulse jet filters and industrial scrubbers. However, these have a limited and clearly defined area of coverage, and therefore, cannot treat fugitive emissions very effectively.

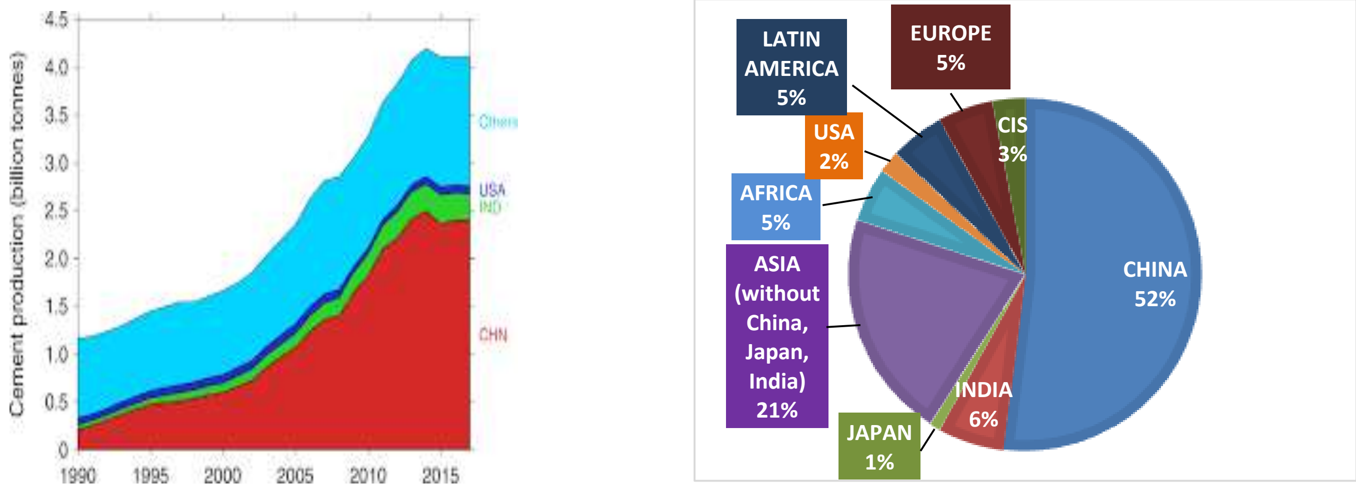


Figure-8: Comparative and total carbon dioxide emission and up-taking in different countries [6]

The above mentioned methods are energy-consuming, require regular maintenance and are expensive, given their capacity of coverage. They are not very effective in treating ambient air pollution. In India, which produces three times the amount of cement produced by the US, the influence is more and stronger pollution control technology needs to be implemented. The cement producers regularly need to find new ways to reduce emissions efficiently and cost-effectively as emissions limits are constantly being revised. The technology for carbon dioxide capture and storage (CCS) is considered by the International Energy Agency (IEA) to be a crucial technology capable of lowering CO_2 emissions in the cement sector by 56% by 2050 [9]. CO_2 Capture technologies for the cement production process and analyses economic and financial problems relevant to carbon dioxide capture in the cement production has an important trend for study. The compliance efforts have focused on pollutants including: Dust and other particulate matter (PM), Nitrogen oxides (NOx), Sulphur dioxide (SO_2), Carbon monoxide (CO), Ammonia (NH3), THC (or TOC), Mercury and other heavy metals, HCl, Dioxins/furans, Hydrogen fluoride (HF).

IV. Sustainable DEVELOPMENT IN CEMENT MANUFACTURING

Sustainable development meets the needs of the present without compromising the ability of future generations [10]. Whether building a new plant, upgrading capacity or optimizing existing operations, sustainability required. Optimizing different sustainability parameters such as volume, mix, cost, quality, environmental considerations, safety and health are very essential now for today competitive manufacturing. The complex nature of processes and various different parameters and there optimum setting becomes difficult to in desired outcomes. Regardless emissions limits regardless of the fuel, we need to select and apply the most appropriate solution for each individual situation for sustainable manufacturing. The figure-9 indicates the breakup of manufacturing cost and energy consumed in cement plant. Different sustainability practices followed by Indian cement industry:

- Blend in cement by substituting clinkers with fly ash, which is readily available, gypsum, slag etc. to produce clinkers.
- Using electrostatic precipitators, etc. to check air pollution.
- Using alternative fuel resources. To mention a case, The Ultra-Tech Cement aims to get 25% of their power requirements from green energy by the end of 2015.
- Co-processing, i.e., using waste materials as fuel by burning them in the high temperature of the kilns, like biomass fuel.
- Lime CaO is the main ingredient to produce Portland cement.

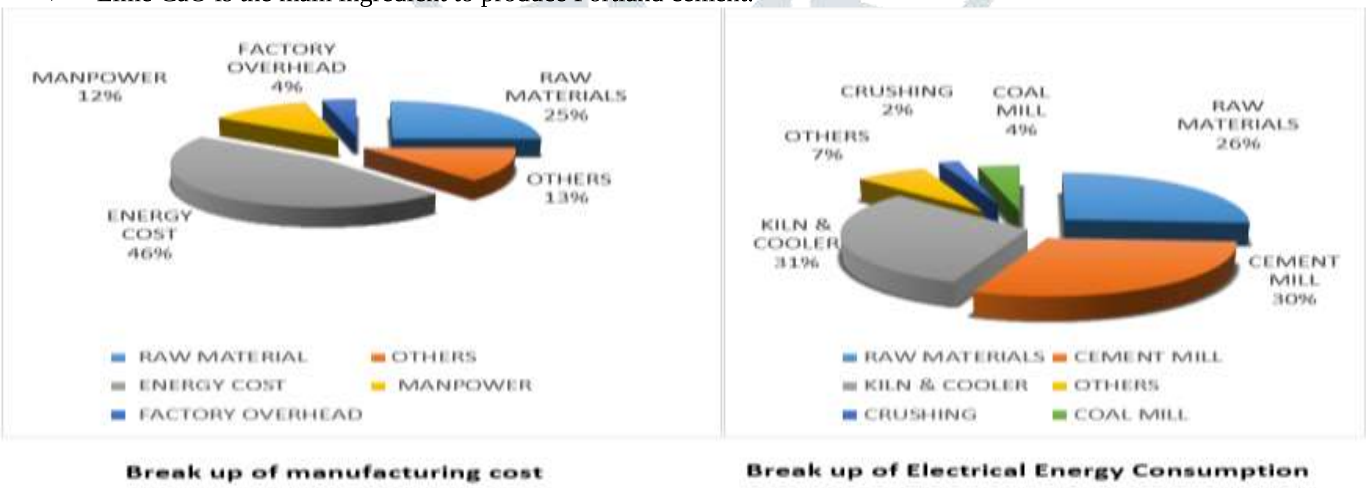


Figure-9: Indian Cement plant Manufacturing Cost and Energy consumption break up [1]

According to BIS standard in India mainly three grades of Portland cement is manufactured: Ordinary Portland cement (OPC), Pozzolana Portland cement (PPC) and Portland slag cement (PSC). The potential for different renewable energy resources uses like, wind, solar, biomass and hydro are very high. The Indian cement industry performance in the world is shown in **Figure-10.**

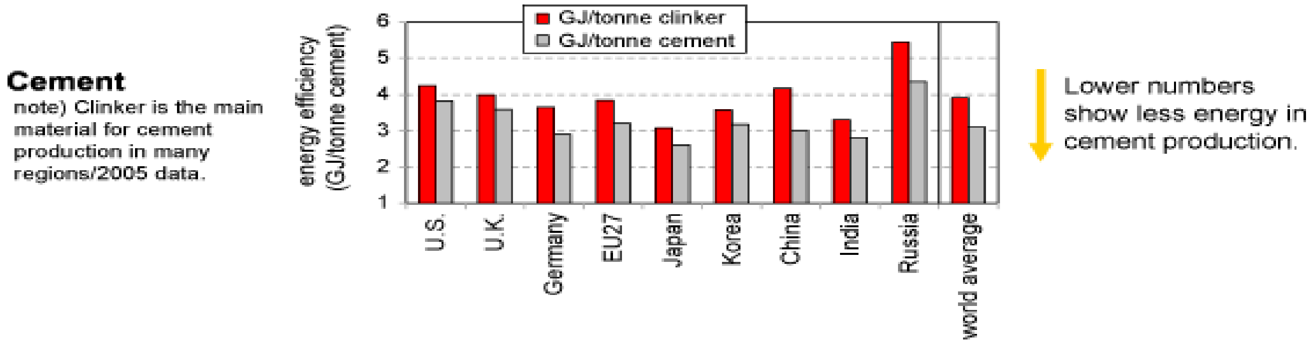


Figure-10: Indian Cement plant journey and Comparative Energy efficiency in different countries of cement industry [7]

V. POLLUTION MINIMIZATION TECHNIQUES IN CEMENT MANUFACTURING

Cement production is an energy-intensive process consuming thermal energy of the order of 3.3 GJ/tonne of clinker produced. Major environmental impacts developed by Portland cement are the energy required for production and transportation of clinker, the emission of greenhouse gases during manufacture, and the mining, resource depletion and waste production. Application of clean fuel, use of good quality coal, process optimization and efficient use of waste heat and energy with help of energy efficiency improvement, are the areas which control pollution and environment. Best dust collection system, use of good quality burners and best burning practices. The solid waste obtained from waste recovery can be used as additives in raw material as blend. Increasing the blend in cement is other way to reduces pollution. The dust collection system should be properly maintained and control and effective emission monitoring system is required. Government has made strict norms for the cement industry, so that the emissions of PM to not more than 30 milligrams per cubic meter, from March 2017. The "limited availability of technology" made it difficult to comply with the regulation enacted by the Union Ministry of Environment, Forest and Climate Change [4]. **Figure-11:** Indicates comparative total atmospheric emission by different Countries.

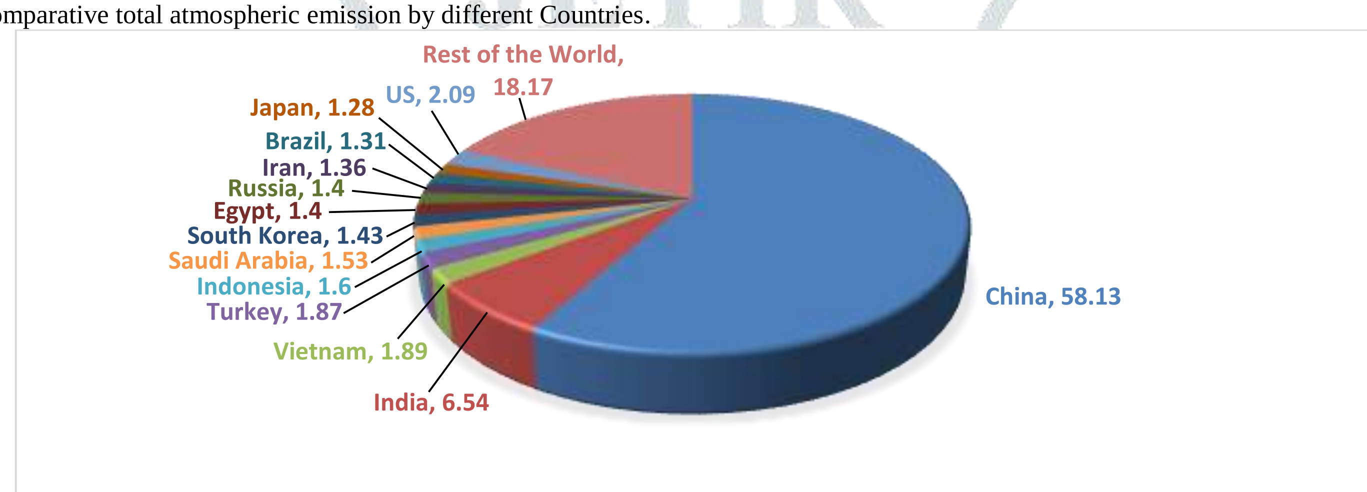


Figure-11: Comparative total atmospheric emission by different Countries [8]

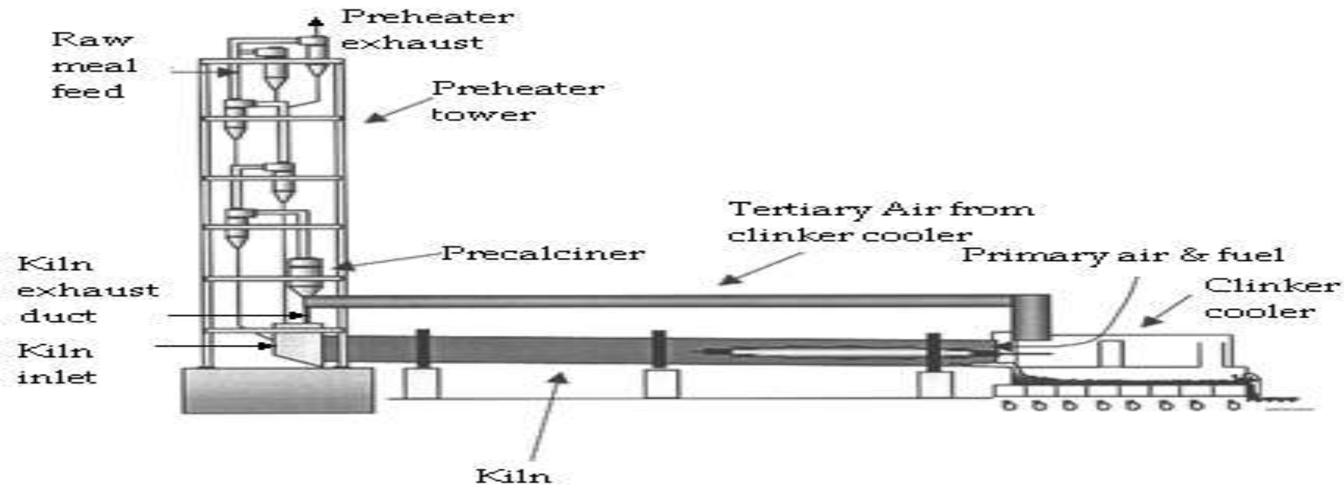


Figure-12: The Kiln System

The use of preheater in cement manufacturing is very useful to maximize the process efficiency and to reduce energy losses (**Figure-12**). Increasing blend in cement production, clinker optimization, use of biomass fuel, biodiesel, green fuel are other techniques. The production of clinker leads to process CO_2 emissions, and the clinker amount in different cement manufacturing varies widely. To reduce greenhouse gas (GHG) emissions in the cement industry, the percentage of clinker cement mixtures can be reduced by using various other materials, such as limestone, low grade / dolomitic. Limestone, found in the cement mines itself.

Table-1 provides different alternative fuels available in different forms.

Table 1: Alternative fuel options for the cement industry

Category	Fuels
Gaseous fuels	Refinery waste gas, landfill gas, pyrolysis gas, natural gas
Liquid fuels	Tar, chemical wastes, distillation residues, waste solvents, used oils, wax suspensions, petrochemical waste, asphalt slurry, paint waste, oil sludge
Solid fuels	Petroleum coke (petcoke), paper waste, rubber residues, pulp sludge, sewage sludge, used tyres, battery cases, plastics residues, wood waste, domestic refuse, rice husks, refuse derived fuel, nut shells, oil-bearing soils, diapers, etc.

For furnace heating coal have to burn but the burning temperature of the coal is around 300 degrees and to obtain this diesel will be burned in the kiln and after obtain the temperature the diesel firing is stopped and coal is fired to calcinated the raw materials. High amount of diesel is used to maintain temperature and emitted lots of CO_2 and sulphate and nitrates. Alternative fuel can be used as per table-2, to lighten up the kiln to save the consumption of fossil fuels and reduce the quantity of GHGs in atmosphere.

Table-2 Alternative fuel PPF comparison with Diesel for the lighten up the kiln [4]

Diesel	Petro polymer fuel
Calorific value of diesel 10800 kcal/kg	Calorific value of PPF 10250 kcal/kg
High nitrates and carbon monoxide emissions	Low nitrates and carbon monoxide emissions
Net carbon dioxide emissions (CO_2) is 3T/T diesel fired	Net zero carbon dioxide emissions
Made from crude oil	Recycled fuel from waste plastics
Does not follow green environment norms	Follows green environment norms

Pet coke is a refined product from delayed cooking units, crude oil is converted into petrol, diesel fuel, jet fuel, lubricating oil and wax; and as a product, raw residue is produced. The raw material may be further refined into a so-called cooking process, in which large hydrocarbon molecules are broken down to produce pet coke. The composition of petroleum coke is mainly carbon based (usually more than 85-90% Carbon dry and sulfur content of about 8.5% (size)) per high temperature and very low ash content (usually less than 1-2%) down to produce pet coke.

The proposed fuel, namely Pet Coke available as waste from the refinery, is readily available in the Indian market. Pet coke is use as an alternative to fuel. The use of Pet Coke in Cement Kiln will facilitate sub-grade use Limestone at a high level leading to high quality clinker. Fly ash content in pet coke is negligible. The SO_2 emissions are absorbed by limestone in kiln. Table-3 shows the comparative analysis of Pet coke and Coal.

Table-3 Comparative Analysis of Pet coke and Coal [8]

Types of coal	Calorific value
Petroleum coal	8000 kcal/kg
coal	3500 kcal/kg

Every tonne of ordinary Portland cement produces an equivalent amount of GHGE to the atmosphere. To manufacture the cement high amount of CO_2 is released during calcination of limestone to make clinker. Portland limestone cement (PLC) is another type of Portland cement in which blended limestone (low marginal grade LS, dolomitic LS) is added in the clinker to make PLC [13]. Fly ash, gyption and slag are also blended. There are two types of the PLC

- Containing 6-20% of limestone
- Containing 21-35% of limestone

Advantages of PLC-

- PLC cement reduce GHGs emissions
- Conserving fast consuming limestone reserves
- Utilizing unused low grade limestone
- Reducing energy consumption In cement mill (LS is softer comparison to clinker)
- Reducing CO_2 directly as same percentage as we add limestone in cement
- Indirectly reducing thermal energy to make clinker.

Thermal energy savings: up to 170-180 kcal/kg cement PLC (up to 25% clinker replacement by limestone)
Electrical savings: up to 11-12 kWh/ton PLC (up to 25% clinker replacement by limestone)
CO_2 Reduction (direct): up to 200-250 kg CO_2 /ton PLC (for PLC cement with 25% by mass of limestone)
CO_2 Reduction (indirect): 10-11 Kg CO_2 /ton PLC (for PLC cement with 25% by mass of limestone)

Alternative fuels and alternative sources of energy usually fall under eight broad headings: biofuels; natural gas; waste-derived fuels; wind energy; hydroelectric power; solar energy; hydrogen; and nuclear energy. Alternative fuels discussed are predominantly agricultural biomass, non-agricultural biomass (e.g. animal waste and by-products), chemical and hazardous waste, and petroleum-based fuels. All these modern techniques needed a good monitoring and control system.

VI. RESULTS AND DISCUSSION

Indian cement industry is now becoming more competitive in order to improve profitability by reducing cost by minimizing process losses and wastages. The sustainability requires utilization of energy-efficient plants, machinery and alternative fuel sources for manufacture, including combustible solid and liquid wastes. The increased use of renewable and alternative fuels can extend fossil fuel supplies and help resolve air pollution problems associated with the use of conventional fuels. Alternative fuels can be used instead of conventional fuels such as PPF, oil, pet coke and natural gas. A wide range of other fuels such as gas, oil, liquid waste materials, solid waste materials and petroleum coke have all been successfully used as sources of energy for firing cement-making kilns, either on their own or in various combinations. Due to uncertainty about the availability of coal connections and rising prices of imported coal, it is proposed to use as much pet coke as much as possible. The sustainable cement manufacturing are obtained by process different losses control, energy efficiency maximization, process optimization, alternating raw materials and fuels and blend in production.

With growing energy, resource and infrastructure cost in the future, a sustainable concrete that is more durable and economical, is desirable with losses control. The use of alternative fuels in cement manufacturing, therefore do not only afford considerable energy cost reduction, but they also have significant ecological benefits of conserving non-renewable resources, the reduction of waste disposal requirements and reduction of GHG emissions. The preference on low carbon and green alternatives for good quality cements manufacturing. The use of modern technology like advanced vertical mill grinder also helps and waste heat recovery plant maximizes final profit.

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