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Research Article

IMPACT OF ENVIRONMENTAL, OCCUPATIONAL HEALTH & SAFETY ASPECTS IN CEMENT PLANTS

Sandeep Bhatnagar*

Dy. General Manager, Aditya Birla Group-UTCL

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ABSTRACT

Climate change is considered as major environmental challenge for the world. Emissions from cement manufacturing are one of the major contributors in global warming and climate change. Cement manufacturing is a highly energy intensive process, which involves intensive fuel consumption for clinker making and resulting in emissions. Beside Fuel consumption, the calcining Process is a major source of emissions such as NOx, SOx, CO2, particulate matters etc. In this paper, the role of cement industry is reviewed in causing impact on environment and health. It describes the cement production process and its emission sources followed by overview of emissions and their environmental and health impacts. Review study has focused on emission generation from clinker production and excluded the emissions due to indirect energy (electricity, transportation, supply chain etc.) used for cement operations. This review observed a comprehensive literature in term of peer reviewed journals, industry sector reports, websites etc on cement industry and associated emissions and health impacts.

Scientific progress has made life more comfortable; but there exists the potential for permanent anatomical or physiological damage due to hazards especially among industrial workers. Traumatic occupational injuries leadto10,000 deaths among workers annually. The International Labor Organization (ILO) has observed that an estimated 50 million work related injuries occur every year or 160000 every day India's potential in infrastructure is vast and cement plays a vital role in the growth and development of the nation. India is the second largest producer of cement in the world. The cement industry has been expanding on the back of increasing infrastructure activities and demand from housing sector over the past many years. Cement consumption in India is expected to rise by 8–9 per cent over the next year, taking the estimated cement consumption in 2013–14 to about 280–285 MT, from around 260 MT in the 2012–13 fiscal, as per the Cement Manufacturers Association (CMA).

Safety is a priority of any industrial activity. It is a positive cultural element that allows other improvements in the factory. An administration that does not attain to manage safety is not in a position to manage other functions. However, as work accidents and occupational diseases have an enormous impact on the health of workers and considerable economic and social impacts [3]. In addition, with the increasing complexity of industrial tissue and with the rapidity that the techniques develop in the big factories, risks assessment becomes a crucial and strategic answer to preserve workers health and safety on the one hand and to maintaining a qualified labor on the other hand. The Health and safety performance of the cement industry as a whole is lagging behind that of other, more proactive, sectors of manufacturing industry. Within the sector, there is a wide range of performances. The better companies have demonstrated that it is possible to achieve injury rates similar to the average for the manufacturing industry. However even the best have room for further improvement. There is a particular need for the industry to encourage and help those companies and plants that are significantly under-achieving to raise their safety standards to ensure a sustainable industry that meets social and employment expectations. In addition, with the permanent evolution of work, even its risks, it becomes increasingly insufficient to establish general safety rules of, relying solely upon standards and regulations to comply, but move to awareness, information, training and motivation of staff on the role of health and safety at work, steps previously required for the implementation of a prevention, even to a mitigation measures relevant and effective. That allows to define a general policy of prevention and to bring to successful management of industrial risk within the entity.

Hence, it has become essential to give all staff a real sense of safety that will predict and act in very affectiveway; objective of this work. This study will present a technique of analysis to better understand the dynamic ofthe policy in terms of health and safety at work established in the cement plants.

INTRODUCTION

It is impossible to envisage a modern life without cement. Cement is an extremely important construction material used for housing and infrastructure development and a key to economic growth. Cement demand is directly associated to economic growth and many growing economies are striving for rapid infrastructure development which underlines the tremendous growth in cement production. The cement industry plays a major role in improving living standard all over the world by creating direct employment and providing multiple cascading economic benefits to associated industries. Despite its popularity and profitability, the cement industry faces many challenges due to environmental concerns and sustainability issue.

Cement is an essential component of infrastructure development and most important input of construction industry, particularly in the government's infrastructure and housing programs, which are necessary for the country's socioeconomic growth and development. It is also the second most consumed material on the planet (WBCSD 2002). The Indian cement industry is the second largest producer of cement in the world just behind China, but ahead of the United States and Japan. It

Corresponding author:* **Sandeep Bhatnagar
Dy. General Manager, Aditya Birla Group-UTCL

is consented to be a core sector accounting for approximately 1.3% of GDP and employing over 0.14 million people [5].

Health and safety is the number one priority for the cement industry for its employees, contractors, end-users and those who are neighbors to its operations. It is a positive cultural element that allows other improvements in the factory. An administration that does not attain to manage safety is not in a position to manage other functions.

However, as work accidents and occupational diseases have an enormous impact on the health of workers and considerable economic and social impacts. In addition, with the increasing complexity of industrial tissue and with the rapidity that the techniques develop in the big factories, risks assessment becomes a crucial and strategic answer to preserve workers health and safety on the one hand and to maintaining a qualified labor on the other hand. These are data, among others, that have triggered the alarm signal and impose the necessity of an increased safety in the factories. Therefore, a priori assessment of these risks and the implementation of a prevention approach within a factory are required to become one of the main drivers of progress. Hence, for some employers, employees and their representatives, health and safety at work do not mean so much. In addition with the permanent evolution of work, even its risks, it becomes increasingly insufficient to establish general safety rules of, relying solely upon standards and regulations to comply, but move to awareness, information, training and motivation of staff on the role of health and safety at work, steps previously required for the implementation of a prevention, even to a mitigation measures relevant and effective.

In all the cement production processes there are hazards that can be classed in:

Routine and general hazards such as

- Safe behavior
- Environment, work and passage areas
- Work equipment
- Safety labeling
- Personal Protective Equipment (PPE)
- Manual load handling

Special hazards during the cement production phases such as

- Quarrying
- Crushing
- Clinker production
- Milling processes at raw mill, cement milling and coal milling
- Material transport
- Filtering
- Storage
- Loading and delivery of final products
- Fuel storage activities
- Use of hazardous material
- Generating units

Special hazards as a result of the work environment

- Dust
- Noise
- Fire
- Emergency response

The pollutants in the cement industry are emitted from the various production processes from the material such as the raw material, crusher, rotary kiln, cranes, mills, storage silos and packing section, etc., Airborne reparable dust levels from less than 5 to more than 40 mg/m 3 have been recorded in the work place air of cement factory workers. The aerodynamic diameter of the cement dust ranges from 0.05 to 20 μm, making the whole respiratory tract a target for cement deposition.

Emissions from cement manufacturing

The most significant environment health and safety issue of cement manufacturing is emission. Cement industry is potential anthropogenic source of air pollution. It has estimated that cement production originates about 5% of global manmade CO2 emissions. The typical gaseous emissions to air from cement production include NOx, SOx,CO, CO2, H2S, VOCs, dioxins, furans and particulate matters. These major pollutants can be classified in two categories- gaseous and particulates. Fuel combustion process is the source of gaseous emissions which include oxides of nitrogen, oxides of sulfur, oxides of carbon and volatile organic compounds and hydrogen sulfide. Quarrying, drilling, blasting, hauling, Cement mill, fuel preparation, packaging, road cleaning and stacks are sources of particulate matter in the form of dust and carbon particle.

There are many other sources of emissions from cement manufacturing, such as emissions from transportation equipment used in the mining and transporting raw and finished material, fuel used for electricity production for operating other process in cement manufacturing. Types of fuel used in cement industries for few selected countries SO2 and O2. But the highly alkaline condition in the kiln can absorb 90% of the sulphur oxides. Sox emission can be controlled by using low slphur fuel and raw material.

The sulfur oxides react with water vapor and other chemicals high in the atmosphere in the presence of sunlight to form sulfuric acids. The acids formed usually dissolve in the suspended water droplets, which can be washed from the airon to the soil by rain or snow. This is known as acid rain. It is responsible for so much damage to life and health. Respiratory illnesses such as bronchitis are seen to increase with sulfur oxide levels. Increased level of SOx in the atmosphere can also degrade agricultural productivity and death of some plants.

Nitrogen Oxide (NOx)

Nitrogen oxides are produced in the combustion flame of rotary kiln, which enter the atmosphere with the exit gases, and undergo many reactions in the atmosphere. Majorly NOxare formed by thermal oxidation, which happens in temperature range between 1,200-1,600 °C. Due to high temperature significant amounts of thermal NO are generated in the Kiln. Combustion of nitrogen-bearing fuels such ascertains coals also produces N2, or NO.

$$N2 + O \rightarrow NO + N$$
$$N + O2 \rightarrow NO + O$$

As temperature increases, NO formation also increases. About90% of the nitrogen oxides are produced in the form of nitricoxide (NO) and the remaining 10% are in the form of nitrogen dioxide (NO2) [21].

Produced NO converts to NO2 at the exit of the stack at atmospheric conditions and appears in brown-yellow color.

NO + 1/2O2→ NO2.

NOx causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitricacid, nitrous oxide, nitrates, and nitric oxide.

Similar to sulphur dioxide, NOx react with water and other compounds to form various acidic compounds. When these acidic compounds that are deposited to the earth's surface, they can impair the water quality of different water bodies and acidify lakes and streams. Acidification (low pH) and the chemical changes result in making it difficult for some fish and other aquatic species to survive, grow, and reproduce.
Acid rain can also harm forest ecosystems by directly damaging plant tissues.

Nitrous oxide is a greenhouse gas and it accumulates in the atmosphere with other greenhouse gasses causing a gradual rise in the earth's temperature. This will lead to global warming and climate change.

NOx and volatile organic compounds react in the atmosphere in the presence of sunlight to form ground-level ozone, which causes smog in cities and rural areas. This ground level ozone when breathed, it causes respiratory disease and other health problems. Nitrogen dioxide affects body functions such as difficulty in breathing, chronic lung diseases, such as chronic inflammation and irreversible structural changes in the lungs, which with repeated exposure, can lead to premature aging of the lungs and other respiratory illness.

Carbon dioxide (CO2) & CO

Cement industry is a major source of CO2 emission. CO2 is emitted from the calcinations process of limestone and from combustion of fuels in kiln. It estimates that half of the CO2 is generated from fuel combustion and half originates from decarbonization of raw material. An indirect source of CO2and other pollutant in cement production is from consumption of electricity, assuming that the electricity is generated from fossil fuels.

CaCO3 → Cao + CO2
(1 kg 0.56 kg + 0.44 kg) [9]
MgCO3 → MgO + CO2 [16]

The amount of CO2 released in calcination can be calculated from the component formula weight ratios for of limestone. CO2 emissions from different fuels combustion can be calculated from emission factors of fuels defined by the Inter government Panel on Climate Change (IPCC). The amount of CO2 emission during this process is directly related to the type of fuel used like coal, fuel oil, pet coke, natural gas, alternate fuel. Typically, kiln is fueled with coal as other fossil fuels are too expensive to be used in cement production. However carbon based waste material such as tires are commonly used in cement kiln to use its energy content.

Process-related CO2 emissions from cement production are the second largest source of industrial CO2 emissions in the United States. A number of studies have suggested that,the cement industry contributes about 5% of total anthropogenic CO2 emissions, worldwide. It has longbeen known that carbon dioxide emissions contribute to climate change. Constantly increasing CO2 emissions are responsible for an increase in temperatures, which is expected to continue over the coming decades reaching up to +1.4˚ to+5.8˚C globally by the year 2100. Increasing temperature can cause severe droughts in some parts of the world, extreme weather conditions, the loss of ecosystems and potentially hazardous health effects for people.

Particulate matters (PM10, PM 2.5)

Particulate matters are emitted from quarrying, hauling, crushing, grinding of raw material and clinker, fuel preparation, clinker grinding and cement packing. Particulate matter is consisting of fine particles that can remain suspended in the air which include dust, soot, and liquid droplets.

Types of dust and their generation causes at cement plants (VDI, 1985; USEPA, 1995a)

Type	Generation mechanism
Raw material dust	Quarrying, crushing and handling of raw material
Feed material	dust Feeding, milling, stacking, blending, reclaiming, conveying, and transferring of feed material
Cement kiln dust	Feeding and processing of materials involving countercurrent circulation of hot gases
Clinker dust	Cooling involving air circulation and open-storage of clinker
Cement dust	Feeding, milling, conveying, bagging and loading of cement materials

The main environmental problem resulting from dust emissionis reduced visibility and deteriorated ambient air quality. When the dust is washed with rain, it can also pollute water bodies [17]. Particulate emissions contain potentially harmfultoxic metals and compound such as lead, chromium, nickel, barium, which can pose serious health impact on human health. These emissions are toxic as it carries carcinogens, mutagens, immunotoxins, respiratory toxins, neurologicaltoxins etc. Physical properties of such particles decide the degree of their effect on human health. Coarse particulate (>PM10) are considered to cause local nuisance than creating health hazard and fine particles (<PM10- PM2.5) are majorly big concern for health hazard due to their repairable nature.

The main route of entry of dust particles in the body is the respiratory tract or the gastrointestinal tract or both by inhalation or swallowing. When PM (diameter less than10µm) are inhaled, they penetrate deep into the respiratory system and Pm less than 2.5 µm go on to the lungs and pass into the blood stream. It is determined that short term exposure to Particulate matters (PM2.5) significantly increases the risk for cardiovascular and respiratory diseases. PM can also cause eye and throat irritation, bronchitis, lung damage, increased mortality rates, increased heart ailment. Some studies show that cement dust can cause respiratory and non respiratory diseases. Cement dust also affects plant productivity due to reduced chlorophyll content of the leaves which obstruct the

photosynthesis process. It has adverse impact on agriculture in nearby areas.

Objectives of the study

- To identify the Health, Safety and Environment related problems in the industry under study.
- Gap identification and analysis between ideal situation and current status of Health, Safety and
- Environment in the industry.
- Addressing the gaps identified.
- Provide possible corrective actions for all the identified hazards.
- Recommendation of corrective action of the problems.

Methodology Adopted

Firstly the Indian policies and legal framework relevant to the safety policy and management will be reviewed, to understand the legal requirements and the difficulties in enforcement.

- Baseline data collected from the cement manufacturing industry. Data is being collected for different activities and processes of cement manufacturing. Questionnaires and checklists were being used for the study.
- Occupational, health and safety aspects were being monitored in the industry.
- Compliance of various statutory regulations and standards followed by the industry was being checked thoroughly.
- Various problems related to health, safety and environment in the industry was being addressed.
- Mitigation strategies and corrective actions based on findings and best practices adopted by the industry were being provided.

RESULT AND OBSERVATION

1. Industry is well equipped with all the necessary PPE's required by the workers.
2. Strict compliance of rules, regulations and all safety standards is being done.
3. It is having a fully fledged safety policy, safety manual.
4. It provides proper training to the workers and employees.
5. It is having advanced technology designed equipments and machineries to manufacture premium quality of cement.
6. It has sufficient equipments to control and prevent environmental degradation.

CONCLUSION

Control measures at source, path and persons exposed to the hazards, together with education in occupational health and safety are the ideal means of preventing occupational diseases and injuries from the manufacture of cement. Workers' knowledge about the hazards associated with their jobs and workers education especially instructions on control and use of personal protective measures is helpful to reduce and may even eliminate some occupational health risks.

Thus it can be seen that the health and safety problems in cement manufacturing industry can be reduced by maintaining safe working conditions, preparation and implementation of safe operating procedures, study of environmental conditions, and enforcement of safety procedure, training of employee and periodic medical supervision and use of personal protective equipment. All these activities are possible only with the support of top management and co-operation of workers as well as active participation of supervisory staff.

Recommendations

- Use earmuff or ear plug where the noise level is more than or equal to 90dB (A).
- Use earmuff or ear plug if any employee feel uncomfortable even though the noise level is in prescribed limit of CPCB.
- Short circuit/ loose electric connection should be strictly avoided.
- All construction material i.e. beam, pipes, power equipment etc which cannot be remove to a safe location, they are to be lashed in place in the best possible manner known.
- Use of fabric filter system (baghouses) instead of electrostatic precipitator will be more reliable and efficient.
- Covered conveyor belts for transportation of raw materials, covered shed for additives.
- Benchmarking the best practices and measures with the leading competitors to ensure best safety policy in the industry.

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