TRUST RE

PERSPECTIVES

THE NEED FOR EFFECTIVE RISK MITIGATION IN CEMENT PLANTS

RISK ENGINEERING DEPARTMENT, FEBRUARY 2018

Introduction

Cement is the most widely used binder for mortar and concrete used in civil constructions throughout the world. An estimate reveals that there are more than 2,000 cement production plants in operation across the globe in more than 160 countries; this is in addition to 500+ clinker grinding facilities. The predicted global growth of consumption of cement is estimated at around 4.5%, year on year, in relation to the present global cement production capacity which is more than 4 billion tons per annum. The consumption pattern of cement is expected to grow steadily in the MENA (Middle East & North Africa) region in the coming years. The quantum of cement production grew substantially in MENA region in the past two decades; it is believed that the demand for cement had tripled in MENA region in the last 15 years. Iran, Saudi Arabia & Egypt are the top three cement producing countries in MENA region and their combined produced capacity is around 200 million tons of cement.

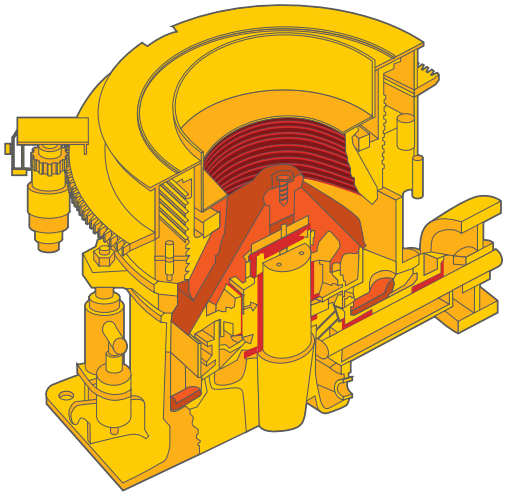
In light of these statistics, Trust Re is pleased to publish this technical paper. Through it, we share our views and expertise on mitigating the risks associated with the cement manufacturing process, including machinery breakdown and maintenance as well as the location of the plant itself. From a risk engineering point of view, we also explore important underwriting considerations to factor in when developing an insurance programme for a cement plant. As a customer centric organisation, we are committed to regularly sharing our views and expert knowledge, for the mutual benefit of our partners and us.

Raw materials & cement manufacturing process

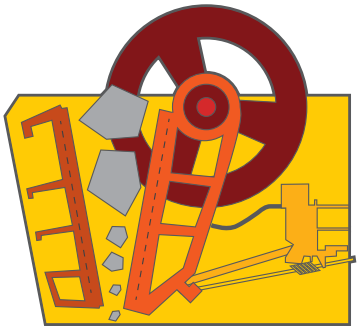
The main raw material for cement manufacturing is limestone which is first dried and blended with other ingredients like clay, sand, iron ore etc. and ground coarsely using primary type crushers like jaw crushers/gyratory crushers etc. Then the blend is calcined in slow moving long kilns (fired by coal/gas/oil) at a very high temperature (up to 1,500°C) to produce cement clinker.
The cement clinker coming out from the kiln is then cooled and pulverized (> 90 µm in size) to produce cement. The cement thus produced is stored in silos, packed in bags or transported by bulk carrier for distribution. There are two different methods of cement production, namely 'Dry' & 'Wet' methods, however, most of the modern cement plants use the Dry process. The basic difference between the processes is that in Wet process raw materials are crushed in slurry form and then calcined. The rest of the processes' parameters are more or less similar.

Issues related to machinery breakdown and maintenance

Cement processing plants are generally regarded as less prone to catastrophic losses. However, they may produce a high degree of attritional losses due to machinery breakdown as the cement plant machinery mainly includes rotating machines which are very heavy and installed in the open. The rotating machinery in cement plants includes raw material crushers, clinker grinders and the kiln which is regarded as the heart of the cement plant. Although the kiln rotates very slowly, it operates at very high temperatures. Cement kilns are regarded as one of the heaviest rotating machines used in industry.
The types of heavy machinery used in cement plants and the potential issues related to their breakdown are highlighted in the next section.



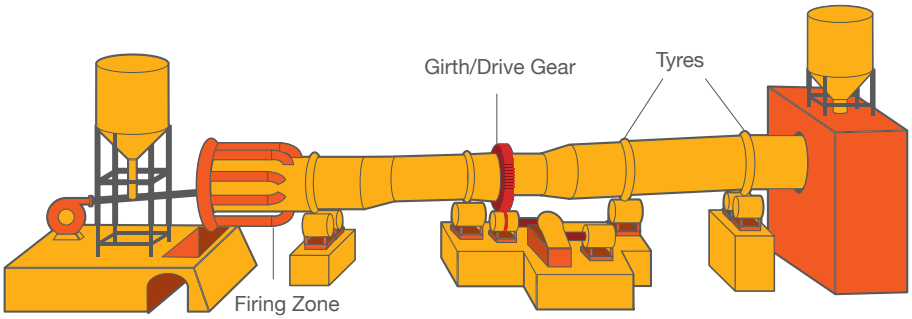
Gyratory Crusher



Jaw Crusher

Crushers

The crushers used for size reduction of the raw materials include jaw crusher, gyratory crushers, cone crushers, etc. These are high impact oriented machines which are generally associated with heavy gear boxes and exert high dynamic forces on the bearings. Machines like gyratory crushers generally exert a high degree of eccentric (off-centric) loading on the foundation grouting fasteners. Since these machines also handle large chunks of rock, the failures of the crusher rotor and subsequent damage to shafts and gears are fairly common. In general, this type of rotating machine with high impact elements and with heavy gear boxes needs a robust preventive maintenance schedule.



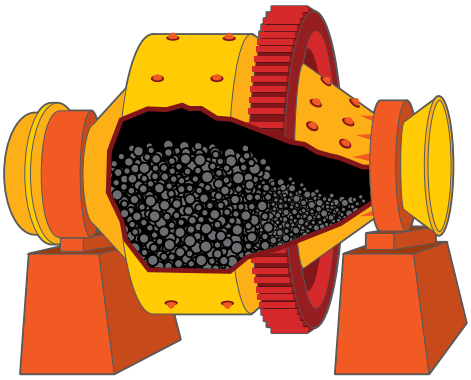
Cement Rotary Kiln

Cement Kiln

The kiln is the heart of the cement processing operation. It is heavy, expensive and a piece of equipment with a long lead time. The kiln is normally installed in inclined fashion with a downward slope of 3-4% and rotates at a speed of 1-2 revolutions per minute. The blended raw material enters from the upper end of the kiln and slowly works its way downwards to the bottom - the hottest portion of the kiln where firing takes place.

The outer shell of the kiln is provided with tyres and the entire weight of the kiln is supported by the rollers placed below the tyres. Experience shows that the root cause of most of the expensive machinery breakdown incidents involving the kiln is its misalignment. Some standards suggest the best defense against such breakdown is checking and adjusting the alignment of the kilns at least once a year. There are several other breakdown issues associated with the kiln, the most important of which is deflection of the kiln from the original position due to ovality of the kiln (the kiln shell becomes oval in shape during the course of its operation). As a preventive measure, some cement kilns are now provided with a kiln deflection sensor to warn operators to take corrective action in advance.

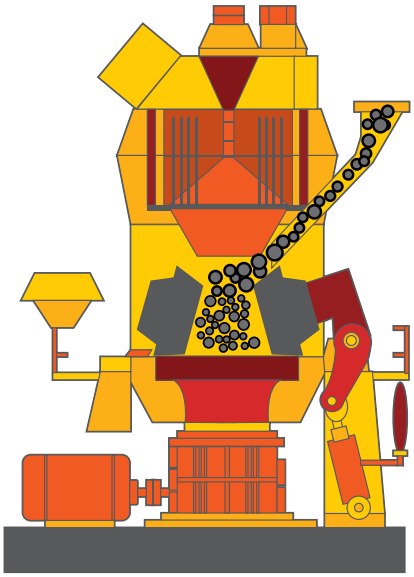
Adequate maintenance and proper lubrication of the gear assemblies of the kiln are also important to reduce the damage of the kiln's girth gear teeth and drive gear assembly.



Ball mill

Ball mill/Tube mill/Vertical Roller mill/ Clinker grinder

Traditionally the ball mill (which is also known as the tube mill) is used for grinding and pulverizing of the cement clinker. Generally a closed circuit grinding philosophy is adopted for grinding operations where the product is continuously sieved and oversized particles are fed back to the grinding system. The vertical ends of such mills, also known as trunnion walls, through which material enters and discharges, are most susceptible to machinery damage due to several factors. One of the major factors is the heavy oscillating loading pattern of this type of mill which makes it vulnerable to trunnions and trunnion bearings failures. Presently the trend is to use vertical roller mills which are energy efficient and less prone to mechanical breakdown as they use the principle of roller grinding, pressurised hydraulically.



Vertical Roller Mill

Electrical Drives

The operation of cement plants by nature of its functionality tend to generate considerable amounts of fine dust. The dust naturally settles over the ventilation ports of the machines, and due to the hygroscopic nature of this type of dust, they tightly block such holes by absorbing atmospheric moisture resulting in temperature rise and subsequent failure of the electrical machines in particular.

Efficient dust control helps in reducing costly machinery breakdowns particularly the electrical drives of the rotating machines. These machines need very closely monitored regular checks.

Therefore, the cement plant with an effective routine maintenance regime, coupled with a robust preventive maintenance system supported by an efficient dust control mechanism, makes the plant less prone to machinery breakdown losses.

Issues related to fire and explosions

Cement plants are generally regarded as less prone to major fire and explosion losses. That said, there are instances of costly fire losses associated with cement plants. Cement production facilities involve a high degree of material handling therefore a considerable amount of combustible rubber belt conveyor systems is generally present in the plant. Apart from that, cement plants use substantial amounts of fuels like coal, fuel oil, natural gas, etc. for kiln firing. Some of the major exposures related to fire and explosions hazards in a cement plant are enumerated below.

Conveyor System

Jammed rollers/idlers can cause friction resulting in ignition of conveyor belts (usually rubber) and the spread of fire throughout the conveyor belts. The condition of rollers/idlers should be properly monitored and attended to. The conveyor system also needs to be earthed properly for quick dispersal of static charge accumulations, formed due to rapid movement of conveyer belts over the idlers/rollers. It is preferable that fire resistant type conveyor belts are used for such duties.

Spontaneous Combustion & Dust Explosion

Those cement plants which use coal/lignite as fuel need to have fairly large coal storage yards. Adequate care needs to be taken while storing the coal as some types of coal and lignite are susceptible to spontaneous combustion and there are also possibilities of dust explosion involving coal dust. Lignite/ Coal is crushed and pulverized prior to feeding to kilns. The crushing and pulverizing process generates a considerable amount of dust which, in combination with air, can cause explosive mixtures which in turn cause dust explosions. There is also the possibility of dust explosion in Electrostatic Precipitator (ESP) generally provided in Coal/Lignite fired kilns to reduce dust from flue gases and the coal handling system's cyclones separators. In such plants, special care should also be taken to avoid the build-up of an explosive carbon monoxide/air mixture in the kiln so that explosions can be prevented in ESPs.

Kiln Operation

There is probability of fire and explosion in the kiln due to accumulation of dangerous fuel air mixtures inside the kiln or in the air ducting. Modern kiln firing systems are generally equipped with several safeguards such as BMS (Burner Management System), Flue Gas analyzer to provide early warning of incomplete combustion and formation of explosive CO (Carbon Monoxide) in the kiln. If these systems are not provided, extra care needs to be taken, specifically while lighting the burners.

Bagging Operations

Large amounts of paper/plastic or jute-based bags/cartons are stored in cement plants. They are used for bagging and packaging of the product; these items generally have substantial fire load and need to be stored carefully from a fire safety point of view.

Fuel Storage & Handling

There are the usual fire hazards associated with the above ground liquid fuels storage tanks used for liquid fuel fired cement kilns. The cement plants use liquid fuels like FO (Fuel Oil) or Diesel for the kiln firing and these need to be stored and handled as per the supplier's guidelines; whereas fire hazards in a cement plant using natural gas as fuel for the kiln is considered to be less likely since there is usually no storage of gas and given that natural gas is much lighter than air, it disperses quickly into the air if it leaks out.

Electrical Systems

The typical fire hazard is associated with the electrical system of the cement plant, including electrical sub-stations, transformers etc. It is preferable that the proper condition monitoring systems are installed while maintaining such facilities which include performing thermographic analysis of electrical systems, conducting Dissolved Gas Analysis (DGA), Furan and corrosive Sulphur tests for transformer oils at certain accepted intervals.

Fire protection systems' requirements

Fire Protection System

As per worldwide norms, installing the following fire protection systems is generally recommended for different sections of the cement plant (not exhaustive). Also, these systems need to be designed, installed and maintained as per standard norms.

- Hydrant system – It is preferable that the entire plant premises is covered by a hydrant system designed as per NFPA (National Fire Protection Association USA) norms or as per country standards of the plant location.
- Sprinkler system – It is advisable that empty packing/baggage material storage area is provided with approved type of sprinkler system as per NFPA or the country norms.
- Water spray system – Since the transformer is critical for continued operation of the plant, it needs to be protected with a high velocity water spray system designed as per NFPA or country standards. The hydraulic oil tanks of the hydraulic systems of different crushing/ pulverizing machines should also be provided with adequate water spray protection. The hydraulic oil tanks of such systems should ideally have secondary containment.
- Gaseous protection system – All unmanned electrical sub-stations and control rooms should preferably be protected with an automatic gas based fire protection system designed as per NFPA or country standard.
- Fire detection system – Preferably, all offices and cable trenches should be protected with an automatic fire detection system.
- Plants which use natural gas as fuel for the kiln, should be provided with hydrocarbon detectors at strategic locations.
- Cable pass seals – All the cable penetrations through walls need to be sealed with intumescent or any other approved materials to restrict propagation of flame through cables in case of occurrence of fire.
- Portable fire extinguisher – All the areas of the plant need to be provided with appropriate type and number of Portable fire extinguisher as per standard norms.

Natural hazards & other exposures

Landslide

Cement plants are generally located close to limestone mines for logistical reasons; good numbers of cement plants are located in close proximity to limestone mines situated in remote, hilly terrain.

Therefore, the probability of damage to plant and machinery due to a landslide could be an area specific issue.

Earthquake

Cement plants are mostly open type outdoor plants where machinery is normally supported by steel structural members, except the silos which are generally made of concrete. Such type of construction is likely to be less affected by an earthquake of moderate magnitude.

Flood

In cement plants, machines are usually required to be installed on a high pedestal and both raw material and finished goods silos are constructed well above ground level. Apart from that, there is no technical requirement for provision of basements in cement plants therefore, the effect of flood is also likely to be less severe in cement plants. However, the probability of flood losses is associated with open raw material and finished goods storage (if existing).

Cyclone & Storm

Cement plants are also generally regarded as less prone to damages due to stormy and cyclonic weather as they are open type plants of moderate height; although in newer plants there may be tall storage silos, however, they are generally made of heavy cement concrete.

Subsidence

In the recent past, a couple of incidents of total collapse of cement and raw material silos had been reported probably due to land subsidence. Since cement plants are generally equipped with tall and heavy silos, the possibility of colossal collapses does exist in the cement industry.

Underwriting considerations

There could be several underwriting factors and technical issues that need to be considered while developing an insurance programme for a cement plant. Some technical issues which are generally factored in while developing insurance programmes for cement plants are enumerated below.

Project Insurance

- Cement plants are generally constructed in remote locations close to mine sites; in such areas, help from the public fire service is generally delayed in case fire occurs. Therefore, a reasonably strong fire protection facility needs to be maintained at the project site.
- The projects handled by reputed EPC (Erection, Procurement & Construction) contractors is preferred as cement plants' kilns involve careful application of refractory lining. Costly damage to refractory lining in the commissioning stage has been known to occur in the past.
- It is advisable to closely monitor the time schedule of projects if the project insurance is extended to cover Advance Loss Of Profit.

Operational Insurance (all risk)

- Generally plants are designed for a life span of 25-30 years; however, plant life can be extended by taking action based on the residual life evaluation studies. Experience shows that the upward trend of occurrences of machinery breakdown losses becomes prominent after five to six years of plant operation.
- In cement plants, any proposal for covering material under processing needs to be studied carefully as there will always be huge amounts of material under processing in the kiln and such materials generally do not have much salvage value.
- Careful consideration also needs to be given while providing cover for raw material and finished goods storage in the open as the materials can be washed away during heavy rain/floods. Since cement is hygroscopic in nature, the condition of indoor bag storage areas for cement should preferably be ascertained while considering support.
- The inner surface of the cement kiln is provided with refractory lining of substantial thickness. The refractory lining has a finite life period. It is preferable to factor in the quantum of residual life expectancy period for refractory lining for the purpose of claims settlement if it is also covered along with the plant machinery.
- The cement production process generates substantial amounts of dust, hence good housekeeping plays a crucial role in keeping the machinery breakdown incidents controlled within a reasonable level. Cement plants with robust preventive maintenance programmes, effective dust control systems and good housekeeping management may be given preferential treatment.
- In many cases, the attached limestone mines under the same management as cement plants are covered along with the operational plant. Such mines may use heavy mining machinery and store explosives for blasting; it is therefore preferable to assess the condition of the mining machinery as they are subject to heavy wear & tear and to arrange for storage of explosives, while considering support.

Operational Loss of Profit insurance (Fire & Machinery)

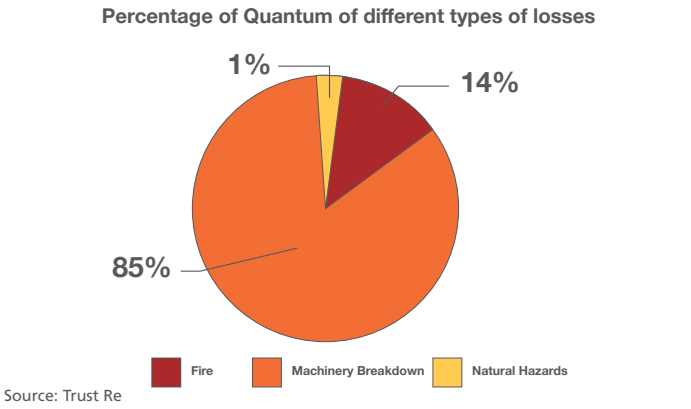
- Cements plants are generally located in remote areas close to limestone mines and usually obtain the power supply from a single transmission and distribution source through transformers in the plant. The transformers are generally regarded as long lead time and high value equipment; they are very crucial from a business interruption point of view. Therefore, while covering such plants, it may be checked if the oil filled transformers of the cement plant are protected with an automatic high velocity water spray or any other approved type of automatic fire protection system. Such systems should be designed, installed and be maintained as per standard norms. Apart from that, the oils of transformers (if more than 5 years old) should preferably be subjected to periodic condition monitoring through DGA, Furan & Corrosive Sulphur tests etc.
- Since there is very little machinery redundancy in cement plant operations and most of the machinery is long lead time oriented machines (although availability of the technology is not an issue) a cautious approach may adopted while providing such support.

Lessons learnt from past loss experiences

The analysis of a fairly large number of past loss records of cement plants located in different parts of the world, reveals that a big chunk of losses had occurred due to failure of machinery parts related to kilns or cement grinding mills of the plant. Most of the fire losses in the cement industry, however, occurred in connection with the material handling system like conveyor belts etc. due to lack of effective maintenance or poor housekeeping.

An analysis of the loss record of multi-location cement plants of a large cement producer of a Far Eastern country over a period of five years (2012-2016), revealed that the quantum of machinery breakdown losses is more than double that of fire losses.

The graphs below illustrate the scenario.



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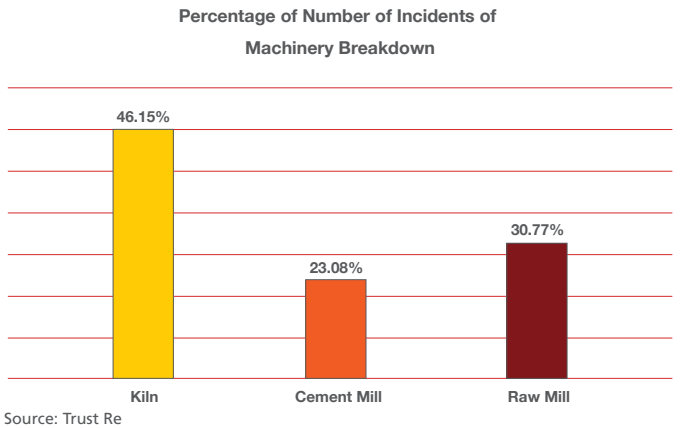

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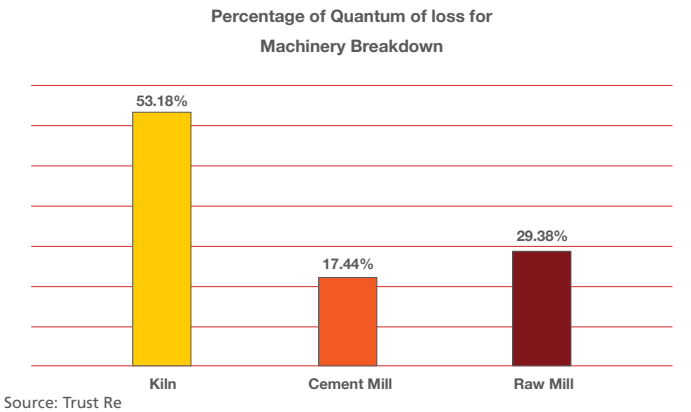

Source: Trust Re

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Trust Re Claims archives

Author: Abhijit Das, Head of Risk Engineering, Trust Re.