Cement Industry

A. PROCESS DESCRIPTION

Cement industries typically produce Portland cement, although they also produce masonry cement (which is also manufactured at Portland cement plants). Portland cement (OPC) is a fine, typically gray powder comprised of $2CaO.SiO_2$, $Ca_3Al_2O_6$, and $Ca_4Al_2Fe_2O_{10}$, with the addition of forms of $CaSO_4$. Different types of Portland cements are created based on the use and chemical and physical properties desired. Portland cement types I and II are the most common in Iraq also the use of Sulfate resistant cement (SRC) is used widely in south of Iraq due to the salty soil. Portland cement plants can operate continuously for long time periods (i.e., 6 months up to 1 year) with minimal shut down time for maintenance.

The air pollution problems related to the production, handling, and transportation of Portland cement are caused by the very fine particles in the product , this has been overcome by using Air bag filter which is able to exhaust gases with max 20mg/m^3 of air

The following illustrates the stages of cement production at a Portland cement plant:

1. Procurement of raw material or preparations from lime and clay quarries.
2. Raw Milling – preparation of raw materials for the pyroprocessing system.
3. Pyroprocessing – pyroprocessing raw materials to form Portland cement clinker
4. Clinker Cooling
5. Storage of clinker
6. Cement Grinding or Milling
7. Packing plant of cement bags and cement bulk loading

1. Raw Material Acquisition

Most of the raw materials used are extracted from the earth through mining and quarrying and can be divided into the following groups: limestone, Clay ,silica ,and iron ore. usually limestone, is the predominant raw material, most plants are situated near a limestone quarry or receive this material from a source via inexpensive transportation. The plant must minimize the transportation cost since one third of the limestone is converted to CO2 during the pyroprocessing and is subsequently lost. Quarry operations consist of drilling, blasting, excavating, handling, loading, hauling, crushing, screening, stockpiling, and storing.

2. Raw Milling

Raw milling involves mixing the extracted raw materials to obtain the correct chemical configuration, and grinding them to achieve the proper particle-size to ensure optimal fuel efficiency in the kiln and strength in the final concrete product. generally two types of processes may be used: the wet process, or dry process. In the wet process, water is added during grinding(this process is very old and it's been developed to dry process). the dry process is used, the raw materials are grind either by ball mill (Tube mill) or vertical roller mill which is now widely used for the low rate maintenance cost , the milling also uses air separators and Quadra cyclone to insure the fineness material to be store in the raw material silo.

3. Pyroprocessing (Preheater and Kiln)

In pyroprocessing, the raw mix is heated from around 350C up to 950-1000 C at the bottom of the preheater tower to gain 94% of calcinations for producing the clinker before entering the kiln and producing clinker. Clinker is hard, gray, spherical nodules with diameters ranging from 0.32 – 5.0 cm created from the chemical reactions between the raw material in the kiln, and then moved and cooled in the clinker cooler . The pyroprocessing system involves three steps: drying or preheating, calcining (a heating process in which calcium oxide is formed), and burning (sintering).The pyroprocessing takes place in the burning/kiln department.

4. Clinker Cooling

The clinker cooling operation recovers up to 30% of kiln system heat through called secondary air and tertiary air , preserves the ideal product qualities, and enables the cooled clinker to be maneuvered by conveyors. The most common types of clinker coolers are planetary, and rotary (very old system) , reciprocating grate cooler (named the 3rd generation) and the latest generation called walk-through cooler which has no fine particles returns to the system. the Air sent through the clinker to cool it. and its is directed to the rotary kiln where it nourishes fuel combustion. The fairly coarse dust collected from clinker coolers is comprised of cement minerals and is restored to the operation(grate cooler types). Based on the cooling efficiency and desired cooled temperature, the amount of air used in this cooling process is approximately 2 kg/kg of clinker. The clinker temperature at the outlet of the clinker cooler is ambient temp. + 65C.

5. Clinker Storage

Although clinker storage capacity is based on the design capacity of the kiln daily production of clinker, a plant can normally store 7 days of its daily clinker production capacity. Equipment such as conveyors and bucket elevators is used to transfer the clinkers from coolers to storage areas and later to the cement mill. Gravity drops and transfer points typically are vented to dust collectors.

6. Cement Grinding or Milling

During the final stage of Portland cement production known is cement milling, the clinker is ground with other materials (which impart special characteristics to the finished product) into a fine powder. Up to 5% gypsum and/or natural anhydrite are added to regulate the setting time of the cement. Other chemicals, such as those which regulate flow ability or air entertainment, may also be added. These materials are sent through ball or tube mills (rotating, horizontal steel cylinders containing steel alloy balls) which perform the remaining grinding . The modern technology uses vertical roller mills as well to produce more fine and high capacity grinding with low power consumption . The grinding process occurs in a closed system with an air separator that divides the cement particles according to size. Material that has not been completely ground is sent through the system again, the remaining portion sent through a bag filter to get the fineness material up to 3200 cm^2/gm (blain)

7. Packing plant and bulk Loading

Once the production of Portland cement is complete, the finished product is transferred using bucket elevators and air slides to storage silos in the packing department. Most of the Portland cement is transported in bulk by truck silos or in 50 kg multilayer paper bags , by a roto-packer machines which is capacity around 120 t/h of bagged cement

B. <u>SOURCES OF POLLUTION</u>

Although Portland cement plants generate the same final product using similar processes, plant layouts vary according to fuels and raw material used, location, climate, site topography, and manufacturer of the equipment..

C. POLLUTANTS AND THEIR CONTROL

This section discusses the nature of the pollutants generated from, and controls used at, several sources in the cement manufacturing process. Air pollutants are typically of greater concern than solid or liquid wastes.

Air Pollutants

Air pollutants generated during the cement manufacturing process consist primarily of particulates from the raw and finished materials, and fuel combustion by-products. Controlling particulate emissions from sources other than the kiln usually entails capturing the dust using a hood or other partial enclosure and transporting it through a series of ducts to the collectors. The type of dust collector used is based on factors such as particle size, dust loading, flow rate, moisture content, and gas temperature. The best disposal method for collected dust is to send it through the kiln creating the clinker. However, if the alkali content of the raw materials is too high, the dust must be discarded, or must be preheated before introduction into the kiln. The highest allowable alkali content is 0.6 percent (as sodium oxide).

Additional air pollutants emitted include such materials as sulfur oxides and nitrogen oxides generated from the kiln and drying processes. Sulfur dioxide is generated from the sulfur compounds in the ores and the combusted fuel and varies in amount produced from plant to plant. The efficiency of particulate control devices is inconclusive as the result of variables such as feed sulfur content, temperature, moisture, and feed chemical composition, in addition to alkali and sulfur content of the raw materials and fuel. The combustion of fuel in rotary cement kilns generates nitrogen oxides from the nitrogen in the fuel and incoming combustion air. The amount emitted depends on several factors including fuel type, nitrogen content, and combustion temperature. Both sulfur dioxide and some of the nitrogen oxide react with the alkaline cement and are removed from the gas stream.

a. Raw Material Acquisition

During raw material acquisition the primary air pollutant emitted is particulate matter is also emitted from the handling, loading, unloading, and transport of raw materials. In certain areas, exhaust from portable equipment may also be a consideration. The following methods are used to control particulate emissions generated from the quarry and handling of raw materials:

Fabric filters (pulse-jet or reverse-air/shaker)

- Equipment enclosures
- Water sprays (with and without surfactants)
- Enclosures
- Silos (with and without exhaust venting to wind screens fabric filters)
- Foams
- Mechanical collectors
- Bins
- Chemical dust suppressants
- Paving
- Material storage buildings

Dust that is collected by these means is restored to the process. For quarry operations, newer plants typically use the pulse-jet fabric filters while older plants employ the reverse-air or shaker-type fabric filters.

b. Raw Milling

Fugitive dust is emitted from raw material feeders, stackers, blenders, reclaimers, conveyor belt transfer points, and bucket elevators used for transferring materials to the mill department from storage particulate emissions from the dry raw mills and subsequent equipment occur during temporary failure or from improperly designed or maintained seals. The following devices are used to collect particulate matter in the raw mill and raw mix storage areas:

- Mechanical cyclones (usually used in series with another control)
- Fabric Filters (Pulse jet or reverse air/shaker)
- Electrostatic precipitator (normally used)

Newer plants typically use the pulse-jet fabric filters while older plants employ the reverse air or shaker type fabric filters.

c. Pyroprocessing

The main pyroprocessing system emissions are nitrogen, carbon dioxide, water, oxygen, nitrogen oxides, sulfur oxides, carbon monoxide, and hydrocarbons.

The cement kiln itself has been designated as best available control technology for the control of SO2. The highly alkaline conditions of the kiln system enable it to capture up to 95% of the possible SO2 emissions. However, if sulfide sulfur (pyrites) is present in the kiln feed, this absorption rate can decline to as low as 50%. Therefore, sulfur emissions can be decreased through careful selection of raw materials. No device to control cement kiln NOx emissions has been developed, but there are several prospects:

- Stable kiln operation (reduces long term NOx emissions);
- Burner configurations for the rotary kiln (efficiency varies);
- Staged combustion for precalciner kilns;
- Recirculation of the flue gas (oxygen deficient air in the rotary kiln); and
- Alternative/low-nitrogen fuels.

Cement kiln dust is the powder retrieved from the exciting gases and is either all or partly returned to the operation or removed entirely. The type of system, the chemical makeup of the raw materials and fuel, and the condition of the system operations all affect the chemical configuration of the Cement kiln dust. Portland cement specifications usually limit the amounts of sodium and potassium. Because bypass Cement kiln dust contains a large quantity of these minerals, Cement kiln dust is usually removed from the process. The preheater tower is composed of the same general elements as the kiln feed and therefore is returned to the process. The handling, storage, and deposition of such dust can generate fugitive dust emissions. The following methods are used to control particulate emissions from the kiln system:

- Reverse-air fabric filters
- Electrostatic precipitators (EP)

d. Clinker Cooling

Reciprocating grate clinker coolers most often employ fabric filters, but EPs and gravel bed filters are also used with a mechanical cyclone or multicyclone dust collector sometimes placed in front. Newer plants typically use pulse-jet or pulsed-plenum fabric filters and older plants use reverse-air type fabric filters which may simply be a smaller form of a kiln fabric filter.

e. Clinker Storage

The devices used to control dust emissions from clinker storage areas are similar to those used in the raw milling process. The particulate emissions generated by dropping clinkers onto storage piles can be reduced .Fugitive dust generated from open storage piles is tempered by rain and snow, wind breaks, and pile covers. Clinker in open piles is moved using front-end loaders. Fugitive clinker dust emitted from open storage piles is common and very difficult to control.

f. Cement Milling

Particulate matter is emitted from mill vents, air separator vents, and material-handling system vents. Newer plants usually use pulse-jet or pulsed-plenum fabric filters with high efficiency separators, while older plants use reverse-air/shaker fabric filters. The cement dust collected by the fabric filter is restored to the system. In cold weather, a plume may develop at the bag house vent; this may be mistaken for particulate matter, but actually is condensed water vapor from the cooling system.

g. Packing and Loading

In the packing department particulate matter is emitted from the silos and the handling and loading operations. Active and passive fabric filters are used to collect this dust. During loading of the product, particulate emissions are controlled by a fabric filter connected to the transport vessel; collected dust is restored to the cement packers. To ensure dust-free loading onto the transport vessel, a flexible loading spout consisting of concentric tubes is used. The outermost tube seals the delivery spout to the transport vehicle. The product is then delivered through the inner tube and displaced air dawn up the outer tube to a filter. New plants typically use pulse-jet fabric filters while older plants use reverse-air or shaker-type fabric filters.

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