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Review

Cleaner production assessment in cement plant using vertical shaft technology

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Cleaner production (CP), conceived as the vital tool to increase productivity as well as achieve sustainable Development, is now being accepted worldwide as an approach to overcome the draw back of the End-of-Pipe (EOP) treatment and also to tap the potential of the minimizing the wastage, increasing profitability of the units and protecting the environment. With reference to above there appears to be good scope for studying "Cleaner Production Options" in Industrial Cement Sector. Introduction outlines briefly the project background, objectives and scope of work and the methodology to be followed for execution of project. Fundamentals of Cleaner Production have been received carefully.

Keywords: Shaft technology, Cleaner production, sustainable Development.

INTRODUCTION

Cement manufacturing process

Raw materials acquisition and handling

The basic raw material for cement manufacturer that is Lime Stone purchased from gadu in Junaghadh district. Petcoke, clay, iron ore and Gypsum acquires from Khambhadiya, Rajkot Bhavnagar and Gandhidham respectively. The limestone contains about 85-90% of Total Carbonate. The other raw materials include coke, clay, Silica etc. Gypsum is applied to the process during the finish grinding operations.

Crushing and grinding

The second step in cement manufacture is preparing the raw mix, or kiln feed, for the pyro processing operation. Raw material preparation includes a variety of operations like crushing, grinding that are designed to provide a feed with appropriate chemical and physical properties.

The lime stone is subjected to crushing in a primary jaw crusher and then in the secondary hammer mill. The other raw material such as clay, coke and iron ore are stored in silos and are mixed approximately with limestone to form raw mix that is to grinding in a ball mill rotating at a speed of 24 rpm. This product is stored in a silo and is used as feed for the Vertical Shaft Kiln.

Materials transport is accomplished by a variety of mechanisms, such as belt conveyors, bucket elevators.

Nodulization

Controlled amount of water will be added and the pellets/nodules will be formed in the drum. The size of the pellets is 10 to 16 mm. The successful operation of shaft kiln, to a great extent, depends upon the size of nodules, their uniformity, porosity and thermal stability. The Nodulizer consists of an inclined disc or pan rotating about its axis. Raw meal is charged into Nodulizer by means of bucket elevator and water is sprayed, while all the parameters are maintained at optimum conditions.

A specially designed rotating scraper continuously cleans the bottom and the collar of the drum of the raw mix deposited. The nodules slide down the chute and are charged in the Vertical Shaft Kiln evenly all around the periphery continuously with the help of a rotary feeder

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1. Jaw crusher & hammer mill
2. Storage silo for raw material
3. Ball mill for raw mixer
4. Storage for raw mixer
5. Vertical Shaft Kiln
6. Storage silo for clinker
7. Ball mill for cement grinding
8. Storage silo for cement

Figure 1. Process Flow sheet of Cement Manufacturing

situated on the top of the kiln.

Kiln Operation

The vertical shaft kilns are fed with raw mix of appropriate composition in the form of nodules. The vertical shaft kiln in which the nodules are converted into clinker consists of a cylindrical shell with conical portion at the top and lined with fire bricks. These nodules are thus distributed uniformly in the kiln and the kiln is kept changed to a constant level and operates continuously. The material is first dried in the enlarged upper portion and then falls slowly to the narrow portion. Decarbonization takes place at about 950 ^{o}C and the final burning of the clinker takes place at 1200-1500 ^{o}C. The clinker thus formed will be cooled in the lower part of the kiln before it reaches the discharge gate.

The various zones of reaction starting from the top of the kiln are;

- The Drying Zone,
- The Calcining Zone,
- The Sintering Zone And
- The Cooling Zone.
- Kiln Chemistry

While kiln systems vary, there are three major zones:

1. Drying and Preheating Zone

- Water Is Evaporated.
- Driving Off Carbon Dioxide from Limestone-Begins.

2. Calcining Zone

Calcinations is complete, removing carbon dioxide from calcium carbonate to produce the lime (calcium oxide) needed for subsequent reactions.

3. Sintering or Burning Zone

Calcium oxide reacts with silica to form dicalcium silicates and alumina- and iron-bearing materials to form tricalcium aluminate and tetracalcium aluminoferrite. These two compounds, in liquid phase, meld solids together into the pellets called clinker. Remaining calcium oxide reacts with dicalcium silicate to form tricalcium silicate.

4. Cooling Zone

The combustion air supplied by blower ascending from below in the cooling zone absorbs heat from the descending clinker. The whole kiln charge composed of unburnt nodules and clinker rests on a flat grate rotating slowly at the bottom of the kiln and mounted over the kiln shaft. The grate is driven with the help of variable speed motor in order to control the discharge rate of clinker. Finally, the clinker is taken out of kiln bottom.

Cement Mill and Finishing

Thus the clinker formed in Vertical Shaft Kiln will be fed into the cement mill hopper by means bucket elevator where 2% Gypsum will be added and fed to the ball mill for grinding operation. Gypsum helps in initial setting of cement. The cement (OPC) produced is stored in Cement silos and then sent for packing and final dispatch.

Table 1. Cleaner production option

Option No.	CP Option Description
1.	Coal saving by Waste heat recovery from fuel gas by installing preheater
2.	Providing better outer surface insulation to the burning zone of VSK by using ceramic fiber pad
3.	Power generation by using waste heat recovery from fuel gas by using kalian cycle technology
4.	Coal saving by using alternative fuel in the Vertical Shaft Kiln
5.	Water quantity in nodules to be maintained by installation of Flow meter at the Nodulizer
6.	Temperature in various zones of VSK to be maintained by installation of Thermocouple followed by adequate monitoring
7.	Install online oxygen analyzer for the flue gas to control excess air and also to monitor the combustion efficiency of Vertical Shaft Kiln
8.	Arrest leakages coming from crushers, hammer mill
9.	Enclosure for Belt Conveyor from Jaw crusher to Hammer mill
10.	Separate room for storage of Raw Material like Lime Stone, Clay, Coal, Iron Ore etc. to be provided
11.	Incorporation of a Screen to separate fines and small particles to avoid fine generation in crushing
12.	Incorporation of a magnetic separator to separate iron pieces in coal, which may damage the crusher
13.	Reduction in kiln stoppage time by better management practices
Energy related option	
14.	Energy Saving by installation of Variable frequency Drive's for Crushers, Grinders, Kiln, etc,
15.	Energy Saving by using properly size motors
16.	Energy Saving by replacement of inefficient lamps with energy efficient lamps.
17.	Energy Saving by means of adopting Natural Lighting
18.	Usage of rewound motors to be avoided
General option	
19.	Personal Protective Equipments (PPE) to be used by workers
20.	Day to Day cleaning of the plant premises.
21.	Provide training for the plant operators awareness
22.	Rain water harvesting
23.	Provide level concrete surface to prevent losses of Raw material
24.	provision of Laboratory for Checking quality of material & product

Table 2. Summary of cost benefit analysis at a glance

Sl. No.	CP-Measure	Annual Resource Savings	Annual Monetary Savings (Rs.)	Investment Required (Rs.)	Simple Payback Period (Years)	Annual GHG Reduction (Tons CO_2)
		CRUSHER SECTION				
1.	Installation of Variable Frequency Drives	6043 kWh	36256	67500	1.9	5.04
2.	Leakage to be arrested coming out from Crusher side flap	22 Tonne of Limestone	8880	10000	1.13	-
3.	Incorporation of a Plate Type Grizzly Feeder prior to Crusher but after dumper unload	7162 kWh	42970	100000	2.33	5.96
4.	Leakage to be arrested coming out from Hammer Mill	22 Tonne of Limestone	11754	10000	0.85	-
		RAW MILL SECTION				
5.	Installation of Variable Frequency Drives	72511 kWh	435067	810000	1.9	60.402
		PRE-HEATER INSTALLATION				
6.	Installation of Preheater	236 Tonne Coal	831738	1500000	1.803	424.8
		VERTICAL SHAFT KILN				
7.	Insulate the burning zone of Vertical Shaft Kiln with Ceramic Fibre Blankets to prevent heat losses from the surface of kiln	36.359 Tonne Coal	127255	50000	0.39	65.44
8.	Installation of Variable Frequency Drive for the kiln blowers	60426 kWh	362556	453195	1.25	50.33
9.	Use of alternative fuel with coal	204 Tonne Coal	714000	1000000	1.4	367.2
10.	Reduction in stoppage time of kilns	2000 Tonne Clinker	800000	-	-	-
		LIGHTING SYSTEMS				
11.	Replacement of Florescent tube lights with T5's & Incandescent bulbs with CFL's	7704 kWh	46224	46875	1.0	6.42
12.	To provide transparent roofing in order to maximize use of natural lighting during day time	18720 kWh	112320	75000	0.7	15.6
TOTAL			**3529020**	**4122570**	**1.16**	**1002**

Note:
1 T CO_2/year = *Rs. 1500/-*
So potential for GHG savings, cash inflow = 1500 x 1002
= Rs. 1,501,800/-

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