MODIFIED CHUTE DESIGN FOR SLAG REMOVAL IN CEMENT MAKIN

ABSTRACT

Slag deposition in cement factory is a problem that impacts the efficiency and operation of belt conveyor lifetime reduce. The slag deposition problem is depends on chemical composition, chute design and operating conditions. It will reduce the efficiency and capacity of cement production. Numerical empirical and traditional methods, such as slag fusibility, slag viscosity and slagging which are based on the temperature and the chemical compositions, cannot fully predict the complicated slag deposition process. There are various mechanism and technologies available for the prevention of deposition problem such as soot blowers, vibrating damper, air blasters, water lances etc. The above important equipment with the variety of industrial applications but the equipment is not efficient to remove the slag deposition. So preventing slag deposition mainly depends on design of chute. Based on construction and space requirement change the rectangular chute into circular chute. In rectangular chute has the four sharp corners counter flow in the corners velocity distribution is not equal. The velocity distributes at the center of the chute so prefer the circular chute.

INTRODUCTION

In cement industries they have a problem on removal of slag inside the chute. The slag depositions formed inside of the chute sharpen edges. In the mixing zone the additives like fly ash, clinker, gypsum, limestone, and additive slag feed by the weigh feeder. Weigh feeder is the belt conveyor which used to control the flow rate of the additive materials. The clinker comes from the kiln at hot condition is about 100°C or above. Where the slag comes from the storage in wet condition during rainy seasons and it come dry condition during summer. When the materials are feed into the mill, dust raises from the clinker. And this dust mixed with slag. When the calcium oxide reacts with the water it produce calcium hydroxide and releasing heat where crystallization process will begin. This crystalline calcium hydroxide is very hard and removing from the duct surface is much difficult. The slag coating formation will affect the flow rate of the slag and this cause the duct corrosion will occurs. Thus the slag coating removal is very important to improve the performance of the mill and increase the productivity.

What is cement?

Cement is made by grinding together a mixture of limestone and clay, which is then heated at a temperature of 1,450°C. What results is a granular substance called "clinker," a combination of calcium, silicate, alumina and iron oxide.

Additive material

In cement production, the raw material like lime stone (clinker) is used some other additive material are added for cement production such as gypsum, fly ash, slag. The usage of additive material in cement production is to improve the quality of cement, reduce the usage of raw material cost and setting time etc.

Gypsum

Gypsum plays very important role in controlling the rate of hardening of the cement .during the cement manufacturing process, upon the cooling of clinker, a small amount of gypsum is introduced during the final grinding process. The gypsum is added to control the setting of cement. With the use of gypsum in cement, the setting rate of cement is increased hence we can work it little bit longer. If we use the gypsum free cement it will flash surely the set and will get set after a short while with addition of water into it. So, gypsum is used as a retarder in cement at the time of grinding of cement clinker in ball mill.

Fly ash

Supplementary cement material, when used in conjunction with port land cement, contributes to the properties of the hardened concrete though hydraulic activity. The benefits of using fly ash in concrete in hardened state with fly ash shows improved performance with greater strength, decreased permeability, increased durability, improved finishing.

Slag

Slag is a stony waste matter separated from metal during smelting or refining or ore. Slag is the glass like by-product left over after a refined metal has been separated from its raw ore. Slag is usually a mixture of metal oxide and silicon dioxide. However slag can contain metal sulphide elemental metal while slag are generally used to remove waste in metal smelting, they can also serve other purposes such as assisting in the temperature control of the smelting , and minimizing any re-oxidation of final liquid metal product before the molten metal is removed from the furnace and used make solid metal. Ground granulated slag is often used in the concrete combination with port land cement as a part of blended cement. Ground granulated slag reacts with water to produce cementitious properties.

Conventional methods

There are some following methods for removing slag which are listed below

- Air blaster
- Soot blower
- Water lances
- Acoustic removal
- Explosives

Air blaster

An air blaster or air cannon is a de-clogging device composed of two main elements: a pressure vessel (storing air pressure) and a triggering mechanism (high speed release of compressed air). They are permanently installed on silos, bins and hoppers walls for all powdery forms of materials, and are used to prevent caking and allowing maximum storage capacity. They are also used in the entertainment industry for shock value in Halloween haunts and other attractions. Air blasters do not need any specific air supply. Available plant air is enough with a minimum of 4 bar air pressure (60 psi or 400 KPa), although 5 to 6 bar are preferred for better results (75 to 90 psi). The average air consumption is moderate, and depends on the number of firings per hour, size of the pressure vessel, and number of air cannons installed. For instance, a 50-liter air cannon consumes 0.60 Nm^3/hour at 6 bar air pressure (90 psi or 600 KPa), with 2 firings per hour. The compressed air contained in the pressure vessel is instantly released, and the achieved blast, called the impact force, evacuates material sticking to the walls (rat holing), as well as breaking Potential bridging thanks to the shock wave obtained. The blasts are usually organized by using an automatic sequencer.

Soot blower

Wall blowers are provided to clean the slag deposition on wall deposits. The deposition and slagging in duct is required to be removed from the surface walls at regular intervals. The interval period will depend on the area of deposition and the severity of deposition. Wall blowers are found to be very efficient in removing the wall deposits. However, the wall blowers are not effective in the case of hardened slag removal from the walls.

Water lances

Method for cleaning slag from a duct using high-pressure water jets. Thompson Industrial Services uses high-volume, specialized hydro blasting equipment, with pumps that can send up to1, 200 gallons per minute through the hoses. The company also uses remote-controlled robotic cleaning systems and other automated tools to clean boilers. Thompson Senior Business Development Manager Carl Wise said the company is able to use water lances for both online and offline cleaning.

Acoustic removal

Acoustic cleaning system, can knock ash off boiler tubes or selective catalytic reduction systems with acoustic energy without risking damage or fatigue to the units. We're cleaning a volume because the acoustic cleaner is in resonance with flue gas." Acoustic cleaning works especially well on dry and dusty deposits.

Explosives

Using explosives to clean slag from boilers isn't a new process, but it's one still in use that many plant operators prefer. To clean a boiler using explosives, hardy said his company will use primer cord around tubes that are close to avoid damage. The cord has connectors to delay the chargers, which he said is important to avoid destroying the wall or insulation of the boiler.

Motivation

The slag coating forms inside of the chute like hard concrete structure, so the labors found it difficult to remove the slag coating formation. The different methods are being used to remove the slag coating formation in the slag chute. Such as air blaster, soot blower, vibrating damper, pulse detonation, water lances, acoustic cleaning method, But they are not sufficient to remove the slag coating formation in the slag chute because of the wet and hard concrete structure. So we found a new way to reduce the slag coating formation. This motivated us to provide solution for the slag coating removal in the slag chute.

Objective

To change the chute design for remove the slag coating.

Observation

The raw material needed for cement production are lime stone (calcium carbonate) and clay (silicon, Aluminium and iron ore). The additive material used in cement production are slag, fly ash and gypsum. In slag storage, the slag is passed through belt conveyor and stored in hopper. Hopper has 60 tons storage capacity. Slag flows at a rate of 10 ton per hour, through a belt conveyor. Using a belt conveyor the slag is transferred to ball mill. Between the hopper and belt conveyor the slag chute is placed, using slag chute the slag flows to the feeder, then passes through the ball mill. At the same time, gypsum flows at a rate of 2 ton per hour and clinker flows at a rate of 90 ton per hour transferred to the ball mill by using common belt conveyor the clinker is about 90°C from hopper. If a substance flows without disturbance that substance is constant, if some distribution is created then reaction occurs. So clinker flows without disturbance in the belt conveyor when falling on the feeder, the distribution is created by means of hot dust with respect to hot dust falling area, slag flows from

chute, when a hot dust absorbs the wet slag, that wet slag gets deposited on the inside of the chute and feeder. The continuous deposition of slag on feeder forms knife edge coating. After some period of time, knife edge coating slag can tear the common belt conveyor. Common replacement of belt in conveyor is about 2 times per year. But due to above deposition problem, we have to replace the belt 3 times per year. Moreover, inner deposition also affect the flow rate of slag. So the labors are very difficult to remove the slag coating formation in chute. Many removal techniques are implemented in production process such as air blaster, flowing the slag by inclined position (rectangular chute) are failure for this process. So that lot of maintenance cost are increase. Due to above problem the cement production are affected.

Problem identification

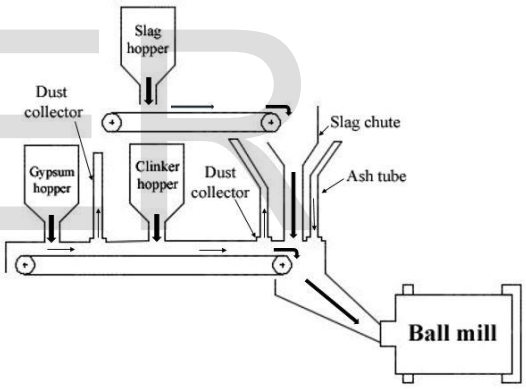
Slag coating formed in the inner side of the rectangular slag chute (sharp edges) due to the friction in the corner of the sharp edges. Thus the pressure drop and the back flow occurs. In the mixing zone the clinker dust (calcium oxide) forms and it rises from bottom to top through the rectangular chute. Slag comes from the storage in wet condition.

The clinker dust is mixed with the slag and it is in wet condition (28°C). The clinker is hot (100°C-120°C) thus the crystallization process begins when mixed with water particle. It forms concrete like structure in the inner side of the rectangular chute.

The slag coating forms at three meter from the surface contact area, but there is no coating formation away from the three meter.

The slag coating formation is like a sharp knife edge at bottom of the belt conveyor and it scratches the belt surface and thus the belt wear and tear of the belt, reduces the belt life.

Existing model



In existing model slag chute the rectangular duct is used to pass the slag into the ball mill. There is some distance (1m) between the chute and ball mill. Near to the chute the belt conveyor is placed which carries a gypsum and clinker .clinker is about 90°C-120°C hot substance when passing through the ball mill hot flying dust is formed, like sticky particles. So it can absorb the wet slag substance that gets deposited on the inner duct and belt conveyor feeder. Due to

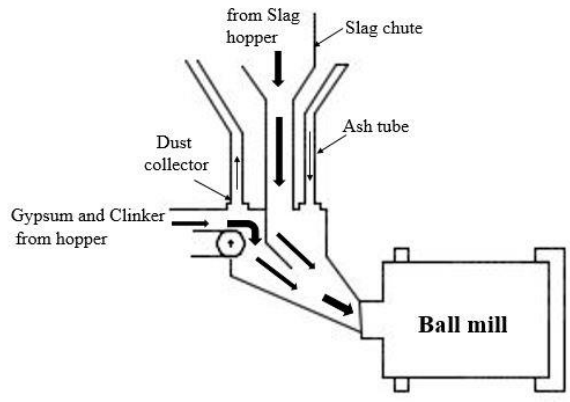
the coating of slag, it is very difficult to remove the slag from duct. To maintain the duct without coating is very difficult and it increases the maintenance cost. The flow rate of slag is reduced. If it gets deposited under the belt conveyor, knife like concrete structure is made and it can tear the belt. Due to the above problem the production process is tampered.

Methods for slag removal

There are three different methods to overcome or avoid coating formation. Initially, in the first two methods, there are some problems the third method has no problems if faced, they can be resolved in this method.

- Separate slag chute method
- Direct to ball mill method
- Feed direct to belt conveyor method

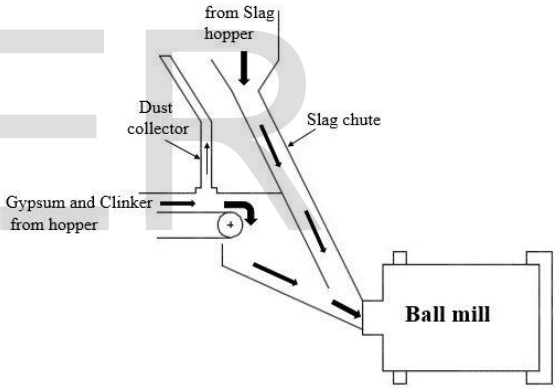
Separate slag chute method



In normal, slag flows in feeder. Separate slag chute method is nothing but a separate chute to slag that flows on feeder and doesn't allow mixing with clinker hot duct. By using this method coating, formation of chute and feeder can be avoided

Direct to ball mill method

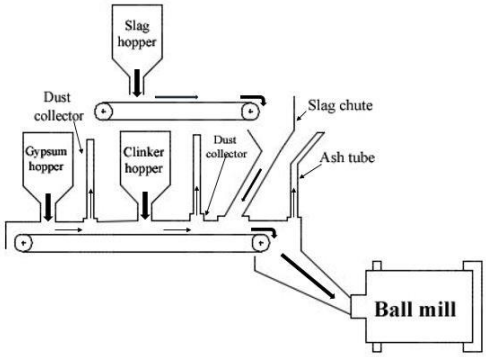
Slag chute method is not convenient, because the heat from clinker is also transferred to the chute, so it is not sufficient enough to remove all the dust particle, but can assure that some of the dust particles are removed. All these above problems are solved by direct ball mill method. In this method, slag chute is placed direct to ball mill entry.



Feed direct to belt conveyor method

There is one major problem in direct to ball mill method that if the beam is considered the entire building could collapse. In order to avoid all this problem we have chosen to feed directly to belt conveyor method. In this method slag chute is placed in inclined was to belt conveyor.

Proposed model: Feed direct to belt conveyor method



The existing model problems are analyzed in proposed model (feed directly to the belt conveyor). Due to available space requirement we chose to feed directly to the belt conveyor. In proposed model, slag chute is circular duct which is like an inclined hollow cylinder placed nearer to the duct collector .there is some distance (2m) between the chute and ball mill. The slag falls directly to the belt conveyor. No hot flying dust is formed. Due to the absence of hot flying dust coating problems are avoided. Knife edge formation of concrete is avoided. Due to this effect the belt lifetime is increased from 2688hr to 4032hr.

Comparison of circular duct and rectangular duct

Circular duct

Circular ducts are definitely the more common type o duct work. There are many merits to circular ducts, from increased air flow, quick installation and lower cost. A cylinder is a closed solid that has two parallel (usually circular) bases connected by a curved surface. A cylinder is a geometric solid that is very common in everyday life, such as a soup can. If you take it apart you find it has two ends, called bases that are usually circular. The bases are always congruent and parallel to each other. If you were to 'unroll' the cylinder you would find the side is actually a rectangle when flattened out. (See Surface area of a cylinder).

- Less friction
- Better, more efficient air flow
- Easy to join pieces together
- Better for medium to high pressure system
- Less noise pollution

Rectangular duct

They allow more noise to escape from the duct which can cause lot of problems and high pressure drop. Due to sharp edges deposition of slag is increased. Continuous deposition internal flow, flow rate of slag is reduced.

Specification of circular duct

Circular duct allows for more efficient air flow with less friction loss, especially on long runs. Circular columns are symmetric about centroid axis. Rectangular column have only four axes of symmetric. Circular column occupy lesser area when compared

to the rectangular column. Better acoustic performance be the curved surface allow less break out noise. Efficient way of conveying air with low pressure. A round duct. However is more efficient than rectangular in performing the same task; it is also smaller in cross-sectional area and has less duct wall exposed to moving air.

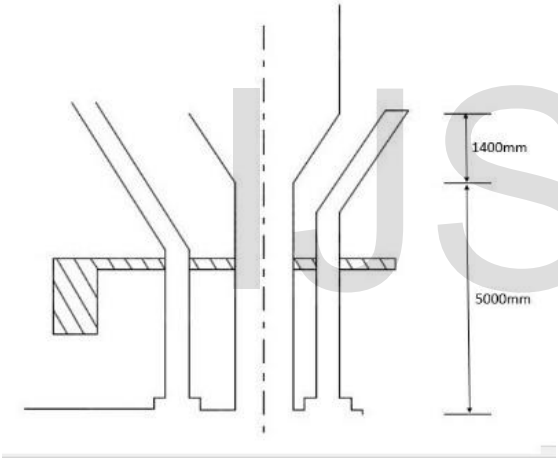
Existing model – design

Rectangular cross-section

Slag chute height (h) = 5000mm

Slag chute length (l) = 680mm

Slag chute breadth (b) = 460mm



Slag chute angle calculation

AB = 1030mm

BC = 5170mm

$AC^2 = AB^2+BC^2$

$AC = \sqrt{AB^2 + BC^2}$

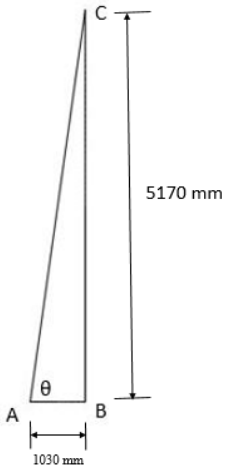
$AC = \sqrt{1030^2 + 5170^2}$

AC = 5271.60mm

$\sin\theta = \frac{opp}{hypo} = \frac{BC}{AC} = \frac{5170}{5271.06}$

$\sin\theta = 0.98$

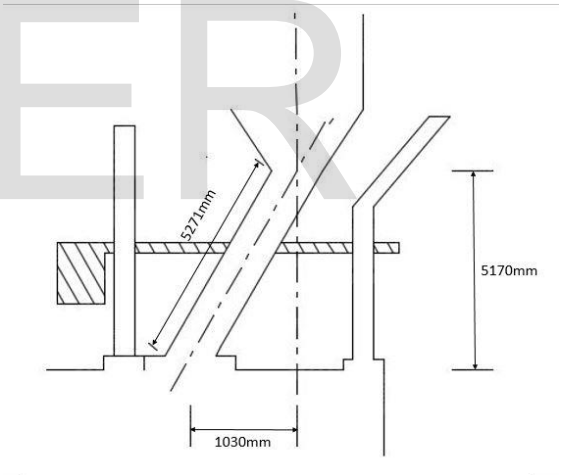
$\theta = 78°43'$



Modified chute – design

Circular cross-section

Chute diameter (d) = 600mm



Chute height (h) = 5170mm

CONCLUSION

In slag chute modification, all the problems and construction structure are analyzed. By the available space requirement, the rectangular chute is modified into hollow cylinder chute. In a rectangular chute, there are four Sharp edged corners are available, when slag falls on chute back pressure is

formed. There is no uniform velocity distribution, at the center of chute. Only the velocity distribution is equal but in four corner the velocity of flow is low. Due to this the slag deposited at the corners. And continuous slag that falls are deposited which into a forms concrete, structure inside the rectangular chute. So we modified the chute into hollow cylinder by analyzing the available space. In hollow cylinder, internal solid flow the velocity distribution is equal and there is no back flow pressure. After modifying the chute the slag falls directly in the belt conveyor so there is no deposition in belt conveyor feeder and the internal coating of chute is avoided. So problems are solved in inclined hollow cylinder. Due to reducing the coating problem knife edge form of slag is avoided so the belt life time is increased to 2688 h to 4032 h. and then, maintenance cost of removal of slag is reduced to 7.14% to 4.76% finally the production of cement is improved to 9600 pack per week to 19200 pack per week.

REFERNCES

[1] Jose-Luis Fernandez-Turiel, et al. (2004) "Ash deposition in Pulverized coal-fired power plant after high- calcium lignite combustion". Energy & Fuels 2004, 18, 1512-1518.

[2] N. Hare, et al. "A review on boiler deposition/Foulage prevention and removal techniques for power plant". Recant advances in energy & Environment.

[3] Cai yongtie, et al. (2017) "Modelling of ash deposition in biomass boilers". Energy procedia 143 (2017) 623-628.

[4] John Lenkar et al. (12 April 2007), "viscous through pipes of various cross-section". Eur. J. Phys. 28 (2007) 521-527.

[5] Steven A.Benson, et al. (2004) "Modeling Fireside Slag Formation and Deposition in Tangentially-Coal-Fired Boilers". Prepr. Pap.-Am. Chem. Soc., Div. Fuel Chem. 2004, 49 (1) 155-156.

[6] Denise L. garmanda et al. (1993) "System for slag removal and the like".

[7] Ken wicker et al. (2003) "A smarter way to remove slag". (www.powermag.platts.com)

[8] Justin mertino, et al. (2014) "Slag, ash deposits on the boiler and cleaning methods for removing slag are acoustic cleaning and water Lance".(webpagepdf.com)

[9] ZIAUL HUQUE, et al. (2009) "application of pulse detonation technology for slag removal".
Fuel processing technology 90 (2009) 558-569.

[10] Arafat A. Bhuiyan, et al. (2016) "Co-firing of biomass and slagging in industrial furnace: A review on modelling approach". Journal of the Energy Institute (2016).