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Improvement in Performance of Ball Mill in Cement Grinding

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Abstract:
This work deals with the energy consumption in cement grinding section and an attempt to improve the performance of ball mill in cement grinding. Specific energy consumption of ball mill, production capacity and factors affecting ball mill performance is given in this research work. Work includes a systematic study about grinding mills and factors are described which are affecting the ball mill performance badly. Work presents an overview of current methodology and study of the current industrial ball mills.This is an attempt to minimize the energy consumption of ball mill. Energy wastage will be a problem in this world in present and it may increase in future. Cement plants consumes very high rate of energy in many forms like electricity and thermal energy. There is a high rate of wastage of energy in kiln section in cement industries. So there will be a waste heat recovery system in the cement plants. This work is included with the performance team in the plant and over 4 million cost of cement production is saved during the project.

I. INTRODUCTION

India is the second largest producer of cement in the world. No wonder, India's cement industry is a vital part of its economy, providing employment to more than a million of people.Various types of issues can be faced by cement plants which give attention to local levels as well as international levels. Cement consumes 83% of total energy which is used in the production. Energy has influence of 20% to 40% on cement cost.

Main energy consuming process is the grinding of cement and the part where limestone and gypsum get mixed together. Portland cement usually called as PPC cement which is used most widely contains 95% of cement clinker and consumes very large amount of electricity.

Large amount of electricity is needed to grind the raw materials. The cement industries rank on 1st position for consuming energy. The total energy costs make up about 30 to 40 per cent of total production cost of cement.

On the basis of electricity consumption the energy utilization is always been the matter of priority in cement industries. Most energy consuming stage is the grinding of clinker which is the last stage.

The study shows that 40% energy is consumed to produce 1 ton of cement. During this stage the size of clinker reduces and it is grinded to get optimal fineness. Various types of factors affected by the improper fineness therefore fineness should be optimal.

Currently, world consumes about 1.6 billion tons of cement per annum. Study shows that the consumption of cement is increasing at rate of 1% per annum.

This leads to increase in consumption of energy. 110kWh/ton of energy is consumed by cement production and about 40% used in clinker grinding.

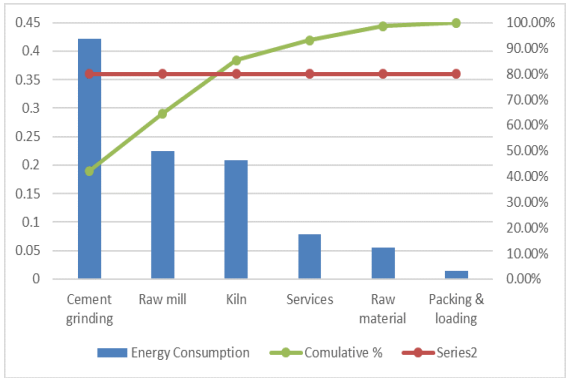


Figure.1. clarifies the energy consumption in cement industry in different sections.

The above chart shows that 80% of energy is consumed by 20% section which is the grinding section. The energy consumption is more in grinding section which is 42.2% and in grinding section cement mill grinding consumes more electricity than cement mill material transport and cement mill gas handling. The cement mill grinding consumes about 34.2% of electricity. So the focus of this research work is on the grinding section of cement.

Areas of focus

The focus of this research work is to work on improving the performance of ball mill by systematic study of mill operation and identifying bottlenecks & improvement thereof. Major scope includes identify potential, suggest measures and support plant team in implementation of feasible ideas for improving mill performance.

The main objectives are

- To find and eliminate operational inefficiencies.
- To study about the operation and maintenance problems.
- To create awareness about energy conservation.
- Reduce specific energy consumption of ball mill.

Delimitation

Delimitation has been made to focus and clarify the boundaries of the project.

- Company wants to reduce the specific power consumption of the ball mill and to maximize the production of the cement.
- Company is using the various types of methods and wants to achieve the optimal results.

Ball Mill

A ball mill is used as a grinder of cement clinker which is horizontal cylinder type mill. A ball mill is filled with the steel balls that rotate on the axis of mill which has tumbling and cascading actions on the balls. Impact forces cause the crushing of material in the horizontal cylinder. Clinker is grinder with impact and friction forces inside the cylinder. Grinding media which is usually called as grinding balls are made up of high chromium steel. A cement mill is the comminution machine which is used to grind the hard and big sized clinker that comes from kiln section of cement industry into the fine optimal powder which is called as cement. Most of the cement in this world is grinded in ball mills and as well as in vertical roller mills which is always considered as more effective than ball mills. Ball mill is divided into two chambers generally called as 1st and 2nd chamber respectively. This is decided on the basis of the size of feed input. Roller press mills usually has single chamber. These two chambers of ball mills are usually because of different sizes of grinding media. Clinker size of over 25mm is grinded in the first chamber which has large balls. Here the ball mill diameter is in the range of 60-80mm. This grinding is also called as coarse grinding. In the second chamber, the grinding media or grinding balls has a size of 15-40mm. Here the clinker from the first chamber is grinded to the finished product which is called as cement. This grinding is also called as fine grinding.

Table.1. Main causes to start project

Project definition and planning	
Root causes to start the research work.	Inefficient performance of cement mill causing high power consumption.
Objectives to be achieved through the project.	Reduction of specific power consumption of ball mill & Increased output
Project mission.	Reduction of specific power consumption from baseline 33.69 kWh/ton in PPC.

Collection of data

The data is collected from the Performance Support Centre department of the industry. The data from the industry includes specific power consumption rates of previous years, total cement production and the audit findings by the team. The study of the research work is included with the training and development team. With the consent from the development team of the industry the study of this research work gets included.

Analysis and detailed description of problems

Once the data is collected, the data needs to be critically analysed. Data analysis is very important that it provides an explanation of various concepts, theories, framework and methods used. It helps in arriving at conclusions. In this research work the data is analysed briefly to identify process problems and to get optimal results.

Optimization approach

To improve the mill performance the entire step divided into several parts. Each part is affecting the whole ball mill performance. Ball mill is connected with various parts and it is called ball mill circuit. The research work will study about the whole ball mill circuit that is affecting the performance of ball mill.

Brainstorming

Brainstorming is a group creativity technique by which efforts are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by its members.

Question Brainstorming

This process involves brainstorming the questions, rather than trying to come up with immediate answers and short term solutions.The answers to the questions form the framework for constructing future action plans. Once the list of questions is set, it may be necessary to prioritize them to reach to the best solution in an orderly way.

Questions are

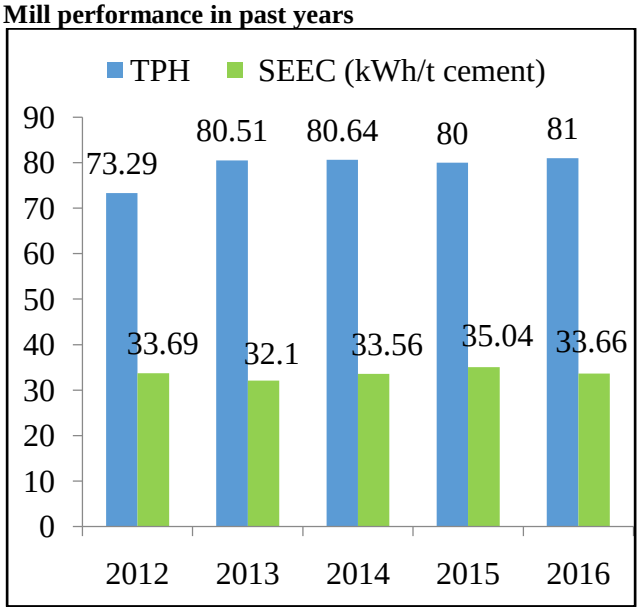
- Why the specific power consumption of ball mills are high.
- Why there is a need to identify the measures and eliminate the errors in ball mill grinding.

The causes of higher specific energy consumption are captured by the help of question query. The causes are defined as follow in calculation part.

Study steps used in improving the ball mill performance in research work

- **Comminution Engineering**
- **"B" Level audit**
- **Separator fan curves and efficiency**

Mill performance in past years



Five years of data clearly showed that mill performance is almost same in the case of TPH from last five years. But in case of SEEC there are variations.

Main observations related to coarse grinding are listed below

- Material level is at optimum level.(Top surface of the media is visible)
- Coating not found on grinding media.
- Gypsum & lime stone big piece found in the mill along the length.
- Nibs of gypsum and lime found stuck up in diaphragm slot.
- Diaphragm slot about 20% choked with nibs and scrap material.
- Grinding ball shape is in good condition.
- Based on the results of longitudinal sieving and comparing with guide value shows that first chamber is grinding efficiently.
- Outer slot are pined shaped which increased the stuck up of nibs.

Figure.2. Gypsum size on weigh feeder

Figure.3. Mill inner conditions

Main observations related to fine grinding are listed below

- Material level in chamber 2 was low, all balls were clearly visible.
- Gap found between back plates of intermediate diaphragm.
- Chamber having lot of deforms and small grinding media (<= 12mm). Hence sorting of grinding media required.
- Classifying of grinding media found satisfactory.
- Outer ring of diaphragm is observed having clinker nibs and small grinding media stuck in it.
- Slot size of discharge diaphragm is 8 to 9mm.

Main finding of B-level audit and visual inspection of mill circuit.

- Material level low in second chamber.
- Gypsum and lime stone nibs stack up in first chamber diaphragm.
- Both diaphragms required regular cleaning.
- Replacement of pinned slotted diaphragm of first chamber.
- Second chamber diaphragm jammed by scrap material.
- 2^{nd} chamber required re-grading as visually lot of deformed grinding media visible.
- Mill ESP discharge material have higher residue and it is going directly in product.
- Separator fan efficiency low (65%).
- Coating on Separator static blade.
- Gypsum and lime stone > 30mm.
- Scrap metal pieces found in both chamber.

Figure.4. Wear found in separator fan

Implementation of optimization measures

- Increased grinding media piece wt. in 2^{nd} chamber.
- Reduced separator seal gap.
- Regular cleaning of both the diaphragms during schedule maintenance.
- Repairing of separator fan casing wear/puncture portion.
- Reduction of gypsum and Lime stone sizes.
- Sorting of deformed grinding media from 2^{nd} chamber.
- Regular cleaning of separator guide vanes.
- Increased of mill ventilation.

II. CONCLUSIONS

Mill performance after the execution of recommendations was improved drastically as depicted from above data.

- Reduction in SEEC by 2.27 kwh/ton cement from base line.
- Mill production rate increased from 81.9 TPH to 90 TPH.

- Cement residue on 45 micron reduced from 8.7 to 5.7 %

	Before	After
MD specific power (kWh/t cement)	28.36	26.29
Separator fan Specific power (kWh/t)	2.60	2.48
Auxiliary specific power (kWh/t cement)	2.73	2.65
Total SEEC (kWh/t cement)	33.69	31.42
TPH	81.9	90
Production (MT)	34322	39367
Blaine (cm^2/gm)	3840	3860
Residue on 45 micron (%)	8.75	5.76

Economic aspects

- Specific power consumption reduction by 2.27 kWh/t cement
- Total cement production in year 2016 = 321136 ton
- Saving in SEEC (kWh) = 2.27 ×321136 = 728978.72 kWh
- Cost of 1 unit of electrical energy = 5.5 INR /kWh

Total saving SEEC (INR) = 5.5×728978.72 = 4009382.96 INR (4 million INR)

Recommendations

To further improve the mill performance following measures proposed.

- O-Sepa fan impeller to be changed with high efficiency impeller (cost 0.5-0.6 million INR).
- Wet fly ash dryer to be installed, to avoid shortage of dry fly ash and losses due to usage of wet fly ash (cost INR 20 Cr.) and time for installation & commissioning 6-7 months.
- Instead of wet fly ash dryer it is also recommended to use the waste hot gases from the kiln section as a wet fly ash dryer. Give rise to waste heat recovery system.

Waste heat recovery

In addition to improve the SEEC in cement industries the waste heat (from kiln section) can be used as a wet fly ash drying mechanism. It is recommended to use these hot gases in order to dry the wet fly ash that is affecting the performance of ball mill and resulting in higher energy consumptions. By the use of waste heat there is no need to install the other equipment like HAG (higher in costs and higher time required to install) to dry the wet fly ash. By this the consumption of additional fuels can be saved. The waste heat includes the gases from kiln section and the gases from preheater. Fossil fuels are not a clean source of energy. Energy savings play an important role in this world. Conservation of energy not only saves the money but much more than saving money both in home as well as in this business world.

III. ACKNOWLEDGMENT

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