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GRINDING: SMARTER SOLUTIONS

Technology and innovation are being used to reduce energy consumption and improve output quality.

Feature: Ready Mix Concrete

"Efficient grinding unit selection impacts profitability."

ICR gets **Vimal Jain, Director - Technical, HeidelbergCement India,** to share his views about the innovations in technology of the grinding process and grinding aids as well as his understanding on how the entire process can be made more energy-efficient and cost-effective.

Explain the grinding process in cement manufacturing.

The grinding process is needed to create surface area for a good chemical reaction and reactivity to occur in cement manufacturing. The grinding process is mainly required for raw material, coal and clinker grinding in the cement manufacturing process.

The process of cement manufacturing involves grinding clinker granules along with blending materials or additives and gypsum to produce a fine powder called cement. Depending on the quality of clinker and type of cement, blending material/gypsum are added in controlled proportion to produce a quality product to meet the prescribed quality as per given codes.

Optimum fineness needs to be found for the type of raw materials, coal, and clinker to avoid over-grinding, which comes with 'excess energy' consumption and has a negative impact on quality and cost.

The quality of cement depends on its physical and chemical properties. Technology has advanced over the period and the grinding process can help in augmenting some properties of cement.

Tell us about the equipment used for grinding raw material and clinker.

The main equipment used for grinding raw materials and clinker are categorised based on their size reduction concept and mechanism as,

Ball Mill (BM):

Size reduction mechanism –

1. Impact: particle breakage by a single rigid force causing fracture.
2. Attrition or Abrasion: arising from particles scraping against one another or against a rigid surface.

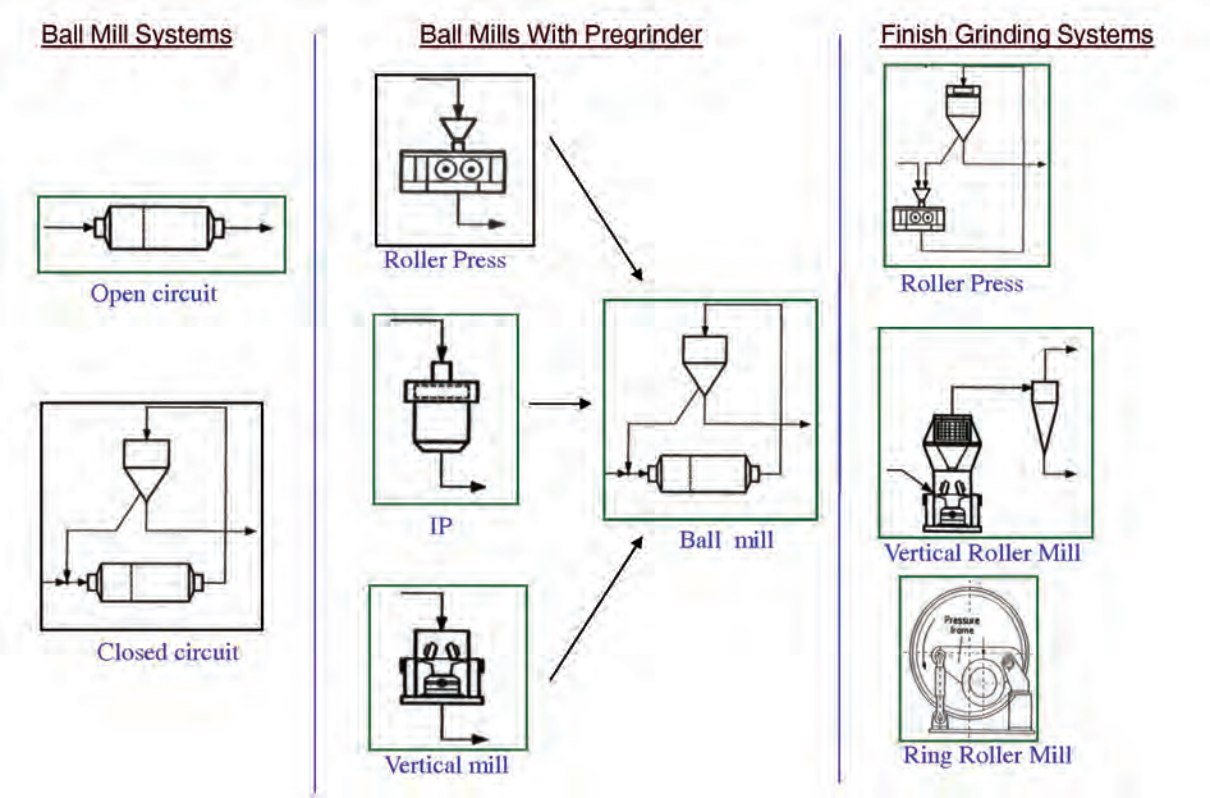
Vimal Jain
Director - Technical, HeidelbergCement India

Ball mills are the most widely installed grinding equipment in the cement industry. It consists of a rotating cylinder filled with steel balls that tumble inside the mill, applying impact and friction forces to the clinker particles. For better grinding efficiency, the mill may be operated with one, two or three internal compartments separated by diaphragms that prevent the transfer of the balls between the compartments while allowing the flow of the ground material through the mill.

Roller Press (RP)

Size reduction mechanism – Compression: particle disintegration by two rigid forces.

The roller press has been extensively used as a



Types of grinding mills

pre-grinder as well as a stand-alone cement mill. It compresses the material in a gap between two counter-rotating grinding rollers lined with wear-resistant material. The output product contains fine and coarse particles with a large number of cracks and weak points that significantly reduce the energy requirement during the further stage of fine grinding.

Vertical Roller Mill (VRM)

Size reduction mechanism –

1. Compression
2. Shear or Chipping: produced by fluid or particle-particle interaction.
3. Attrition or Abrasion

In a vertical roller mill, two-four rollers turning on their axles press on a rotating grinding table mounted on the yoke of a gearbox. Pressure is exerted hydraulically. This mill also has a built-in high-efficiency separator above the rollers. The vertical roller mills offer high drying capacity, comparatively low energy consumption, and compactness.

Hybrid Grinding: a combination of Ball Mill with Roller press

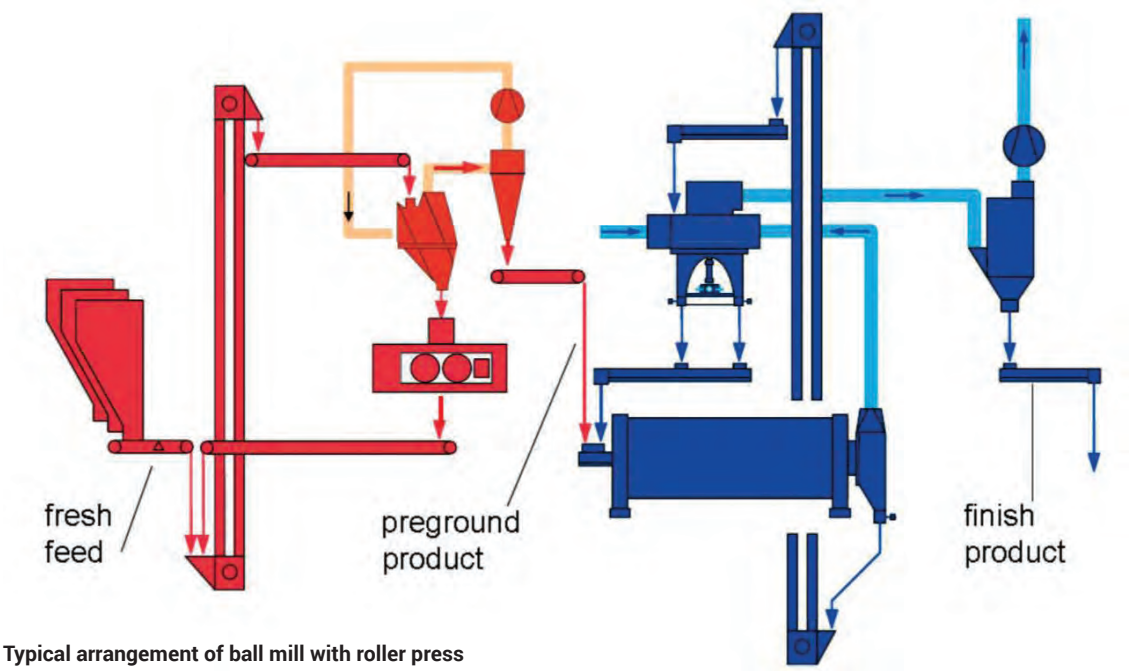
Horo Mill (HM): it is similar to the vertical mill but the roller arrangement differs from VRM.

In the ball mill, RP and Combined grinding system separation take place outside the grinding mill, whereas in the VRM separation and grinding take place in one system.

The technologies involved in cement can be classified as per the following:

Intergrinding: With the intergrinding process, all components of the blended cement are ground together. In that way, the cement is homogenised during the grinding, and at the cement plant only one silo is needed. Because of interactions between the different cement components due to differences in grindability, the PSD of the blended cement and the different components is difficult to control due to differential grindability due to different hardness of materials. Equipment for the inter grindings are Ball mills, roll press/ Pre-grinder + Ball mill, Horo mill, and VRMs.

Separate grinding: The separate grinding process is grinding the various components separately, storing them, and mixing them according to the desired proportions. This process has several advantages: the PSD of each component and of the blended cement can be controlled according to the components' hardness and required fineness, and appropriate grinding equipment can be used for each component. But in this case, several silos for storage are needed at the cement plant. Equipment for separate grinding



Typical arrangement of ball mill with roller press

is all the grinding equipment mentioned above, with the use of blenders required to blend the grounded material in the proportion needed for the specific cement product.

The advantage of separate grinding can be to produce a wide range of cements from one plant.

Grinding systems are either 'open circuit' or 'closed circuit.' In an open circuit system, the feed rate of the incoming clinker is adjusted to achieve the desired fineness of the product. In a closed circuit system, coarse particles are separated from the finer product and returned for further grinding.

What are the key functionalities that are looked at while installing a grinding unit in your plant?

The key factors, which shall be carefully considered, include:

- Product quality requirement: market requirement
- Machine sizing and layout: investment cost
- Raw materials quality and characteristics: input materials
- Mechanical design: maintenance cost and reliability
- Latest design innovations including high grinding efficiency, energy saving and environmental protection, good quality of finished products, etc., performance improvement
- On-demand changes: project-specific requirement
- Product diversification: commercial reasons
- Capex vs Opex economics: budget
- Spare part and service availability: after-sales service

What is the contribution of grinding units in making cement-making processes efficient and productive?

The grinding unit plays an important role in making the operation efficient. Approximately 60 per cent of the cement power is absorbed in the grinding circuit, and to be competitive in the market, power cost plays an important role.

It is also observed that particle size distribution is better in the BM compared to other mills considering the product quality requirement.

The following grinding units are involved in cement making process:

- Raw material grinding: to improve raw meal burning behavior, clinker quality, and kiln output, including thermal energy requirement
- Coal grinding: better combustion of fuels, improves the flame property, and avoids CO2 generation, including improved burning process
- Cement grinding: cement hydration, strength development, and water demand

How do grinding units contribute to the profitability of the cement-making process?

The grinding unit contributes to profitability in the following ways:

The electrical energy price is a major contributor to the cost of production. Therefore, producing cement with less energy is becoming a key element of profitability: as the grinding process consumes about 60 per cent of the total plant electrical energy demand and about 20 per cent of cement production

variable cost. So efficient grinding unit selection impacts profitability of cement manufacturing. Optimum fineness needs to be found to avoid over grinding and consuming excess energy

Final product PSD (particle size distribution) improves quality and profitability. Where two types of cement have identical surface areas, the cement with the narrower PSD will have a higher compressive strength.

Maximum use of low-cost blending materials, technology and layout such that the repairs and maintenance and manpower costs are lower, etc.

> This capex vs opex economy is also to be considered at the time of deciding which grinding mill is to be installed.

What are the materials and equipment that aid in the process of cement grinding?

Grinding Aid (GA): In the grinding process, agglomeration takes place, due to this grinding efficiency is reduced and the output and quality of product effects. The GA is a very efficient way to avoid the agglomeration mechanism and improve the over-grinding efficiency. Therefore, GA helps to increase the grinding mill output and reduces the electrical energy consumption, resulting in improving profitability.

Performance Enhancers/Quality Improvers: Due to the quality of raw materials and variation in the burning process, desired clinker phase formation does not take place, which impacts the cement performance, workability, and durability. Therefore, in addition to a grinding aid, additional chemicals are used to improve the cement performance and properties, such as setting time and strength development

Functional Additives: The additive imparts a specific property, such as air entrainment in masonry cement or chromium (VI) reduction.

Supplementary Cementitious Materials (SCM): Supplementary Cementitious Materials (SCMs) are added to cement mixtures for various reasons, including improving durability, decreasing permeability, aiding in pumpability, mitigating alkali reactivity, and improving the overall hardened properties of concrete. This also helps to reduce the carbon dioxide footprint in cement manufacturing. The use of SCMs also reduces the dependency on natural resources and enhances the circular economy.

Equipment: Raw materials storage, dosing station, raw material transport conveyors/elevators, weigh feeders, air separators, baghouse, product transport and storage silos are the key equipment of the grinding units.

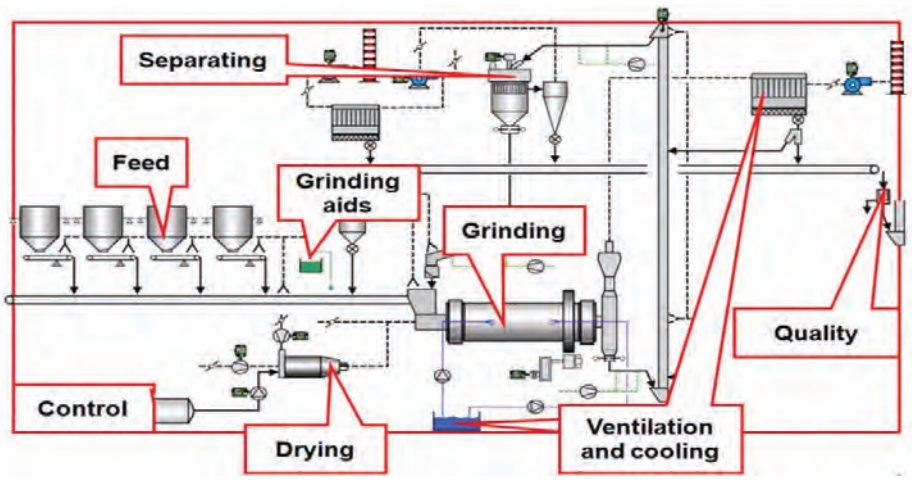
Air Separator is one of the vital equipment for grinding systems that plays a significant role in maintaining product quality and increasing the grinding system productivity.

QC Lab: It's a must for sampling and testing so that consistent quality material is produced and supplied to customers.

How do you ensure standards in the process?

During manufacturing, quality control parameters are established with reference to the national standards, and accordingly, the sampling and testing plan of the company is maintained. There are very well descriptive quality control and assurance plans at various stages of the manufacturing/operations.

At each of our plants, we have state-of-the-art laboratories to produce quality cement much above the spec from the BIS. We have a very low standard deviation in the finished product that indicates the consistency in the cement. We are certified with



Typical arrangement of close circuit ball mill with dryer.

Supplementary Cementitious Materials (SCMs) are added to cement mixtures for various reasons, including improving durability, decreasing permeability, aiding in pumpability, mitigating alkali reactivity, and improving the overall hardened properties of concrete.

applicable ISO standards to ensure that the product supplied is safe, environmentally compliant, and quality consistent.

How often is the same monitored?

Cement manufacturing is a continuous process and monitoring is done in 24x7 mode to ensure cement quality.

The quality control starts from the mine to the cement packing, and there are well-defined testing protocols at a sampling frequency. Plants are equipped with various material feeding and transportation systems to maintain the quality and process.

What challenges do you face in the process of cement grinding?

Availability and economics of outsourced materials are major challenges these days. The key challenges are as follows:

- Availability of reliable and economical energy sources, power generation is becoming expensive due to increasing fuel prices and quality of fuel.
- Right quality and Quantity of SCMs (Supplementary Cementitious Materials) are needed to achieve cement quality and also to mitigate the challenges of CO_2 reduction in the cement-making process
- Production of multiple cement types needs more storage facilities and impacts mill performance and product quality
- SCMs with high moisture content demand drying arrangements resulting in a need for more capital as well as operational expenses.
- Skilled manpower for operation and maintenance.

What are the innovations you would like to see in the technology of the grinding process and grinding aids?

Innovations play an important role in the cement industry. The quality of the product can be enhanced by adopting the right technology and the optimum key performance indicators for producing a quality product at a competitive price. We would like to see further innovation for:

- Energy efficient equipment and drives to lower the power consumption
- Separate grinding of cement to improve product quality and lower power consumption to reduce CO_2 emission.
- New hybrid formulations in grinding aid to improve product quality, specific energy consumption and reduce clinker ratio in cement.
- Innovation for cement production by substituting max possible clinker incorporation by alternative / lower quality cementitious materials but maintaining the product quality.
- New wear materials for enhancing the life of wear components to reduce the consumables cost per ton.

- Kanika Mathur