Technological Trends in Cement Industry - Energy and Environmental impact

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About the author:

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Introduction

Indian cement industry has come a long way in technological upgradation, production and quality. India today, is the second largest cement producing country in the world with an installed capacity of 119 million metric tons per annum. The cement industry in India has a distinction of operating very large to very small capacity and very modern to very old technology plants. Some of the modern plants can be compared to the best plants in the world in terms of quality, variety of cements produced and energy efficiency. Indian cement industry has been very proactive in adopting various technological advancements taking place all over the world. This was particularly triggered by the partial decontrol of cement industry in 1982 followed by full decontrol in 1989 giving the resultant free market competition an opportunity for growth in production and productivity.

The share of energy inefficient wet process plants had slowly decreased from 94.4% in 1960 to 61.6% in 1980. Thereafter as a result of quantum jump in production capacities through installation of modern dry process plants as well as conversion of some of the wet process plants, the share of wet process has reduced to less than 5% today.

During the last two decades (80's and 90's), major technological advancements took place in design of cement plant equipment/systems basically in the following major areas

a) pre-calcination
b) high pressure grinding
c) automation in process control
d) high efficiency particle separation
e) clinker cooling

These resulted in sea change developments globally and the Indian cement industry followed the international trend. The special features noticeable were:

(i) standard size of the new plants neared a million tonnes per annum
(ii) large areas of limestone even in remote areas exploited by cluster of plants
(iii) active search made for the latest type of technology and equipment to continually bring down the energy costs
(iv) large number of old wet process plants closed down or converted into dry process on account of high cost of operation
(v) introduction of multiple grades of cement on strength parameters surpassing the Bureau of Indian Standards (BIS) specifications
(vi) many plants taking to automation, computer controlled systems and man power reduction
(vii) Improvement in packaging with the use of HDPE/PP/paper bags in place of conventional jute bags
(viii) shift in the marketing strategy with specific emphasis on quality associated with brand The industry never looked back. The financial investments were justified on energy conservation, quality enhancement and environmental consideration.

Energy Conservation

A typical modern cement plant has heat consumption of 680-720 kcal/kg clinker and power consumption of 70 - 85 Kwh/tonne of (OPC-43) cement.

A few recent technologies that helped Indian cement industry to consolidate in sustained energy savings are broadly discussed below.

Raw Material Grinding

Raw material grinding is a critical mechanical operation predominantly determining the sizing of equipment in a cement plant. Raw grinding process consumes about 20% of the total energy consumed in the plant. Various grinding systems used in Indian cement industry for raw material grinding are:

a) Ball mills
b) Vertical Roller Mills (VRM)
c) Ball mills with high pressure grinding rolls.
d) High pressure grinding rolls
e) Horizontal roller mills

Selection of type of grinding mill depends on the raw material's several physical characteristics most important amongst which are hardness of the material and moisture content. Availability of the major grinding equipment in appropriate capacity decides complexity or otherwise of layout, auxiliary equipment sizing etc. which ultimately decide plant's pyro-processing capacity.

Vertical roller mills have been widely accepted for combined grinding and drying of moist raw materials in view of their excellent drying capacity and low energy consumption. Although the principle of the vertical roller mill did not change over the years, many improvements have been made in design of mill and other equipment in the grinding circuit resulting in less energy consumption and improved reliability. Introduction of external re-circulation of material, adjustable louvre ring and modification of mill body to improve the air and material trajectories are examples of such design changes.

While a number of plants are still using ball mills, many have installed pre-grinders like roller press to improve energy efficiency. Here, the extent to which the roller press is loaded determines the efficiency of the grinding circuit. Use of roller press alone as a finish grinding equipment to give the final product is also a new development.

Horizontal roller mill is yet another improvement in grinding systems incorporating the advantages of vertical roller mill and roller press. An additional advantage with the horizontal roller mill is its low space requirement due its compact size. A compact horizontal roller mill with an in-built separator is now in the process of development. This kind of a mill would eliminate many small conveyors carrying material to separator and from separator.

The efficiency of the grinding circuit and power consumption of the mill fan greatly depend on the performance of the classifier. Perhaps classifier is the part that has undergone maximum changes and has been the target part for efficiency improvement. A variety of high efficiency classifiers are employed in grinding circuits.

Apart from the main equipment viz., mill, classifier and fan the efforts have been on improving the performance of internals e.g. table liners in case of vertical roller mills and classifying liners in case of ball mills. Use of mechanical conveying systems like bucket elevators is becoming more common in place of pneumatic conveying giving substantial savings in energy.

Pyro-processing

Pyro-processing section in a cement plant comprises preheater, rotary kiln and clinker cooler. Pyro-processing section is considered to be the heart of a cement plant as actual cement clinker formation takes place in kiln. The size of a cement plant is determined based on pyro-processing section and the sizes of all other equipment are determined to match pyro-processing. The shape of cement plants changed with the advent of preheater in 70's. With the introduction of pre-calciners in 80's, the size of cement plant had considerably increased. A 600 tpd considered to be economic size of kiln earlier went up to 3300 tpd in 80's and further to 7000 tpd currently. A variety of preheaters with different designs of precalciners have come into existence.

Preheaters can be classified into the following 5 categories irrespective of the manufacturer.

a) preheater without calciner
b) inline calciner with air passing through the kiln
c) inline calciner with external tertiary air duct
d) separate line calciner
e) separate line calciner with inline calciner

With the above five modes of operation, different equipment manufacturers came out with different designs normally designated in the manufacturing company's name. Cyclones are basic units in a preheater system. Pressure drop and change of temperature of gas across each stage determines the efficiency of cyclones. Introduction of Low Pressure drop (LP) cyclones has brought the pressure drop across each stage to around 50 mm WG from around 150 mm WG in conventional cyclones. This has resulted in more and more plants adopting 5 or 6 stages of preheater. A typical 6 stage preheater with LP cyclones will have a preheater exhaust gas temperature of around 2500C and draught of around 500 mm WG. This in turn lead to decrease in preheater fan power consumption. The reduced temperatures at preheater exhaust contribute to environmental improvement.

The burners also play an important role in determining the thermal efficiency of the pyro processing system. There has been a continuous effort on operating the burners with the least possible primary air. The advent of multi-channel burners taking only 5% primary air are being installed in many plants giving a direct thermal energy saving of 15 kcal/kg clinker. Apart from saving thermal energy, the modern burners also enable easy flame control.

Clinker cooler is a critical equipment and the size of clinker cooler some times becomes a bottle-neck for increasing production from rotary kiln. The function of a clinker cooler in a cement plant is dual i.e. reducing the temperature of the clinker to a level that is acceptable for further transport and grinding and recover energy from the sensible heat of the hot clinker by heating the cooling air. Thus thermal efficiency of clinker cooler is very important in deciding about the type of cooler. Mainly two types of clinker coolers are used at present in cement industry. They are

a) Grate cooler
b) Planetary cooler

In majority of the existing plants, conventional grate coolers are used. These coolers have lower recuperation efficiency, occupy more space and need more cooling air. Inspite of these draw backs, grate coolers are more widely used than planetary coolers primarily due to comparatively higher thermal efficiency. There have been a number of design improvements in grate coolers in recent times, mainly on grate plate to improve the efficiencies simultaneously reducing the cooling air intake. The specific load of clinker on grate plate can be as high as 50 tpd/m2. These modern coolers are compact in size. High efficiency coolers operate on the principle of Horizontal aeration. More and more cement plants with conventional grate coolers are retrofitting the coolers with high efficiency coolers.

By installing high efficiency coolers, it is possible to reduce the cooling air to about 1.8 Nm3/kg clinker from conventional value of more than 3 Nm3/kg clinker. This has resulted in low electrical energy consumption in cooling air fans and also in cooler ID fan. Thus high efficiency coolers give rise to both thermal and electrical energy conservation.

The inlet and outlet seals of kiln are important, as they help to reduce the air infiltration into the system. With the improved kiln seals available today, not only heat loss is reduced but also the environment around kiln has become almost dust free. A pneumatic seal for kiln inlet and spring loaded mechanical seal for kiln outlet are considered to be very effective in modern kilns.

Cement Grinding

Cement grinding is another energy intensive operation in cement manufacture Cement grinding consumes around 25-30% of the total energy consumed in a cement plant. Typical cement grinding systems in use are

a) open circuit mills
b) closed circuit mills
c) roller press with open circuit ball mill
d) roller press with closed circuit ball mill.
e) roller press in finished mode
f) vertical roller mill
g) horizontal roller mill

Ball mills have traditionally been in use for many years in open circuit and closed circuit mode. In recent past, roll press as pre grinders have been introduced. This has given a substantial benefit in energy consumption. Use of vertical roller mill for cement grinding is very recent and the performance results are reported to be encouraging. A typical modern cement grinding circuit will have a roll press as pre grinder with ball mill. Horizontal roller mills combine the advantages of roll press and vertical roller mill. These mills are reported to be highly energy efficient. Horizontal roller mills are best suited for slag grinding.

Separator is crucial equipment in cement mill section as it has direct bearing on production and quality of cement and energy consumption. High efficiency separators are used in modern cement plants and old plants are also going for a retrofit.

Auxiliary items like mill liners and diaphragms have been improved continuously and these items in different designs are available contributing to energy reduction in cement grinding.

Quality Consideration

In an environment of growing competition witnessed in the post decontrol era, one of the major development has been in the introduction of higher grades of cement. 43 Grade and 53 Grades of normal portland cement have now conquered the market. The 3 day, 7 day, 28 day strength parameters obtained are far higher than the BIS' specified standards for these grades of cement. In fact ISI marking has now become redundant from consumers' point of view. 33 Grade cement has, however, been a casualty. It has been driven out of market by the easy availability of higher grades. The war of grades and competition among brands have also affected considerably the market for pozzolana and slag cements, which, in fact have some special attributes far superior to even higher grades of normal portland cement.

Today it is the publicity on strength properties that make the higher grades sell. However, realisation is growing fast amongst the consumers at large, that the properties of durability are of greater importance than the 3 day, 7 day, 28 day strengths. Moreover, strengths specified serve only the limited purpose of design and use of form and shuttering work with no realistic contribution on long term strength and durability of construction. In fact, by research and practice, it has been found that high early strength cements need not necessarily perform well in durability characteristics. On the contrary, the high-grade cements based on strengths achieved with higher C_3S contents are more likely to yield poor quality and less durable concrete than the normal 33 grade portland cements.

Therefore concrete manufacturers and users would in the near future ask for performance standards of cement in preference to the product specifications. Sooner, the cement manufacturers stop this race on higher-grade cements and attend the more important requirement of developing "durable" cement, it would take them to better price realisations in future.

Environmental and ecological consideration

Almost all cement plants now a days are equipped with high efficiency dust collection systems like Electro Static Precipitators. It has been realised that house keeping, running the plant in environmentally friendly way has direct bearing on the profitability and image of the company. It also improves the employee morale.

A very important development in cement technology is in the field of rational utilization of cement. Most of the developments related to the rational utilization of cement directly or indirectly have positive impact on environment and contribute considerably for maintaining ecological balance. Use of blended cement, utilization of waste heat in cement plant to generate electrical energy and use of alternate fuels are a few examples explaining the concern of cement industry not only towards protection of environment but also ecological balancing.

Waste Heat Recovery

There have been many attempts to recover the heat lost in exhaust gas streams of cement plants. With the use of 6 stage preheaters, high efficiency coolers and better refractory management practices, the quantity of heat lost from the cement plants has come down significantly. Traditional methods of recovering heat from exhaust streams, which have not been very efficient, have also undergone changes and efforts are directed towards increasing the efficiencies. Now technologies are available to recover the heat from exhaust gas streams from preheater and clinker cooler and generate electrical energy. More cement plants in India are expected to adopt such waste heat recovery systems mainly to counteract the power shortage. As the electrical power generated from waste heat does not require combustion of any fossil fuel, such an attempt would enable the cement plant to significantly contribute to the movement of reduction in green house gases.

Blended cement

The blended cements are hydraulic binders in which a part of portland cement is replaced by other hydraulic or non-hydraulic materials. Their general behaviour is quite similar to that of normal portland cements, but in addition they display some superior properties directly related to durability. It has been found that fly ash generated in thermal power plants and slag generated in steel plants are suitable for manufacture of blended cements. Fly ash or slag are inter-ground with cement clinker to produce blended cement. Many developed countries started using such blended cements in large quantities in construction of critical structures such as rocket launch pads, sea water jetties, huge dams etc. Production of blended cements directly increases the plant capacity without any need for creating additional clinker making capacity. This reduces the limestone usage and fuel usage in cement plants. To the extent of reduces limestone and fuel consumption, the green house gases are eliminated. In addition to conservation of limestone, fuel and reduction of green house gases, a few other advantages of using blended cements include:

a) low heat of hydration with consequent reduction in thermal cracking
b) superior performance under elevated temperature curing conditions
c) good long term strength
d) control of alkali - silica reaction
e) resistance to acids and sulphates
f) reduced permeability with consequent improvement in durability characteristics and
g) reduced chlorine diffusivity.

Apart from the proven benefits in quality, manufacture of blended cement is also a cost saving measure, since nearly 70% of electrical energy is consumed in the production of clinker. Therefore, to the extent clinker is replaced by additives like fly ash, slag etc in the production of blended cements, is the resultant saving on power consumption, though not in direct proportion. When grinding to higher fineness, the blended cements would require higher power consumption than that required for normal portland cements. The saving would still be substantial.

In India, blended cements were introduced primarily to get large volume advantage in cement production without drawing too heavily on clinkering capacity. But until recently, application of blended cements has not got the importance to the extent it deserves due to various reasons. With an availability of over 70 million tonnes of fly ash from the thermal plants and over 10 million tonnes of slag from the steel plants, large potential exists in India for manufacturing blended cements.

It is understood from experience that all applications do not need only very high grade cement. For rural applications and plastering works cements like masonry cement are being considered. Clinker needed for such cements can be manufactured from low grade limestone. This not only conserves precious high grade limestone deposits but also reduces the carbon di oxide generated per ton of clinker produced.

In India, there area large deposits of limestone which have not been utilized due to their low quality of limestone. Research work within and outside India proved that reactive belite cement can be manufactured with low grade limestone. The alite content in such cement would be lower, but belite content would be higher and more reactive than in normal portland cemnts, which would give them matching early and long term strength properties.

Both utilization of low grade limestone and production of blended cement contribute greatly to increase profitability coupled with conservation of limestone deposits and reducing green house gases in environment and energy consumption.

Use of alternate fuels

With increase in scarcity of good quality coal and power at an attractive price, the Indian cement industry is committed to reduce the energy consumption levels and the trend of energy levels shows a continuous reduction. Inspite of this favorable trend of energy consumption, the percentage of energy cost as total production cost is increasing year after year. This is attributed mainly to the raising prices of coal and power. With this background, in line with developed countries, Indian cement plants also started looking at use of cheap alternate fuels like lignite, pet coke, rice husk, groundnut shells etc. In some European cement plants, the cost of fuel is reported to be zero. This is because, cement kilns use 100% waste fuels operating some times as incinerators. In fact, the cement plants are paid for burning the municipal and industrial wastes in such places. Indian cement industry also should aim ultimately to reach such a position of achieving zero cost of fuel. However, this requires development of infrastructure at cement plant site as well as waste generation and collection sites.

The technological advancements in design of cement manufacturing equipment and modern operating principles primarily aimed at productivity improvement and reduced energy consumption. Reduction in thermal energy consumption reduces directly the amount of coal fired in the plant. To that extent, the carbon di oxide content from exhaust gas reduces. Installation of very efficient dust collection systems like ESPs and elimination of transfer points in material conveying circuits and adoption of modern maintenance practices have helped cement plants to maintain a very clean environment in and around the plant site.

Reference:

http://www.greenbusinesscentre.com/casestudy.asp