

Energy Efficiency Opportunities In Cement Industry

-An Overview

Introduction

Cement sector is one of the energy intensive and one of the fastest growing industries in India. Indian cement industry is the second largest consumer of energy in the country and sixth largest producer in the world. The per capita consumption of cement in India (around 100kg) is still among the lowest in the world. The world per capita consumption is around 260 kg. However it is estimated that the per capita consumption of cement is expected to rise to 120 kg in another 5-6 years thereby indicating tremendous potential for growth in this sector.

The table I depicts the status of large and mini cement plants in India as on 31 March 2002.

Table- I				
Size of Cement Plants	Number of Plants	Installed Capacity, million tonnes		
Large	124	135		
Mini	365	11		
Total	489	146		

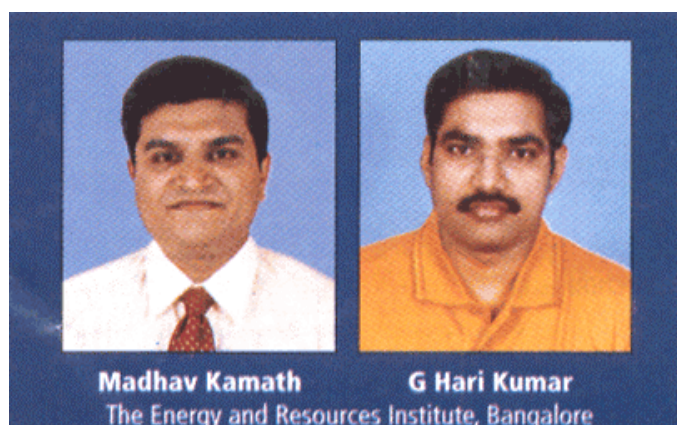
Source: TEEDY handbook 2002/2003

The Indian cement industry is a mix of mini and large capacity cement plants, ranging in unit capacity per kiln as low as 10 TPD to as high as 7500 TPD.

Energy (both thermal and electrical) costs accounts for nearly 40% of the total cost of production and will continue to increase in near future due to increased energy prices. Thermal energy is generally obtained from primary sources of energy such as coal, fuel oil, etc, and electrical energy is obtained from grid or from captive power plant within the unit.

As regards the energy consumption, the specific electrical energy consumption for the modern plants is around 6590 kWh/MT of the production while for the older plants the figure seems to be higher to the tune of 95-120 kWh/MT. The specific thermal energy consumption for modern plants is as low as 690 kCal/ kg of clinker, while the older plants it is as high as 900 kCal/ kg of clinker. The wide variation for the specific energy figures from modern to the older plants is mainly due to the adaptation of new process/ technology developments. The newer generation plants that have been set up in India have energy consumption norms comparable with the best and most energy-efficient plants in the world.

Considering the above scenario in Indian cement plants, there appears to be significant scope for energy efficiency to reduce the specific energy consumptive figures (both electrical and thermal). This will further result in reduction in carbon emissions from the atmosphere. The opportunities are on the higher side particularly for the older installations.



Types of Processes adopted for Cement Production in India

The cement plant processes in India generally falls in to three major categories, namely:

- Dry process
- Wet process and
- Semi-dry process.

Out of the above, 93% of the total kiln capacity comprised of dry process, 5% wet process and 2% semi-dry process.

Wet Process

In this process, grounded raw meal is mixed with water to form slurry, which normally contains 30 to 40% of water. The slurry formed is easy to blend and homogenize and is directly fed into a long kiln. The main advantage of this process is that relatively poor grade limestone having moisture content of more than 12% can be effectively utilized and enriched through the process of beneficiation requiring use of water as a process medium. The process, however, consumes more thermal energy, which falls in the range of 1300 to 1600 kcal/kg clinker.

Semi-wet/ Semi-dry Process

This process was evolved to counter the high fuel consumption of the wet process. In the semi-dry process, raw meal grinding is done in dry state and the powdered material is converted into nodules by adding controlled quantity of water. In the semi-wet process, on the other hand, slurry of ground raw meal is prepared first (as in wet process) and it is de-watered in a filter press to form filter cake. These nodules or the cake, thus formed, are fed on to a moving grate for partial calcination. This partially calcined raw mix in the form of nodules/cake is further charged into a rotary kiln for complete calcining and sintering to form clinker. The fuel consumption by this process improves to about 900 to 1100 kcal/kg of clinker but it poses a number of operational and capacity problems.

Dry Process

In the dry process, the raw materials are normally dried using kiln and cooler exhaust gases (which may be supplemented by auxiliary hot furnaces, if required) in a grinding plant to reduce the moisture content below 1%. The ground raw mix is blended and homogenized in large silos and charged to the first stage cyclone of the normal 4-stage suspension pre-heater. Partial calcination of the raw mix takes place as it moves through various stages of preheater (due to heat transfer with hot kiln gases) before it enters into the kiln. This process gives the maximum benefit in fuel consumption, which is typically in the range of 850 to 900 kcal/kg clinker for Indian plants. Further modifications and refinements like pre-calcining make it possible to reduce this value to 700 to 800 kcal/kg clinker.

The Table II gives the specific energy consumption figures for the types of processes involved.

Category	Specific Energy Consumption, kWh/MT				Specific Thermal	
	Up to Clinkerisation		Up to Cement Packing		Energy Consumption kCal/kg	
	Range	Average	Range	Average	Range	Average
Dry Plants	59-95	80	86-125	110	720-930	805
Semi Dry/ Semi Wet Plants	74-102	87	106-143	118	810-990	880
Wet Plants	60-121	80	99-180	122	1280-1827	1480
Source: Specific Energy Consumption norms in Indian Cement Industry by Confederation of Indian Industry						

From the above it is evident that dry plants have specific energy consumptive figures on the lower side when compared to other plants.

Major Energy Consuming Equipments in a Cement Plant

The energy consumption in a cement plant is distributed over many sections. The section in which electrical and thermal energy is used as tabulated in Table III. The table also provides the norms for setting up a new cement plant.

From the above it can be seen that reclaimer, grinding and transport, Kiln feed, kiln and cooler and cement grinding and transport constitute to around 80-85% of the electrical energy consumption. As a first priority, the focus should be given in these areas to identify the possible opportunities for energy efficiency improvements.

Table III			
Electrical energy		Thermal Energy	
Energy consuming areas	Norms kWh/MT	Energy consuming areas	Norms, kCal/kg of clinker
Mines, crusher and stacking	1.5	Kiln	715
Reclaimer, grinding and transport	18.0		
Kiln feed, kiln and cooler	22.0		
Coal mill	5.0		
Cement grinding and transport	23.0		
Packing plant	1.5		
Lighting, Pumps, and Services	4.0		
Total	75.0		715
Norms are for OPC 43 grade cement, Source: Unido website			

Mines, Crusher and Stacking

Crusher is the first equipment in the cement manufacturing process. In many old cement plants (mostly with ball mills) two stage crushing is done. In this case the specific energy consumption is to the tune of 2.5 kWh/MT of product. However where single stage crushing is involved (VRM's or roll press-ball mill combination), the specific energy consumption is 1.5 kWh/MT of product. Major part of the energy is consumed for the crusher main drive. In view of the above, efforts should be taken to reduce idle running of the crusher.

Reclaimer, Grinding and Transport

Raw mill is a major energy consumer and should be designed based on the grindability and moisture of the limestone available. The vertical roller mill has 30-35% lesser power consumption than the conventional ball mill system.

In this section (where VRMs are installed) the major energy consumption is by the main drive which constitutes around 40-45% of the energy in this section followed by the vent and the ESP fans. The fans should be high efficiency fans equipped with backward curved and VSD controls wherever necessary. As regards energy conservation approach, TERIs experience indicates substantial potential exists in the centrifugal fan system. Opportunities can be like replacing the existing with a high efficiency fan or speed reduction to avoid throttling of dampers or incorporation of VSDs etc.

Kiln Feed, Kiln and Cooler

Kiln is the heart of the cement plant, as the critical step of "clinkerisation" takes place here. The kiln is the major consumer of thermal energy and also one of the major electrical energy consumers in the cement plant. So any inefficiency in the kiln section will reflect directly on the whole plant irrespective of the inefficiencies of the other parts of the plant. Hence the kiln section needs to be systematically and seriously concentrated upon to achieve maximum energy efficiency.

In electrical consuming areas, preheater fans, ESP fan, kiln cooler fans together consume around 60-65% of the total energy in this section. In Kiln system both feed and coal conveying is through pneumatic conveying systems. These systems consume around 1 kWh/MT of product. Installing a mechanical conveying system reduces the specific energy consumption by about 70-75%.

Coal Mill

Coal mill is also a major energy consumer with majority of the energy is consumed by air swept ball mills. The VRM has been installed in some of the modern plants with at least 30-35% lower specific energy consumption, in comparison to the conventional ball mill system.

Cement Grinding and Transport

Cement mill is the last and the critical step of cement manufacturing. Majority of cement mills in India are open circuit ball mills. In some of the plants, closed circuit has been done, to increase the capacity and reduce the specific energy consumption. In some installations recently VRM has also been installed for grinding of cement. In some plants the specific energy consumption value of 23-24 kWh/MT of OPC-43 has been attained.

The closed circuit ball mills with roll press consume around 10-15% lower specific energy consumption values over conventional ball mills.

Packing Plant

The packing plant in a cement plant is small consumer of energy. The specific energy consumption value for a packing plant is around 1.5 kWh/MT of product. However some plants in India also operate at specific energy values closer to 1.0 kWh/MT of product.

Lighting, Pumps and Services

Lighting, Pumps and other services like roots blowers, compressors consume significant amount of energy. The norms of specific energy consumption for such utilities are 4.0 kWh/MT of product.

Technological Improvements for Energy Conservation

Specific energy consumption levels largely depend upon the types of technology in use in a particular plant. Adoption of appropriate technology and energy efficient equipment would contribute to substantial energy savings. Some of the major energy efficient equipment and technological improvements for various applications in cement plant are given below:

Limestone Crushing

- Use of gyratory crusher instead of jaw crusher.
- Introduction of single stage compound crusher.
- Use of horizontal impact as a pre grinding device to ball mills.

Raw Meal Grinding

- Use of vertical roller mills replacing over conventional closed circuit ball mills.
- Up gradation of technology in existing vertical roller mills.
- Use of high pressure rolls for dry and hard raw materials.
- Use of high efficiency separator to segregate fine and coarse particles of output from finish mill.

Pyroprocessing

- Conversion of wet process to dry process.
- Use of precalinator in existing SP kiln.
- Adoption of 5/6-stage preheater system and low pressure cyclones.

Coal Grinding

- Use of vertical roller mills and ring mills instead of ball mills.
- Use of dynamic classifiers.

Cement Grinding

- Use of high pressure rolls as pre-grinders
- Use of high efficiency air separator like SEPAX, etc.

Energy Efficiency Opportunities in Individual Sections in a Cement Plant

The possible energy efficiency improvement options in individual sections of a cement plant are given in the Table IV.

Table IV	
Section/ Department	Possible Energy Conservation Measures
Mines, Crusher and Stacking	<ul style="list-style-type: none"> ➤ Increasing utilization of crusher ➤ Use of soft starters for motors ➤ Compressed air optimization by incorporating on/off controls. ➤ Interlocking of crusher auxiliaries such as bag filter fans, belt conveyors with main drive to reduce idle running.
Reclaimer, Grinding and Transport	<ul style="list-style-type: none"> ➤ Installation of high efficiency mill internals. ➤ Installation of high efficiency fans. ➤ Incorporation of VSDs, change in pulley sizes ➤ Operation of mill in closed loop which results in enhanced output. ➤ Installation of high efficiency separators which results in enhanced output with subsequent reduction in specific energy consumption. ➤ Replacing conventional ball mills with new technology vertical roller mills-results in reduction in energy consumption to the extent of 30-35%.
Kiln Feed., Kiln and Cooler	<ul style="list-style-type: none"> ➤ Optimizing kiln firing coal conveying air. ➤ Installing bucket elevator in place of airlift for kiln feed ➤ Introduction of water spray to reduce fan power consumption. ➤ Installing low pressure drop cyclone ➤ Installing high efficiency fans ➤ Installing Variable Speed Drives for fans ➤ Utilize cooler vent air as primary air ➤ Improving insulation in the preheaters ➤ Installation of high efficiency coolers
Coal Mill	<ul style="list-style-type: none"> ➤ Optimization of capacity of coal mill fans ➤ Increased capacity utilization of coal mills
Cement Grinding and Transport	<ul style="list-style-type: none"> ➤ Installation of high efficiency mill internals ➤ Installation of pre-grinding system ➤ Closed circuiting of cement mills ➤ Optimization of conveying system. ➤ Installation of high efficiency fans ➤ Incorporation of variable speed drives for fans. ➤ Change in pulley sizes for speed reduction in fans
Packing Plant	<ul style="list-style-type: none"> ➤ Optimization of compressed air requirement for bag filter fan ➤ Installation of high efficiency fans ➤ Incorporation of VSDs for fans ➤ Change in pulley sizes for fans
Lighting System	<ul style="list-style-type: none"> ➤ Use of lighting voltage controllers ➤ Use of electronic chokes in place of conventional chokes ➤ Use of 36W slim tube ➤ Retrofitting of some lamps based on application ➤ Use of timer controllers
Pumps	<ul style="list-style-type: none"> ➤ Use of appropriate size pumps

	<ul style="list-style-type: none"> ➤ Replacing low efficient pumps with high efficiency pumps ➤ Optimization of operation of number of pumps base on process requirement
Compressed Air System	<ul style="list-style-type: none"> ➤ Optimization of compressed air generation pressure ➤ Use of cold ambient inlet air ➤ Cleaning of fouled heat exchangers ➤ Changing of V-belts to synthetic flat belts ➤ Use of refrigerant driers in place of heat of compression driers ➤ Centralization of the compressed air network ➤ Decentralizing low pressure air network by suitable sizing of the compressor.

Impact on Environment by Implementing Energy Efficiency Measures

Like all industrial processes, cement manufacturing produces carbon emissions (CO₂). Very high temperatures are needed to burn raw material and give the clinker its unique properties. CO₂ is generated from three independent sources.

- De-carbonation of limestone in the kiln (about 525 kg CO₂ per tonne of clinker)
- Combustion of fuel in the kiln (about 355 kg CO₂ per tonne of cement) and
- Use of electricity (about 50 kg CO₂ per tonne of cement).

Here it may be noted that opportunities exist in reducing emissions from combustion of fuel in the kiln and use of electricity since emissions generated from de-carbonation of fuel is generated in the process. Technological changes in raw material mix, their constituents are essential to reduce the carbonaceous emissions generated in the process.

Cement industry has made tremendous strides in technological up gradation and assimilation of latest technology. At present ninety three per cent of the total capacity in the industry is based on modern and environment-friendly dry process technology and only seven percent of the capacity is based on old wet and semi-dry process technology. There is tremendous scope for waste heat recovery in cement plants and thereby reduction in emission level.

Conclusion

There exists ample opportunity to improve energy efficiency in cement industries. While some of them are able to implement and envisage the benefits by implementing energy efficiency measures. Some others are taking the steps at a later date resulting in long drawn benefits. The implementation of the improvement measures not only will result in reduction in specific energy consumption norms but also reduce the impact of environmental degradation.

Reference Book:

IEEMA Journal (Energy Conservation Week 14-21 Dec., 2004)
Energy Conservation Special Issue