2.0 TECHNOLOGICAL ADVANCEMENTS IN INDIAN CEMENT INDUSTRY

The Indian cement industry is the second largest producer in the world comprising of 130 large cement plants and 206 operating mini cement plants consisting 13 rotary kiln plants and 193 VSK plants. The installed capacity and production during the year 2006-07 are expected to be 180 mn.t and 162 mn.t respectively.

Modernization and technology up-gradation is a continuous process for any growing industry and is equally true for the cement industry. The Indian cement industry today is by and large comparable to the best in the world in respect of quality standards, fuel & power consumption, environmental norms, use of latest technology and capacity. The productivity parameters are now nearing the theoretical bests and alternate means, like alternate fuels and raw materials have to be found to ensure further improvement in productivity and reduce production costs.

Cement industry being energy intensive, the energy conservation and alternate cheaper, renewable and environmentally friendly sources of energy have assumed greater importance for improving productivity. The major challenges confronting the industry today are raging insecurity in indigenous fuel availability, perennial constraints like higher ash content, erratic variations in quality of indigenous coal and inconsistent power supply with unpredicted power cuts. Keeping these challenges in view, the efforts by the industry towards energy conservation and finding alternate cheaper, renewable and environmentally friendly sources of energy are given utmost importance.

Review of Technological Status

Process Profile

The Cement Industry today comprises mostly of Dry Suspension Preheater and Dry-Precalciner plants and a few old wet process and semi-dry process plants. Till late 70's the Cement Industry had a major share of production through the inefficient wet process technology. The scenario changed to more efficient large size dry process technology since early eighties. In the year 1950, there were, only 33 kilns out of which 32 were based on wet process and only one based on semi-dry process. Today, there are 162 kilns in operation out of which 128 are based on dry process, 26 on wet process and 8 on semi-dry process.

Changing Process Profile of Indian Cement Industry

Item	1950	1960	1970	1983	1995	2001	2006
Wet Process							
Number of Kilns	32	70	93	95	61	32	26
Capacity (TPD)	9151	25011	38441	39641	25746	13910	11420
% of Total	97.3	94.4	69.5	41.1	12	5	3
Dry Process							
Number of Kilns		1	18	50	97	117	128
Capacity (TPD)		300	11865	51265	188435	282486	375968
% of Total		1.1	21.5	53.2	86	93	96
Semi-Dry Process							

Item	1950	1960	1970	1983	1995	2001	2006
Number of Kilns	1	3	8	9	8	8	8
Capacity (TPD)	250	1200	5000	5500	5244	5260	4195
% of Total	2.7	4.5	9	5.7	2	2	1
Total Kilns	33	74	119	154	166	157	162
Capacity (TPD)	9401	26511	55306	96406	219425	310706	391583
Average Kiln Capacity (TPD)	285	358	465	626	1322	1921	2417

Kiln Capacity and Size

The economic unit capacity for cement plants in India till early sixties was about 300 TPD. In mid sixties this was standardized at around 600 TPD for both wet and dry process plants. About a decade later, i.e. from mid seventies, the new plants installed were of 1200 TPD capacity. The advent of precalciner technology in mid eighties provided an opportunity to the industry to modernize and increase the capacity of existing dry process plants, to convert plants from wet to dry process as well as to set up large capacity plants incorporating the latest technological advancements. This led to installation of single line kilns of 3000 TPD (1 MTPA) capacity and more. The present trend indicates the preference of still larger kilns of about 6000 TPD capacity and above. Already there are nine kilns of 8000 tpd capacity in operation and three kilns of capacity 10000 – 12000 TPD are under installation. The green-field plants being installed now are based on most advanced and the best available technology.

Plants with a total capacity of two million tonne and above at a single location, numbering 25, are having a total capacity of 65.6 MTPA accounting for 41% of installed capacity of large plants, whereas plants with a capacity between 1 to 2 million tonnes, numbering 48 are having a total capacity of 68.4 MTPA, accounting for 43% of installed capacity. Balance 57 plants are of capacity less than 1 MTPA, having a total capacity of 25.8 MTPA, accounting for 16% of total installed capacity of large cement plants.

Average annual installed capacity per plant in India is about 1.2 MTPA as against more than 2.1 MTPA in Japan. This is due to blend of small and large plants coming up at various stages and still operating in India as against smaller plants having been decommissioned in Japan.

Present Status of Technology

A comparison of the status of the modernization in equipment and also the technologies absorbed or implemented by the Indian cement industry alongwith status of Global Technology is as under :

Present Status of Technology

	Low Technology Plants	Modern Plants	Global Technology
Mining & Material Handling	Conventional	Computer aided	Computer aided
Crushing	Two stage	Single stage	In-pit crushing & conveying
Conveying of Limestone	Dumpers/Ropeway/ Tippers	Belt conveyors	Pipe conveyors, Belt conveyors

	Low Technology Plants	Modern Plants	Global Technology
Grinding	Ball Mills with / without conventional classifier	VRM's Roll Presses with dynamic classifier	VRM's, Roll Presses, Horo Mills with dynamic classifier
Pyro Processing	Wet Semi Dry Dry - 4 stage preheater - Conventional cooler - Single channel burner	Dry - 5/6 stage preheater - High Efficiency Cooler - Multi Channel Burner	Dry - 6 stage preheater - High Efficiency Cooler - Multi Channel Burner - Co-processing of WDF - Co-generation of power - Low NO_x/SO_2 emission technologies
Blending & Storage	Batch-Blending Silos	Continuous Blending silos	- Continuous Blending - Multi-Chamber Silos - Dome silos
Packing & Despatch	Bag	- Bag - Bulk	- Bulk - Palletizing & Shrink Wrapping
Process Control	Relay Logic / Hard Wired / PLC	- DDC - Fuzzy Logic expert system	- DDC - Neurofuzzy expert system
Plant Size, TPD	300-1800	3000-6000	6000-12000

The directions in which the modernization activities are proceeding are as illustrated below :

Mining

For rational exploitation of the raw material source, a systematic mine plan is developed by cement plants. Computer-aided techniques for raw material deposit assessment to arrive at proper extraction sequence of mining blocks, keeping in view the blending operational requirements, are envisaged and put to use in number of units.

Crushing

Mobile crushers have come in use in some of the newer plants, keeping in view the split location of limestone deposits and long conveying distances. The mobile crushing plant is stationed at the mine itself and raw material is crushed at the recovery site.

Grinding

Vertical Roller Mills (VRM) have given the real breakthrough in the area of grinding. The VRM draws 20-30 % less electrical energy as compared to the corresponding ball mill system, apart from its ability to give much higher drying capacity. These mills can accept larger feed size and hence mostly be used with single stage crushing. VRMs are now being used in clinker and slag grinding and also as pre-grinder to existing grinding installations.

Another breakthrough that has come with the application of high pressure grinding rolls (HPGR) has been widely adopted in Indian cement industry. The HPGR is being used as pre-grinder for upgrading the existing ball mill systems. Different modes of operating HPGR in open circuit, pretreatment with circulation, pretreatment with de-agglomeration and recirculation and closed circuit are in operation. Such installations could achieve an increase in capacity upto 200% and savings in power consumption to the extent of 30 to 40% as compared to ball mills.

High efficiency separators are now widely used for better classification of product and help in increasing the mill capacity besides reducing the specific power consumption. The new classifier designs include two stage separation integrating primary and secondary separation. High efficiency separators are also used now with VRM's for further improvement in their performance.

A new mill system called Horizontal roller mill has been developed which is capable of producing uniform raw meal and have advantages in processing raw materials containing higher percentage of quartz.

Pyro-processing

The introduction of precalciner technology has increased the production from the kiln by 2.0 to 2.5 times and enabled utilization of high ash coals with lower calorific value, as well as various agricultural and industrial combustible wastes. Systems have been developed to use fuels like lignite and petcoke and various alternate fuels.

The advantages of economy of scale are fully exploited by the cement industry through the precalciner technology. Many single kilns capable of producing more than 6000 tpd capacity have already been installed and are operating with state-of-the-art technology and kiln capacities in the range of 10000-12000 tpd are under installation.

Many cement plants have some excess capacity at both upstream and downstream, which could be utilized economically if the kiln output can be increased at modest costs. Traditionally, the kilns have been designed with specific volumetric loading of 1.5 to 2.2 tpd/m^3 for SP kilns and 3.0 to 4.0 tpd/m^3 for precalciner kilns. The corresponding thermal loads in burning zone for such kilns have remained between 3.5 to 4.5 x 10^6 Kcal/m^2/hr. Many cement plants have gradually increased the specific volumetric loading upto 7-7.5 tpd/m^3, ensuring much higher than originally designed output.

The introduction of high efficiency and low pressure-drop-cyclones have led to conversion of conventional 4-stage cyclone preheaters to 5-stage and even 6-stage cyclone preheaters with improved thermal efficiency.

The latest development like controlled flow grate clinker cooler system and cross bar cooler ensure better clinker distribution, increase in cooler heat recuperation efficiency, decrease in clinker exit temperature and reduced maintenance costs.

The limitations of the conventional straight pipe burner have been overcome by use of highly flexible multi-channel burner. The multi-channel burner enables easy and sensitive flame shape adjustments as well as gives rise to better entrainment of secondary air.

High Alumina refractory bricks which were mostly used in pre-heating / precalcining zone in the past, are now replaced by light weight high strength insulating bricks. The Aluminum-Zirconium-Silicate bricks with coating repellent properties are also in use now in transition zones. With the new improved refractory bricks it is possible to increase the refractory lining life and reduce the radiation losses in the kiln. Greater use of monolithic refractories in preheater, precalcinator, cooler, kiln outlet zone etc. is in practice now.

Conventional analog instrumentation is gradually being replaced with digital instrumentation. The large mimic diagrams used of late are being replaced by cathode ray tube (CRT) display. Motor control by relay sequence is being changed to programmable logic controllers. Analog PID controllers are being replaced with multi-loop digital controllers. Due to the advent of microprocessors, a variety of advanced control concepts like adaptive control, self-tuning control, feed forward control, etc. have been introduced in the Indian cement industry.

As a corollary to automation, quality is also maintained by continuous monitoring of the raw mix composition with the help of X-ray analyzer and automatic proportioning of raw mix components. New type of on-line bulk material analyzers have also been developed based on Prompt-Gamma-ray Neutron Activation Analysis (PGNAA) for giving maximum control over raw mix. The analyzer quickly and reliably analyses the entire flow-on-line providing real time results. The latest trends in on-line quality control include computers and industrial robots for complete elemental analysis by X-ray fluorescence, on-line free lime detection and particle size analysis by latest instrumental methods and x-ray diffraction techniques respectively.

It is also important to phase out the manual sampling systems especially so when the super high capacity plants are being installed. Auto sampler technology should be dovetailed into the plants for ensuring disciplined sampling and control.

Upgradation of Technology of Low Technology Cement Plants

The technological spectrum in the industry is very wide. At one end of the spectrum are the old wet process plants, while at the other end, are the new state-of-the-art technology plants presently being built by the Industry. In between these two extremes, are the large number of dry process plants built during the period 1965-90. These plants could not fully modernize or upgrade side by side with advent of newer technologies and had thus remained at intermediate technology level. Also, the level of technology is not same at all the plants built during the same period.

Majority of the cement plants in the country in the capacity range of 0.4 to 1.0 MTPA were set up more than 15-20 years ago i.e. before 1990's. They were based on state-of-art technology at that time. Since then, numerous developments have taken place in the cement manufacturing technology.

Though some of the old plants have been modernized to a limited extent by retrofitting the new technologies, substantial scope still exists for adopting the state-of-art technologies and bringing the old plants at par with world-class plants in terms of productivity, energy efficiency and environment friendliness, leading to cost competitiveness.

Moreover, the emission norms are likely to become more stringent in future and at the same time, the cement plants will be required to utilize waste derived raw materials and fuels to a large extent. The modifications of old plants to comply with these future requirements will also become inevitable. Therefore, there is a need to carry out a comprehensive assessment of all the earlier generation plants in the country to identify the extent of modernization required to improve their all round efficiency and enable them to meet the future criteria of viability, competitiveness and compliance with regard to energy consumption enabling them to comply with the provision of the Energy Conservation Act 2001.

Perceived Benefits of Technology Upgradation

It is envisaged that the technology upgradation measures for the Pre-1990 era cement plants would result in :

- Increase in capacity : 25-30 MTPA
- Reduction in thermal energy consumption : 15-20 kcal/kg clinker
- Reduction in electrical energy consumption : 5-10 units/t
- Reduction in cost of production of cement : 5-10% because of above initiatives
- Reduction in energy costs through co-processing : 10–15%
- Reduction in the CO_2 emissions (through blended cements & energy conservation) : 20%

Future Modernization Needs of the Indian Cement Industry

Although the industry has largely set up plants with energy efficient equipment, there are still some areas for further improvements like:

- Appropriate pre-blending facilities for raw materials
- Fully automatic process control and monitoring facilities including auto samplers and controls.
- Appropriate co-processing technologies for use of hazardous and non hazardous wastes
- Interactive standard software expert packages for process and operation control with technical consultancy back-up
- Energy efficient equipment for auxiliary/minor operations
- Mechanized cement loading operations, palletization/shrink wrapping
- Bulk loading and transportation, pneumatic cement transport
- Low NO_x/SO_2 combustion systems and precalciners
- Standards for making composite cement so that all the flyash and other industrial wastes viz. slag are fully used.
- Co-generation of power through cost-effective waste heat recovery system (only one demonstration unit in operation)
- Horizontal roller mills (Horo Mills) for raw material and cement grinding
- Advanced computerized kiln control system based on artificial intelligence

Fuel Requirements and Alternate Sources of Energy

Fuel

Coal continues to be the main fuel for the Indian cement industry and will remain so in the near future as well. The industry is mainly using coal from various coalfields in the country. It is also procuring coal through open market and direct imports. Lignite from deposits in Gujarat and Rajasthan is also being used by cement plants. Pet coke has also been successfully utilized by some cement plants, mainly in Gujarat, Rajasthan and MP, thereby substituting main fossil and conventional fuel coal upto 100% in some plants. In the recent past, waste derived fuels including hazardous combustible wastes have also been tried due to economic pressures in cement manufacturing process owing to tough competition in

domestic and global markets as well as ecological reasons on account of waste disposal and co-processing in cement rotary kilns being most effective mode of waste treatment.

Use of Industrial Wastes

i) Cement plants in India utilized about 19% of flyash generated by power plants and 100% of granulated slag generated by steel plants (year 2005-06), as compared to almost 100% flyash and 84% of granulated slag in the Japanese cement industry.

ii) Recycling of Industrial wastes in manufacture of cement is highest in Japan followed by India.

Use of Alternate Fuels

i) Use of hazardous and refuse derived combustibles and Municipal Solid Waste (MSW) as fuel is common in countries like Canada, EU, Japan and Korea, but regulations do not yet permit in India.

ii) CPCB is actively engaged in plant level trials in respect of wastes viz. used tyres, refinery sludge, paint sludge, Effluent Treatment Plant (ETP) sludge and Toluene Di-Isocyanite (TDI) tar waste from petroleum industries and in formulation of guidelines for use of these wastes as fuel by cement industry.

Energy Management

The industry's average consumption in 2005-06 was 725 kcal/kg clinker thermal energy and 82 kWh/t cement electrical energy. It is expected that the industry's average thermal energy consumption by the end of Year 2011-12 will come down to about 710 kcal/kg clinker and the average electrical energy consumption will come down to 78 kWh/t cement.

The best thermal and electrical energy consumption presently achieved in India is 667 kcal/kg clinker and 68 kWh/t cement which are comparable to the best figures of 650 kcal/kg clinker and 65 kWh/t cement in a developed country like Japan.

The improvements in energy performance of cement plants in the recent past have been possible largely due to :

- Retrofitting and adoption of energy efficient equipment
- Better operational control and Optimization
- Upgradation of process control and instrumentation facilities
- Better monitoring and Management Information System
- Active participation of employees and their continued exposure in energy conservation efforts etc.