Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 4, pp.3575-3583, April, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

TECHNOLOGICAL DEVELOPMENT AND CHANGE IN CEMENT INDUSTRY IN INDIA

Pardeep Kumar

Department of Commerce Keshav Mahavidyalaya University of Delhi

ARTICLE INFO

Article History:

Received 14th, March, 2015
Received in revised form 23th, March, 2015
Accepted 13th, April, 2015
Published online 28th, April, 2015

Key words:

Technology, Change, Development, Dry process, capacity, and consumption.

ABSTRACT

In October 2013, the Indian cement industry had entered into the 100th years of its existence having, inter alia, state of art technology and world class cement production. Since its inception the Indian cement industry have been gone through the various types of technological changes. Organizational Development is a field of applied behavioural science related to planned change. The basic objective of change is the total organizational and its system. Organizational Development is a newly emerging discipline directed towards using behavioural science knowledge to assist organization in solving problems and dealing more rapidly with the problem of change. Change is the essence of business growth. The external pressures are driving change at an alarming rate and affecting every aspect of organization. Identifying environmental and market changes quickly is a part of survival and growth. This present paper have been analyzed a revolutionary change occurring in technology in cement industry in India, where new and improved methods need to be developed to deal with such changes. Leavitt describes a model of the major targets of changes, which lead to the resolution of three major problems. Changes in these variables cause alterations in organizational behaviour, which is crucial to survival: technology, structure and people. This paper presents the technological development and changes in cement industry in India. This paper studies the impact of technological changes on organizational growth and analyzing the technological changes in India Cement Industry.

INTRODUCTION

Indian cement industry is a vital part of its economy, providing employment to more than a million populations. Even since it is deregulated in 1982, the Indian Cement Industry has attracted a lot of investment, making it the second largest in the world. It is been forecasted that the cement industry in India grow at a CAGR of 8.96% during the period 2014-19. Technology refers to information, equipment, techniques, and processes required transforming inputs into outputs in the organization. Scientific management, mass-production assembly lines, computer technology, and operations research are the forms of technology change. In general, the introduction of new technology in the form of new equipment or new methods for using existing resources leads to changes. Organizational change portrays how mangers maintain viable organization. One consequence of the need to maintain organizational viability is that the system must be prepared to accommodating itself to changes. The dynamic environment is constantly requiring their organizational to adjust and adopt their methods of operations. Indian Cement Industry also has gone through the various technological changes in the past three decades and contributes to the Cement growth in India. The Indian Cement Industry, as it stands today, is a curious mixture of old and small capacity wet process plants and precalcinator plants of large capacity incorporating the latest technological advancements. The improved financial conditions of the industry gave an impetus to the state of art technology. Indian cement industry is presently constructing technologically advanced cement plants which are contemporary to the plats being built elsewhere in the world. The main objective of this paper is to analyze al the technological changes takes place in the Indian Cement Industry.

REVIEW OF LITERATURE

Cement industry is one of the major and oldest established manufacturing industries in the modern sector of Indian economy. It is an indigenous industry is which country is well endowed all types of necessary raw materials, skilled manpower, technology and know-how. Till yet, there is no comprehensive study to be carried out on the problem of cement industry in India, however a good deal of analytical literature available on various aspects. This research paper makes an humble attempt to through some light on the existing relevant studies on cement industries in India.

In 1977, 1980, 1990, and 2000, the **Institute of Applied Manpower Research** had conducted a study on Manpower in the cement industry in India. The main objectives were analyzing the manpower availability and shortage of manpower in cement industry in India.

Corresponding author:* **Pardeep Kumar
Department of Commerce Keshav Mahavidyalaya University of Delhi

Goel and Nair have made an important contributions on Productivity tends of the cement industry in India.

Ramanathan, Comprehensive Report on Cement Industry in India.,1970, examined the trends in wages, productivity and human resource by taking the data of CMI and ASI.

NACER, Basis of Cement Industry, 1990-2000, attempted to assess the series of financial data on Cement industry and on its financial structure by evaluating its financial strength and expansion programmes.

Dr. Parikh, 1965, Quantities Significance of Economic Factors in Production of Cement, conducted a significant study on economic factors influencing the investment in plants and machinery and technology

Rao and Chander*,"* Assessment of Financial Efficiency of Cement Companies".1980, NCAER, attempted to make an assessment of the financial efficiency of the cement industries.
Singhania and Balkrishna, Relative Performance of Public and Private Sectors, sought to analyze the relative performance of public and private sectors units primarily with the purpose of determining the technical efficiency.

Need Of The Study

The brief survey of the existing literature on different aspects of industry indicates that there is not a single comprehensive and intensive research paper touching upon the various aspects on technological development and change as yet. In regards to the other industries in India, different researchers and institutions have undertaken a lot of advanced and highly scientific studies, and the cement industry unable to draw the attention of researchers to any noticeable extent. Of course, there exists a good deal of analytical study on some of the aspects like productivity, locational, finance and human resource, etc., of the industry. But the studies on technological changes are very useful and attract a lot of attention in the competition era. Most of the analyses are not seriously concerned about the subject. These are unsuccessful to reduce the prevailing maladies of the industry for which these were basically intended. Most of the studies are pertaining to prior nineties, which render the studies outdated.

Paucity of data has refrained the researcher to undertake any up-to-date-in-depth study, and the problems of technological in the cement industry have not been addressed so carefully till now. This research paper attempts to highlight those issues which are important for technological up gradation and give new shape the Indian cement industry. This research paper portrays how managers maintain viability in technological aspect of the cement industry. Hence, there is a necessity of a comprehensive view by analyzing the important segment of technological aspect of Indian cement industry.

Objective Of The Study

Technological development and change portrays how manager maintain viable organizations and how the organization adjust itself to the new changes in technological processes, Furthermore, technological changes and development appears to be the major ingredients for organizational growth, creates the necessity for change. The major orientation of this research paper is to find out the technological change takes place in the cement industry over the past few decades which change the entire paradigm of the Indian cement industry. The research paper has the following important objectives:-

1. To analyze the technological advancement and changes take place in the Indian cement industry.
2. 1 Identify the technological gaps and changes with reference to global practices and trends
3. Suggestions and recommendations for improvement in technological process.

RESEARCH METHODOLOGY

The research paper is based upon the Primary as well secondary data. Information have been gathered /sourced mainly from the secondary sources; and technologies have been analyzed by observing the current practices on the production sites/operational sites of cement manufacturing.

The primary source of data is based on questionnaire, interview, observations and other various unobtrusive measures.

The important source of secondary data are the publications of Cement Controller, Reports of Cement Manufactures Associations, Annual Reports of Cement Industry, Journals and Magazines, Reports of Cement Research Institute, Planning Commission Reports, Ministry of Industry etc.

Statistical Devices/Analysis Method: The following statistical devices have been applied in the study: Historical data trends/Ranges, Index Numbers, Percentages, Averages, Standard Deviations, and correlations wherever applicable, and judgmental and depth analysis have been made on the basis of available data.

Sampling

The data are obtained from the entire universe and each and every unit of cement industry:

Universe:- Cement Industries in India/Major Players:- Associated Cement corporations, Cement corporations of India, Ambuja Cement, Aditya Birla group, J&K Cement, L&T Cement. Ultratech cement, Grasim Industries, and Jaypee Cements.

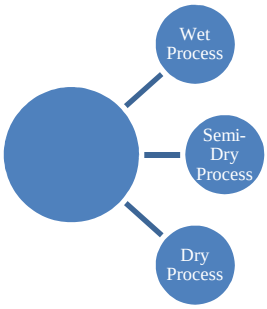
Segment: - Public Sector, Private Sector, Mini-plant
Size: - 70% of the total production capacities of Indian cement industry. 183 Large Cement plants and 350 mini cement plants

Techniques:-Convenience sampling techniques

It is being decided in the research paper that those sampling units which have a major production proportionate in the total production of cement in India, have been taken into account for research

Process In Cement Manufacturing

Cement is a fine powdered mixture of compounds like calcium silicate, calcium aluminates in certain fixed proportions. The most important raw materials used in the cement production are limestone, sand, clay, gypsum and energy inputs primarily in the form of coal , electricity. Preparation of raw materials varies from process to process. The three widely known cement manufacturing processes are, namely, Wet, Semi-dry, and Dry:-



Wet Process: In wet process, raw mix is fed into the kiln in the form of homogenized slurry, which may have water content of 30 to 40%. The wet process becomes indispensable in cases where naturally occurring raw material have high moisture content where relatively poor grade limestone has been enriched through the process of beneficiation requiring use of water a a process media. The slurry is easy to blend and homogenizes, however the fuel consumption is higher in this process due to the raw material meal being in slurry.

Semi-Dry Process:- This process was evolved to counter the main drawback of the wet process, which has higher heat consumption. In this process, powdered raw meal is either converted into nodules by adding controlled quantity of water in a nodulising pan or by de-watering slurry in a filter press to form filter cake of the raw material.

This has moisture content of about 12-14%. Hence, this process requires less heat input, but it needs more electricity than wet process. These nodules or cakes thus formed are fed onto a moving grate where raw meal gets partially calcined. This is further charged into a rotary kiln for complete calcining and sintering in the form of clinker.

Dry Process: In the dry process, raw material are dried in a combined drying a grinding plant to reduce moisture content below 1%. The drying of material is achieved by using kiln exhaust gases, which may be supplemented by auxiliary hot furnaces during rainy season.

The ground raw mix is homogenized in large silos and is fed into either a long dry kiln or short kiln with air suspension pre-heater in which partially calcinations of raw meal takes place. As a further refined and developed of the Dry process, the air suspension pre-heater are now being fitted with pre-calcinators, which ensures nearly complete calcining of raw mix before it enters the kiln. The specific thermal energy consumption is much less in comparison to the two early defined processes, but specific electricity consumption is comparatively high.

Analysis And Intrepretation

The Indian cement industry's achievement in modernization and technological up gradation has been quite impressive. In 1950, about 97% of the total installed capacity was based on old Wet Process Technology. In 1990, Dry Process Technology accounted for 77% of cement production in India, 18%comprised of Wet Process and 5% of Semi-dry Process. At the end of 2,000 the process had radically changed and 89% of the capacity of cement production based on Dry Process Energy and Environment friendly, and only 9% cement production had based upon the Wet Process Technology and remaining 2% on Semi-dry Process Technology. There had been an all-round up gradation of technology in all sections of production like mining, process up gradation, modernization of plant and machinery and computer aided technology, and packaging and transportation. Adoption of modern techniques like photo-grammatical and remote sensing has enabled the industry to discover the virgin reservoir of limestone.

Table No. 1 Changing process profile of Indian cement industry

Item	1950	1960	1970	1983	1995	2001	2006	2010
Wet process No. Of Kilns	32	70	93	95	61	32	26	9
Capacity TPD	9151	25011	38441	39641	25746	13910	11420	5950
%age of total	97.3	94.4	69.5	41.1	12	5	3	1
Dry process No. of Kilns	-	1	18	50	97	117	18	165
Capacity TPD	-	300	11865	51265	188435	202486	375968	579961
%age of total	-	1.1	21.5	53.2	86	93	96	99
Semi-Dry process Kilns	1	3	8	9	8	8	8	4
Capacity TPD	250	1250	5000	5500	5244	5260	4195	12320
%age to total	2.71	4.51	9.1	5.71	2	2	1	-
Total Kilns	33	74	119	154	166	157	162	178
Capacity	9401	26511	55306	96406	219425	310706	391583	588221
Average Kilns capacity TPD	285	358	465	626	1322	1921	2417	3308

Table No2 Kiln Capacity /Heat Consumption/Power consumption

Year	1950-60	1970	1980	1990	Post-2010
Kiln Capacity(Tonnes/Per Day	300-600	600-1200	2400-3000	3300-6000	4500-12000
Heat Consumption(Kwh/Tonnes clinker	1300-1600	900-1000	800-900	650-750	650-750
Power Consumption(Kwh/Tonnes Cement	115-130	110-125	105-115	96-106	70-90

Source: Cement Manufacturers Association

The advanced equipment like hydraulic excavators, surface miners, large wheel new type of loaders, modern crusher have also facilitate the cement industry for increasing its production capacity. The Indian Cement Industry also adopted the

precalcinator technology in the decade of 1990 contributed to increase the production capacity of cement plants. A number of mega plants have been installed in the country equipped with latest process control equipment, double string preheated towers, vertical roller mills, high efficiency fans and motors with slip recovery system, vertical coal mills, roller press for grinding of clinker and slag and specifically designed computer software systems for raw material evaluation and control of mixing of raw materials. The new Kiln system and dry process technology are energy efficient and 99% of dry processes are energy efficient.

Table No.3 Capacity/Production capacity

Year	Capacity(Million Tonnes)	Production(Million Tonnes)
1982-83	33.51	23.30
1996-97	105.68	76.22
2007-08	209.8	174.31
2010-11	323.80	228.30
2016-17	479.3	407.4
2022-23	811.4	710.0

Source: Cement Manufacturers Association Report

Source: CMA data book 2011, Data collected from ACC and Ambuja. These data does not include data and information from other cement plants which are neither members of CMA nor belongs to ACC and Ambuja groups.

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 technology. After a decade, from the 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 to dry process as well as to set up large plants incorporating the latest technology advancements. This led to installation of single line kilns of 3000 TPD(1 MTPA) capacity and more. The present trends indicate the preference of still large kilns of about 600TPD capacity and above. Already there are nine kilns of 8000 TPD capacity in operation and three kilns of capacity 10,000-12,000 TPD are recently installed.

Plants with a total capacity of two MTs and above at a single location numbering 55, are having a total capacity of 158.75 MTPA accounting 54% of installed capacity of large plants, whereas plants with a capacity between 1 to 2 million tones numbering 58 are having a total capacity of 77MPTA, accounting for 26% of installed capacity. Remaining 59 plants are of capacity less than 1MTPA, having a total capacity of 57 MTPA, accounting 20% of total installed capacity of cement plants.

In India cement industry, modern dry process plants of large capacity co-exist side by side with the old process Wet Plants and semi-dry process technology as well as small capacity plants based on rotary kiln or vertical kiln technology. The wet processes have generally, multiple clinkering units of smaller capacity. The layouts of these plants are too congested to enable retrofitting of modern energy-efficient and down-stream sub-system.

There are more than 183 large plants and more than 350 mini plants. The large producers contributes 97% to the installed capacity while mini plants accounts for the rest. Amongst these, 98% of the capacity is in the private sector and rest in the public sector. India is the second largest cement producer in the world after china, and its state of art cement techniques are excellent amongst the world cement producer, manufacture the cement comparable to the world standard. However, there is wider gap between the Production capacity and production and since onwards independence the gap still persists yet in 2016-17 and it is predicted the gap will be remained in future. The cement industries are not utilizing its fullest capacity in production of cement. In 1982-83, there was a gap of 10.21 million tonnes, 29.46 million tonnes in 96-97, 35.49 million tonnes in 2007-08, 95.50 million tonnes in 2010-11, and 71.9 million tonnes gap projection in 2016-17, and 101.4 million tonnes gap will be projected in the year of 2022.This trends shows the expansion and growth the cement plants as well as increasing in demand in India, and unutilized capacity of cement plants since on years. Almost 99% of the installed capacity in India uses dry process manufacturing, and about 50% of capacity has been built in the last ten years. The industry has been adopting the latest technology for energy conservation and quality control based on state-of –art automation system. The installed capacity has increased at a compared annual growth rate CAGR of 8.8% and matched the growth in production which is averaged 8.7% in 2011-12.

Table No.5 Wet, Dry and Semi-Dry Processes Capacity

Process	%age of Total(TDP Capacity)		
	1990	2000	2014
Dry	77	89	93
Semi-Dry	5	2	6
Wet	18	9	1
Total	100	100	100

Indian cement plants have mostly changed from the wet process to the energy efficient process dry process. Out of 177 kilns, 109 kilns are based on dry process and producing 77% of cement, whereas 60 kilns are based on wet process and producing only 18% of cement in 2000. As of recent now 93% of cement has been produced by dry process technology and only 7% are based upon wet and semi –dry process technology. In Indian cement industry, modern dry process plants of large capacity coexist side by side with old process wet plants as well as small capacity cement plants based on rotary kilns or vertical shaft kiln technology. The cement industry have been changed progressively over form wet process to dry process and from 1% dry process plants in 1960, it had changed over 77% dry process capacity as on 1990, and 93% in 2014-15 as indicated in the above table. The wet processes have been comprised only 1% and 6% are based on semi-dry technology. This technological advancement from the wet process to dry process have been playing an important role on cement production. This study have analyzed that the dry process technology keep on increasing from 77% in 1990, 89% in 2000, and 93% in 2014 and wet process technology only accounted for 18% in 1990, 9% in 2000, and 1% in 2000. Technological advancements has reflected the shift from the wet process to dry process and no of kilns increased day by day. The cement production also touched new heights by the adoption of dry process technology. This shows that the dry

process technology has made a revolution in the production of cement in India.

The public sectors as well as private sector have turned their attention towards the adoption of modern dry process technology for the last two decades. But comparatively the private sectors in India are more prone to the adoption of new dry process technology. The rate of technology change is faster in private sector as compared to public sector

Indian Cement Industry has been passed through many ups and down. It was under strict government control till 1982. Subsequently, it was partially decontrolled in 1982; the industry was opened to the free market economy along with the withdrawal of prices and distribution controls. Finally the industry was totally decontrol and de-licensed in 1991 under the policy of liberalization and globalization and the industry witnessed spectacular growth in production after 1991. Over the time the industry has witnessed spread of plants in several areas of the country.

Table No.6 Distribution of Cement Plants above0.50 Million tones Installed Capacity of above 0.5 Million tonnes

State	No. of Plants	Percentage of Shares
Andhra Pradesh	32	21.33
Assam	1	0.67
Bihar	1	0.67
Chhattisgarh	8	5.33
Gujarat	11	7.33
Haryana	2	1.33
Himachal Pradesh	5	3.33
Jharkhand	3	2.00
Karnataka	8	5.33
Madhya Pradesh	11	7.33
Maharashtra	9	6.00
Meghalaya	1	0.67
Orissa	4	2.67
Punjab	2	1.33
Rajasthan	18	12.00
Tamil Nadu	17	11.33
Uttar Pradesh	8	5.33
Uttarakhand	2	1.33
West Bengal	7	4.67

Table No.7 Distribution of Cement Plants less than 0.50 Million tones Installed Capacity of less than 0.5 Million tonnes

State	No. of Plants	Percentage of Shares
Andhra Pradesh	3	9.09
Assam	1	3.03
Chhattisgarh	2	6.06
Delhi	1	3.03
Gujarat	3	9.09
Haryana	1	3.03
Himachal Pradesh	1	3.03
Jammu & Kashmir	1	3.03
Jharkhand	2	6.06
Karnataka	3	9.09
Kerala	2	6.06
Madhya Pradesh	1	3.03
Maharashtra	1	3.03
Meghalaya	3	9.09
Punjab	1	3.03
Rajasthan	2	6.06

The above table states that the major cement plants above 0.5 MT exist in Andhra Pradesh, and then onwards in Rajasthan, Tamilnadu, Gujarat, Madhya Pradesh and Maharashtra. As these are the larger states and the major portion of the raw material are found in these states. Modern cement plants as comparable with state-of-art plants elsewhere in the world. The average installed capacity per plant is 1.7MPT as compared to more than 2.1MPT in Japan

This table show that cement plants less than 0.5 MT exist in all the states and even these are found in smaller states, but the cement plants of this capacity is not more than three and percentage of share is merely on 9.09 percentage.

Computer aided techniques and surface miners for raw material deposits assessment at proper exhaustion sequence of mining blocks , keeping in view the blending operational needs are envisaged and put to use recently , whereas conventional system were used prior to the 1990s.

Mobile crushers have come in used in newer plants, keeping in view the split location of limestone deposit and long conveying distance. Two-stage in pit crushing system are used in most of the plants recently, and mobile crusher plants is installed at the mine itself and raw material is crushed at the recovery sites.

Vertical Roller Mills (VRM) has given the real breakthrough in the areas of grinding. The VRM draws 20-30% less electrical energy as compared to the earlier used ball mills system prior to 1990s. These mills can accept large feed size and hence can mostly be used with single stage crushing. VRM are now being used clinker and slag grinding and also pre-grinding to existing grinding installation. another breakthrough that have come with the application of High pressure grinding rolls(HPGR) which have been widely adopted by Indian Cement Industry. A new mill system called Horizontal roller mill has been developed , but this technology is yet to be adopted in the Indian cement industry.

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 low calorific vale. Through precalciner technology, the Indian cement industry are fully exploited the advantages of economy of scale. Many single kilns capable of producing more than 600TPD capacity have been already installed and are operating with state-of-the-art technology. The introduction of high efficiency and low pressure drop cyclones have led to conversion of 4 stage cyclone preheater to 5 stage and even 6 stage cyclone preheater with improved thermal efficiency. The latest development lie controlled flow gate clinker cooler system and cross bar cooler ensure better clinker distribution. The limitations of the earlier used technology 1990s based on conventional straight pipe burner have been overcome use of highly flexible multi-channel burner. The large plants built prior to 91990s could not fully modernize or upgrade side by side with advent of newer technologies and thus had remained at intermediate technology level. Also, the level of technology is not the same at tall the plants built during the same period. Majority of the cement plants in the country in the capacity range of 0.4 to 1.00 MTPA were set up more than 15-20 years ago .i.e., 1990. They were based on state-of-the –art technology of that time. Since then, numerous developments have been taken place in the manufacturing of cement.

Table No.8 Present Status of Technology

	Pre-1970	1970-90	1990 & Onwards	Global
Mining &Material Handling	Conventional	Conventional	Computer Aided & Surface Miner	Computer Aided & Surface Miners
Crushing	Two-Stage	Two-Stage	Two stage In-pit crushing conveying	In-pit crushing conveying
Conveying of Limestone	Dumpers/Ropeways/ Tippers	Belt Conveyors	Belt conveyors/ Pipe conveyors	Pipe conveyors/Belt conveyors
Grinding	Bail Mills with or without conventional classifier	Balls Mills VRM's Roller Presses with dynamic classifier	Balls Mills with improved classifier VRM's Roller Presses with dynamic classifier	Balls Mills with improved classifier VRM's Roller Presses with dynamic classifier, Horo Mills with dynamic classifier
Pyro-processing	Wet/Single Chamber Burner	Wet/Semi-dry/ Dry:-4-stage pre-heater/conventional cooler/single channel burner	Dry process:- Dry-5/6 stage pre-heater, High efficiency coller, Multi-channel burner, co –generation of power, co-processing of WDF	Dry process:- Dry-5/6 stage pre-heater, High efficiency coller, Multi-channel burner, co –generation of power, co-processing of WDF, low carbon calciner, low emission technologies, green technologies
Blending &storage	Pre-Blending/Batch Blending Silos	Pre Blending	Continuous Blending/Multi Chamber Silos	Continuous Blending/Multi Chamber Silos/Silos Dome Silos
Packaging & dispatch	Bag	Bag	Bag/Bulk	Mostly Bulk/Palletizing &Shrink Wrapping
Process control	Relay Logic/Hard Wire	Fuzzy Logic Control system/PLC	Micro processor based/DDC/Neuro fuzzy expert system	Micro processor based/DDC/Neuro fuzzy expert system
Plant size TPD	300-600	600-3000	3000-12000	6000-12000

Source:-NCCBM

Table No.9 Technology of Indian Cement Industry at a Glance

	Low Technology Plants	Modern Plants	Global Technological plants
Mining and Material Handling	Conventional	Computer Aided	Computer Aided
Crushing	Two-Stage	Single Stage	In-pit crushing conveying
Conveying of Limestone	Dumpers/Ropeways/ Tippers	Belt Conveyors	Pipe conveyors/Belt conveyors
Grinding	Bail Mills with or without conventional classifier	VRM's Roller Presses with dynamic classifier	VRM's Roller Press
Pyro-Processing	Wet/Semi-dry/Dry-4-stage heater, conventional coller, single channel burner	Dry-5/6 stage pre-heater, High efficiency coller, Multi-channel burner	Dry-6 stage heater, High efficiency coller, Multi-channel burner/Co-procession WDF/Co-generation of power
Blending and Storage	Batch Blending Silos	Continuous Blending Silos	Continuous Blending Silos/Multi-channel Silos
Packaging and Dispatching	Bag	Bag/Bulk	Bulk/Palletizing and shrink Wrapping
Process Control	Relay logic/hard wired/PLC	DDC/Fuzzy Logic Expert System	DDC/Neuro fuzzy Expert System
Energy Consumption Level	90-100 Kwh/t.cem/ 900-1000kcal/kg cl.	75-85 Kwh/t.cem/700-800kcal/kg cl.	70-80 Kwh/t.cem/675-740 kcal/kg cl.
Plant Size(TPD)	300-1800	3000-6000	6000-12000

Generally, cement manufacturing process involves the following stages:-

1. Quarrying, 2. Crushing, 3. Pre-homogenization and raw material grinding, 4. Pr-heating, 5. Precalcining, 6. Clinker Production with rotary kiln, 7. Cooling and storing, 8.Blenidng and 9. Cement grinding, 10. Storing in cement Silos

India is second largest cement producing country in the world with a distinctive of operating plants with varying capacity and varying technologies. Some of the modern plants can be compared to the best plants in the world in terms of variety, quality and energy efficiency. India cement industry remained proactive in adopting technologies advancement taking place in the world. The share of energy inefficient wet process technologies has slowly decreased from 94.4% in 1960 to 61.1% in 1980, 84% in 1990, 92 % in 2000, and 1% in 2010.

During 1980s and 1990s, major technologies advancement took place around the world in design of cement plants equipment system primarily in the following areas:-1.Pre-calcination, 2.High pressure grinding, 3.Automation in the process control, 4.high efficiency particle separation, 5.clinker cooling

The modern cement plants having a Precalcining system, large size crushing system, pre-blending beds for limestone, vertical mills for raw material and cola grinding, large capacity blending silos, 5/6-stage pre-heater with precalcinator, high efficiency channel, high pressure roll press, computerizes system of operating, DDC Neuro fuzzy expert system, lowers consumption level, bigger plant size in terms of TDP. These plants have comparatively high instrumentation and centralized plants operation through computer located centrally. These plants have been able to achieve substantial improvements in energy consumption levels by using advanced dry technology, where the energy consumption level are around 70-80 Kwh/t.cem/675-740 kcal/kg cl. with the plant size comprises of 6000-12,000TDP. A major technological change appears in 21st century and today's Indian cement industries are incorporating the global standard of technological up gradation. The new plants being built now are incorporating state of art technology, the latest in hardware and aim to achieve very low thermal and

electric energy consumption, comparable to plants being built elsewhere in the world.

Technological development in Indian cement industry

1. The cement plants operations have been undergone substantial development with the introduction of Dry Process technology. Indian Cement industry is based on the pre-heater and pre-calciner. Various kilns have been developed to achieve improved fuel efficiency. The size of the modern dry process kilns is now standardized between 150tpd to as high as 4500tpd and as of now the plants size are now about 3000-6000tpd.
2. The development in the other areas include of vertical roller mills in place of ball mills for grinding of raw material and coals, se of pre-blending stock piles and high efficiency separations for energy efficient cement grinding, electronic packaging machines for improved weight reliability and efficiency, packaged bag loading machines , advanced process control and instrumentation
3. The dry process cement plants presently being installed are equipped with most effective pollution control measures to fulfill the stipulation laid down by the Pollution control authorities. Many Old plants are now installing pollution control equipments to meet the stipulation. Suitable pollution control equipment of advanced design including ESP, fabric bad dust collection, gravel bag filters etc, are now available in India from reputed manufacture
4. The cement industry in India has grown from an installed capacity of 5MT's per annum at the end of first five year plan (1951-56)to an installed capacity of about 43 MT's per annum at the end of sixth five year plan, and in 1996-97 with an installed capacity of 105MT,s, 323.80 MT;s in 2010-11 and expected to increase about 500 MT,s in 2016-17.this shows the tremendous growth the growth of the installed capacity of cement industry in India.
5. The modern cement plants in India have been incorporated now the modern way of manufacturing of cement, like by using Computer Aided in mining and material handling, Single Stage curding, conveying of limestone by Belt Conveyors, grinding through VRM's Roller Presses with dynamic classifier, Pyro-processor Dry-5/6 stage pre-heater, High efficiency coller/Multi-channel burner, blending and storage through Continuous Blending Silos, process control DDC/Fuzzy Logic Expert System, energy consumption level 75-85 Kwh/t.cem/700-800kcal/kg cl , with modern plants size of 3000-6000tpd.
6. Indian cement industry backed by the collaboration agreement with world –renowned manufacturers are capable of supplying plant, machinery and equipment for large size cement plants of capacity of 3000tpd and above, based on up to date state of the art technology. As observed in this decade, there is a gradual reduction of import of plant and machinery and modern technological import due the development of indigenous availability of technology.
7. With the free sale and distribution of cement, the cement industry now experience a different market situation and now subjected to increased competition with respect to high quality cement. This means low cost of production, use of modern technology, and quality production
8. In the areas of equipment design and commissioning of services with specific large plant size, indigenous capabilities are improving. Now a day, Indian Machinery manufacturings have the requisite infrastructure supported by cement plants and R&D facilities as well as investment capacity for continuous technology development. Significant progresses have been taking place in the areas of electrical engineering and software design for computer aided process and quality control.

Identifying Technological Gaps and changes with reference to the Global Practices and Trends

The study assess the current technical status and Indian technical status in the areas of raw material, processes, transportation and handling, distribution, and identify technology gaps with references to the global practices and trends:-

1. The Indian cement industry using the old technique of exploring the raw material limestone reserve. It therefore, calls for intensifying in exploration of limestone by using the modern technology like photogrammetric and remote sensing, modern mining equipment, optimization of reserves, and software for computer aided mining planning.
2. Hydraulic excavators and large wheel loaders are replacing conventional rope shovels in quarries by virtue of their mobility and flexibility of operation. Large diameter pneumatic drills and gigantic offline dumpers are now a days are used by modern cement plants. Combination of in-pit crushing and conveying systems has become more acceptable in quarrying. Mobile crushers are used in conjunction with flexibility belt conveyor and would therefore fine more application n the Indian cement industry.
3. The Indian cement industry is a curious mix of old wet process, semi dry process, and dry process technology. It is embarrassing to note that the wet process plants and semi process plants are still in operations. However the first significant change in manufacturing process was the development of the lepol grate and suspension pre-heater system introduced in 1960s which had changed the entire manufacturing process in India. The development of pre-calcinators system in 1980s changed the entire paradigm of Indian cement industry. The plants presently have designed presently for a fuel consumption of 700-725 Kcal/Kg clinker and power consumption of 90-100 Kwh/t.cem. is according the world standard. Presently about 93 % of Indian cement plants meets the global standard in processes and energy conservation.
4. The cement plants in India are based upon precalcinator processes and similar to the plants built elsewhere in the world, but there are some technological gaps are noticed in this study:-1. Lack of pre blending facilities of coal, 2.

Lower efficiency of air separators of mills, 3. No mechanical loading arrangement for wagons, 4. Lack of computer operated plant operation, 5. High power and fuel consumption and pneumatic system.6. pipe conveyor and belt conveyor system, 7. In pit crushing conveying. 8. VRM roller press, 9. Dry 6 stage heater system, Dry-6 stage heater, and High efficiency coller, Multi-channel burner/Co D procession WDF/Co D generation of power, 10.Multiple channel silos, and 11. Bulk/Palletizing and shrink Wrapping, 12. DDC/Neuro fuzzy Expert System, 13. 70-80 Kwh/t.cem/675-740 kcal/kg cl. These are the global standard practices and Indian cement plants are far away from these practices.

5. The cement plants in India are concentrated in six major clusters near the limestone deposits. In view of this, the conventional mode of cement transportation in bags by the railway wagon and trucks may not be able to the meet the remote and increased demand of the consumer. Therefore, alternatives ways have to be developed for the transportation of cement by bulk to the large consuming centres. The need arise to develop Bulk terminal and bulk depots may have been developed by the government. There is gap in the infrastructural facilities of cement industry in India.
6. The cement industry have been lacking of research and development, as the Indian cement industry only spent around less than 1% on R&D, and it shows the interest of the cement industry in technological development. R&D is necessary for the growth of the cement industry. In attempt to getting the desired development, firstly ample funds to be set aside for R&D and research has to be properly focused and goal oriented. In general research efforts should be directed towards;- 1.technological up gradation and modernization, 2. Operational improvements, 3. Proper utilization of reserves and limestone 4. Energy conservation.
7. The cement manufacturing process has undergone s significant improvement since the introduction of pre-calcinations technology. The maximum capacity of a single kiln has gone up substantially. However, most these large plants are yet to settle down to their full rated production efficiency. Analyzing of teething troubles in large plants, it reveals that the causes pertain to poor quality of raw material and coal, non-availability of trained manpower, lack of experience of operating large size plants and advanced technology, failure of indigenous made auxiliary equipment, lack of complete technology economic evaluation of precalcinator technology. Since most cement plants size using the technology is yet to settle down fully, lack of operational feedback and inadequate commissioning and post-commissioning assistance.
8. The study have observed that mechanical failures have been occurred with the auxiliary machinery such as large motors, elevators, screw conveyors, belt conveyors , dampers, gear boxes, electrical and electronic components and others, rather than the main machinery. This needs stringent norms for high degree of efficiency in Indian cement industry.

Recommendations/Future Modernization needs of Indian Cement Industry

1. Modern computer based methods should be installed wherever possible for improvements/optimization of process and quality control, energy conservation, deposit evaluation and mines planning. Efforts' should be made to identify all software packages specifically designed for modernization of cement plants operations in line with the international standard.
2. Systems for gathering relevant operational data of different elements of technology should be initiated. Based on this data base, a periodical technology economic evaluation of their performance could be carried out with the assistance of the appropriate technical organization. Action and recommendations suggested should be supplemented by proper monitoring of the progress to ensure effectiveness of the programme. The concerned agency may provided proper guidance to overcome any bottlenecks during implementation of the recommendations.
3. All the Cement plants should endeavor to set-up computerized kiln and mill simulators which have revolutionized the operators training in these areas for gaining or improving operating knowledge at lower cost; lesser time and practically no risk. To start with, use of these simulators any be taken up on a centralized basis.
4. The cement industry should prepare a follow-up a well conceived human resource development plan instead of ad-hoc training. It should inter-alia cover all areas of training. In view of the erection and commission problems being faced using advanced technology which had/have to depend almost exclusively on expatriate engineers/technicians/experts involving substantial expenditure in foreign exchange, all license agreements should have adequate provision for rendering training to license personal in carrying out such operators independently.
5. An attempt to suitably monitor the technology development taking place in the world and the status of technology of Indian cement industry should be established. Assistance in evaluation could be taken from R&D establishments'. An attempt should be made to have testing facilities, supporting qualified personnel, which are at par with the foreign cements plants manufactures.
6. A centralized training centre may be established under the control of Cement Manufacturers Association in collaboration with leading cement manufactures. The main areas of activity should be manpower development, up gradation of technology, equipment design, manufacturing operations and quality control.
7. An attempt should be made to incorporate the Global Technological practices in manufacturing of cement and for the modernization of cement plants :-Dry-6 stage heater, High efficiency coller, Multi-channel burner/Co-procession WDF/Co-generation of power, VRM's Roller Press, In-pit crushing conveying, Pipe conveyors/Belt conveyors, Continuous Blending

Silos/Multi-channel Silos, Bulk/Palletizing and shrink Wrapping, DDC/Neuro fuzzy Expert System

8. Although the industry has largely set p plants with energy efficiency equipment, there are still some areas for further improvement in Indian cement plants like; Appropriate pre-blending facilities, fully automatic process control and monitoring facilities, appropriate co processing technologies for hazardous and non-hazardous wastes, energy efficient Pyro-processing system, mechanized cement loading, palletization/shrink wrapping, pneumatic cement transportation, low emission combustion system, co-generation of power, Horizontal roller mills for raw material and grinding, retrofitting and adoption of energy efficient equipment, commissioning of new state-of-the –art Greenfield cement plants.

References

1. Anderson, Victor, Energy Efficiency Policies, Rutledge , London, 1993
2. Anita E.T., "Technology Breakthrough in Indian Cement Industry, Cement, XXXIII, Future of Indian Cement, XXXV, Cement CMA, New Delhi
3. Arya I.C., "Size and Technology of Cement Industry in India", *Indian Eco. J*. vol. 20-27, 1992
4. Birla Institute of Scientific Research, " Cement Industry" Sectoral Analysis, BISR, New Delhi
5. CMA, Annual Data of Cement Industry, CMA, New Delhi, 2011,12,13,14
6. CMIE Survey (2001), Investment projects under various levels of Implementation, India Info line Sector Reports
7. Dhir R.K. and Carthy M.J., " Use of conditioned PFA as fine aggregate component in concrete," *Journal of Material and Structure*, 33, 38-42,
8. Global Cement Directory, " Pro Publications International Ltd, Epsom , UK, November, 2012
9. Global Cement Websites, "Cement Industry in India," http://www.ibef.org/Industry/Cement_india.aspx
10. Government of India, Report of Working Group on Cement Industry, Planning Commission, New Delhi
11. High Level Committee, Report of the high level committee on Indian Cement Industry, Parliament, 2011-12
12. International Energy Agency, "Technology Roadmap, low carbon technology for the Indian Cement industry', IEA, 2013, www.ncbindia.com
13. Javel I, Bhatty, F. Macgregor Miller, Steven Kosmatka; editors, Innovations in Portland Cement Manufacturing, sp400, Portland cement association, Skokie, Illinois USA, 2004
14. Krishna Kumar. P., Franklin John. S., Senith, S,. "A study on factors affecting performance of Indian Cement Industry", *European Journal of Business and Management*, vol, 5, No. 29 (2013)
15. Nagabhushana, Sharada Bai. H, "Use of crushed Rock Powder as replacement of fine aggregate in mortar and concrete," *Indian Journal of Science and Technology*, Vol, 4, Issue 8, august, 2011
16. National Council for Cement and Building Material, : Indian Cement Industry, An analytical study, New Delhi
17. NCAER, Cement Industry in India", Problems and Prospectus, National Council of Applied Economic Research, New Delhi
18. NCB, "Reports on Cement Industry, 12th and 13th NCB International Conference on Cement and Building Material, Ministry of Commerce and Industry, 2012-13.www.ncbindia.com
19. Ninety Fifth Reports on Performance of Cement Industry, Rajya Sabha Secretariat, New Delhi, February, 2011
20. Norton. J, "Building with Earth Intermediate Technology", Intermediate Technology,1986
21. Patil, M. R, Sawant Pravin, " Corporate Social Responsibility, Performance and sustainability of Shree Cement Company in India," A case study, Abhinav, International Monthly Referred *Journal of Research in Management and Technology*, Vol 3, No 4, 2014
22. Rajni Bhalla, CSR and Reported by Indian Selected Companies: An Exploration: Prabhandan: *Indian Journal of Management*, January 2013
23. Taylor, H.F.W, Cement Chemistry, Academic Press, 1990

How to cite this article:

Pardeep Kumar., Technological Development And Change In Cement Industry In India. *International Journal of Recent Scientific Research Vol. 6, Issue, 4, pp.3575-3583, April, 2015*

****