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The Changes In Production Technology, and What Comes Next?

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THE CHANGES IN PRODUCTION TECHNOLOGY, AND WHAT COMES NEXT?

Preamble

In general, technology innovation is mainly driven by economics, efficiency, statutory regulations, etc. and the cement industry is no different.

The cement industry is energy- and manpower-intensive, and of late has been subject to stringent statutory regulations worldwide. The Portland cement manufacturing technology, together with allied processes and operations, have come a long way from their initial days—mainly driven by mass scale production, energy efficiency, automation, operational efficiency, ease of maintenance, and compliance with statutory regulations.

The contemporary process for the production of Portland cement comprises the following four basic technologies: mining, comminution (crushing & grinding), pyro-processing, and packing. These basic technologies are supplemented by the following technology-oriented operations in the cement manufacturing process: process control & automation, quality control, production management, environment control, and plant maintenance.

This article briefly touches upon historical advancement in cement manufacturing technology and processes and attempts to predict how cement production technology and operations will evolve in the near future and what the driving factors are.

Insight into future technologies will help cement producers prepare themselves for “first-mover advantage”.

History of Cement Production Technology

The various advancements in cement production technology over the years are depicted in the table below:

	Early Period (1840-1970)	Mid Period (1970-1995)	Contemporary (1995 onwards)
Typical Plant Size (tpd)	50-1,000	1,000-3,000	5,000-12,000
Main Technology			
Mining	Manual	Drilling & Blasting	Drilling & Blasting/ Surface Miners/ Rock Breakers
Crushing	Multiple stage crushing	Double Stage	Single Stage
Grinding	Tube mill/ open circuit ball mill for wet/ dry grinding	Open circuit and closed circuit ball mills for dry grinding/ pre-grinder	VRM/ BMRP/ Horomill
Pyro-processing	VSK/ Wet Process	Semi wet/ Semi dry/ Long dry/ 3-4 stage suspension preheater & planetary/ Grate Cooler	Dry process with 5-6 stage preheater calciner
Packing	Mechanical packer with manual loading	Mechanical packer/ microprocessor controlled packer with manual/ semi-automatic loading machines	Electronic multi spout rotatory packer with semi-automatic/ automatic loading machines
Storages			
Crushed Material	Gantry	Gantry/ Covered Shed	Longitudinal/ Circular covered shed
Clinker	Gantry	Gantry/ Covered Shed	RCC Silo
Cement	Cement Tank	RCC Silo	Inverted cone RCC Silo

	Early Period (1840-1970)	Mid Period (1970-1995)	Contemporary (1995 onwards)
Material Handling & Transport			
Crushed Materials	EOT Crane	EOT Crane/ Tipper Care/ Dozer	Stacker-Reclaimer/ Side Scrapper
	Railway Wagons/ Ropeway	Trucks/ Belt conveyors/ Ropeway	Dumpers/ Belt Conveyors/ Pipe Conveyors/ Ropecon
Raw Meal	Slurry pumps/ slurry elevators/ shaker conveyors, pan conveyors	FK pump/ Air lift/ Fluxo pump/ Elevators	Elevators/ Air slides/ Belt Conveyors
Clinker	EOT Crane	EOT Crane/ Tipper Car/ Dozer	Flow control gate/ Pan Conveyor/ Heat Resistant Conveyor Belt/ Elevator
Cement	Slurry pumps/ slurry elevators/ shaker conveyors, pan conveyors	FK pump/ Air lift/ Fluxo pump/ Elevators	Elevators/ Air slides/ Belt Conveyors
Efficiency KPI			
Specific Heat Consumption	1,200-1,500	800-1,200	680-750
Specific Power Consumption	100-120	80-100	70-80
Alternate Fuel Substitution	Nil	1% (Max)	5-20%
Auxiliary Services			
Quality Control	Manual sampling & conventional testing	Manual sampling & conventional testing/ XRF	Automatic sampling/ Robotic sample preparation/ XRF/ XRD/ CBA
Process Control/ Automation	Hard Wire/ Condition Interlocking	Relay Logic/ Local PLC/ Start-Stop Sequence/ Sequential Interlocking	DCS/ software based Intelligent closed loop controllers/ Fuzzy Logic/ Interface with ERP
Plant Maintenance	Manual	Computer	ERP
Production Planning	Manual	Computer	ERP
Environment Control	Dust Box	ESP/ Bag Filters	Modular Bag house with online emission dust and gas emission monitoring
Source of Power	Grid	Grid/ CPP	Grid/ CPP/ WHRS/ Solar

Cement production technology of future:

Mining

Limestone comprises about 95% of the raw material requirement for clinker manufacturing and thus, both the cost of its acquisition and its quality are critical. Due to the cost impact and quality implications limestone is, by and large, mined by the cement manufacturers themselves, though part of the mining operation may be outsourced.

Historically, technological advancements in mining operations were driven by the need to reduce the cost of production and maintain better quality control. It is envisaged that future technological advancements in mining will continue to be driven by the need to reduce costs and have better quality control, with the addition of addressing environmental concerns and resource conservation.

Some of the technological advancements envisaged in mining operations are as follows:

1) At present, drilling and analysis are available separately. However, in the future it is envisaged that robotic drilling and simultaneous online sampling and analysis will be available in one machine to offer instant results of drilling, and hence the quality of the deposit, thus saving time and ensuring accuracy by eliminating errors in the existing process.

2) For better resource utilisation, precision mining, and security of the environment, the following two technologies are likely:

a) Mining by rotating cutting wheel. Presently, this technology is used for coal mining, but with suitable modifications, it can be used for limestone as well.

b) Laser mining. Currently, this technology is used for stone cutting on an industrial scale. In future, this technology can be used for mass mining of limestone. The precision cutting will also ensure precise separation of ore from other materials embedded in the deposit, ensuring optimal utilisation of resource.

3) Mine planning by Artificial Intelligence (AI).

4) Electric automobile technology-inspired electric heavy earth moving machinery (HEMM).

5) Complete automated mining equipment operation with unmanned or robotic HEMM working in sync with each other and crushing operations.

6) Remote operation of mines with supervision by drones.

7) Multiple, smaller, mobile crushers along with mobile belt conveyors.

8) Transport of crushed limestone by pipe conveyor or ropecon over long distances.

Grinding Technology

Grinding operations account for 60% - 70% of the power consumed in cement production. Additionally, grinding operations also require significant thermal energy, mainly for drying moisture. Technological advancements in grinding technology have been driven by the wish to reduce power consumption, thermal requirement and improve reliability by reducing wear and tear.

It is expected that future technological advancements in grinding technology will be driven by further reduction in energy consumption—both power and thermal.

Today, the following advancements in grinding technology are occurring:

1) Improvements in the performance, reliability and energy efficiency of the two most popular contemporary technologies—VRM and RP

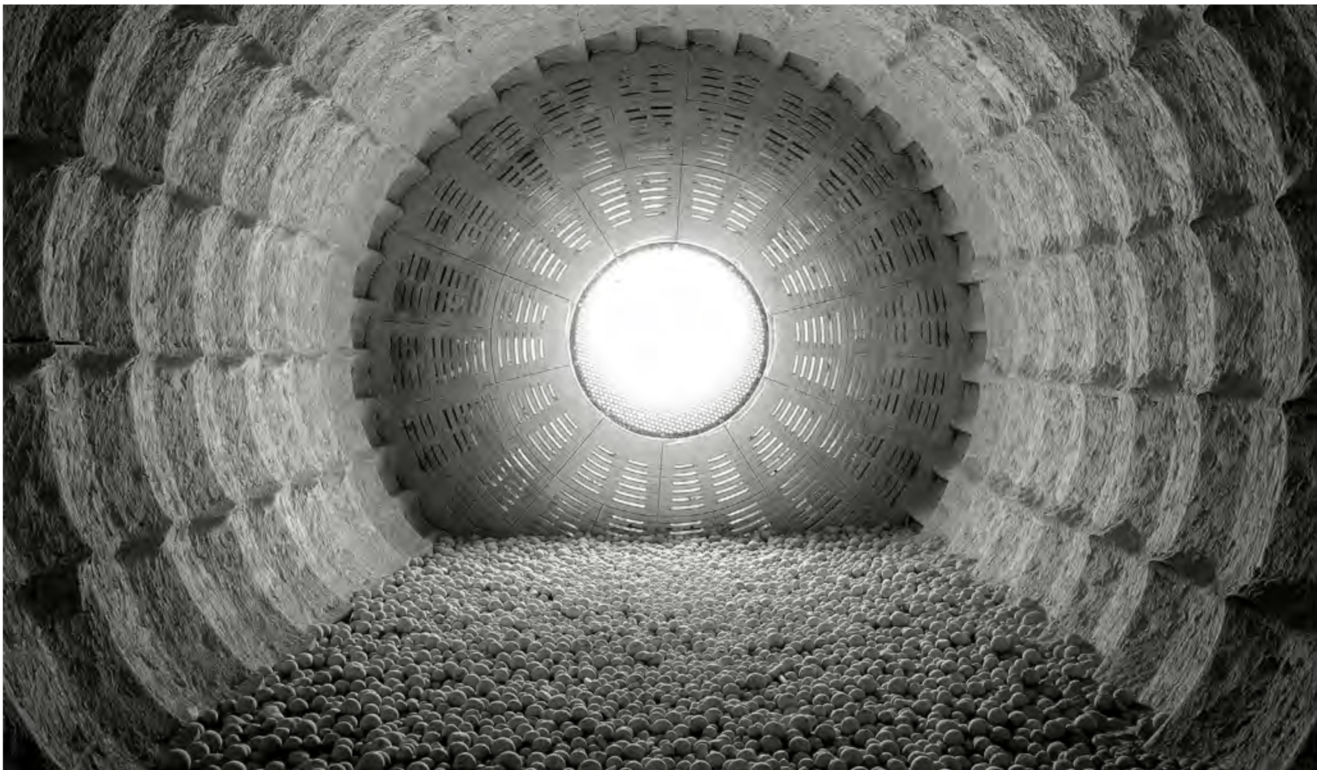
2) In-operation maintenance of contemporary grinding technology

3) AI-based operational control and real-time cloud-based interface with quality control, production management and plant maintenance operations

4) Development and usage of improved "grinding aid"

5) Alternate non-contact methods of comminution such as:

a) Thermal.
b) Shock waves.
c) Chemical.



Pyro-processing Technology

Pyro-processing lies at the heart of cement production and consumes almost the entire thermal energy requirement of a cement plant. The quality of cement is determined to a large extent by the pyro-process control.

Historically, advancement in pyro-processing technology was driven by the need to increase thermal energy efficiency in terms of specific heat consumption.

Some of the technology advancements envisaged in future are as follows:

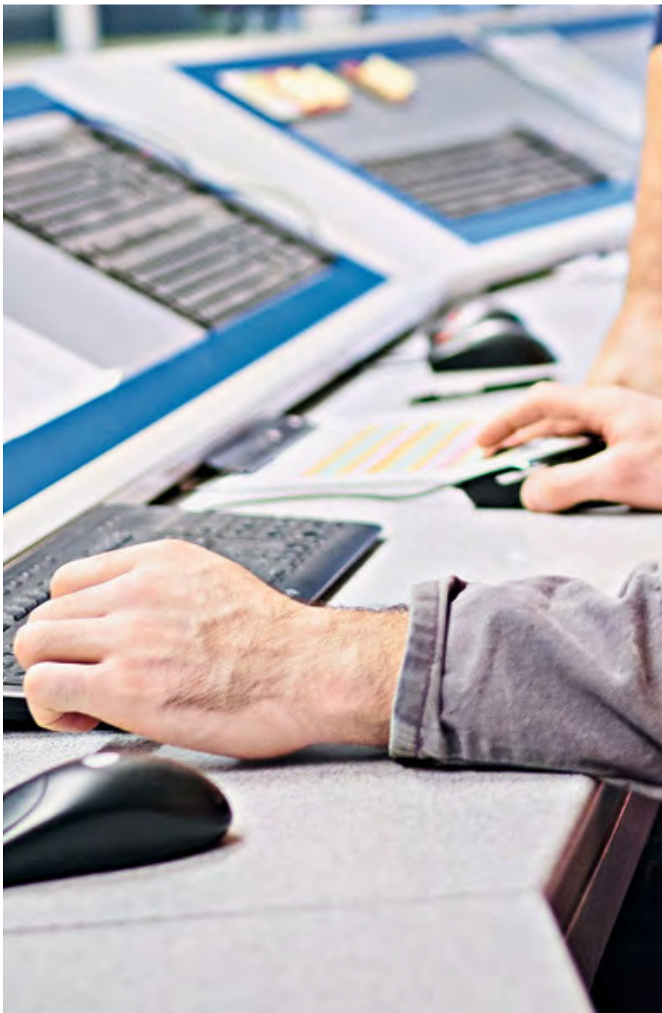
1) Fluidised bed combustion kiln
2) Manufacture of belite cement
3) Optimum usage of alternate fuels for thermal requirement
4) Preheaters with 7th and 8th stage
5) Heat recovery from kiln shell
6) Oxygen injection
7) Double layer refractory lining
8) Improved burnability of raw meal with the addition of mineraliser
9) AI-based process control with cloud-based interface with quality control, production management and plant maintenance operations

Packing & Loading

Cement packing and loading is the final stage of the cement production process. Technology advancements in cement packing and loading have been motivated by weight accuracy and throughput efficiency. Future technology advancements will be driven by multiple products, customised packaging, operational efficiency, interface with sales and logistics, optimum inventory levels, and just-in-time serviceability.

Some of the future technology advancements foreseen for packing and loading are as follows:

1) Off-shore, modular, container-mounted “plug and play” packing plants
2) Truck-mounted modular and mobile packing plants
3) Unmanned operations—completely automated and robotics-based packing and loading machines
4) Cloud-based monitoring and interface with sales, logistics and organisational operations
5) AI-based interface with production planning and logistics



Cement Production Operations of the Future

Technology advancements in the future will probably impact more on cement production operations than the core cement production technology. Cement production operations are increasingly becoming more technology oriented. The main cement production operations that are likely to be impacted by high technology advancement are outlined below.

Process Control and Automation

The production technology in a modern cement plant is complex and involves hundreds of independent variables affecting three main parameters: quality, throughput, and efficiency. In the past, technological advancements in process control and automation have been driven by the need to have sequential operation, interlocking, quality control, higher throughputs, and higher efficiency in terms of power and heat.

In the future, it is envisaged that technological advancements in process and automation control will be influenced by unmanned operations, artificial intelligence-driven controls, a requirement for consistent quality, and sustained optimised efficiency.

Some of the technological advancements expected in the future are:

1)Artificial intelligence will replace closed-loop and fuzzy-logic systems. Some of the process control elements where AI can be used include:

a) Optimisation of fuel mix
b) Optimisation of raw mix
c) Kiln and calciner firing
d) Flame control
e) Air balance
f) Material balance
g) Temperature profile
h) Water spray
i) Blending efficiency

2) Completely automated, unmanned factories
3) Entire process control on cloud, accessible globally to experts
4) Entire plant operation is automated, driven by AI and available on cloud for manual intervention if required

Quality Control

Consistent quality of product is of prime importance for compliance with statutory regulation, process control, and brand image. Historically, quality control technology was mainly driven by the need to comply with local / international standards. In the future, it is envisioned that technology advancement in quality control will also be driven by cost optimisation, process optimisation, efficiency, and environment concerns.

Some of the possible technology advancements in quality control are as follows:

1) Inline and non-contact scanning of in-work material samples with real time adjustments in process and operations by artificial intelligence. Integral and real-time quality assessment and operational control

2) Along with material, gas sampling is likely to be an integral part of quality control, considering upscale usage of alternate fuels and stringent environment regulations

3) Individual quality evaluation and testing equipment shall be on a single cloud-based platform, providing input to AI controlling plant operations and remote experts

4) Completely unmanned laboratories using robotics

5)Destructive and time-lapsed conventional methods of testing will give way to online and real-time measurement, predicting future quality parameters with the help of specialised simulation software

Production Management

Production management refers to operating the plant to produce the desired product. It involves management and monitoring of resources required for cement production, i.e. material, manpower and energy.

Historically, production management was driven by the need to have sustained operations and so the need for technology interface was minimal and limited to the use of computers for data-logging and report generation.

It is predicted that technology advancement in production planning in the coming years will be determined by cost effectiveness, energy efficiency, integrated quality control and operations, and real-time interface with organisation level financial performance.

Some of the technology advancements envisaged in production management are:

1) Production management by AI

2) Production management parameters on cloud, interfaced with organisational aspirations

3) Split-location operations: off-shore, modular, container-mounted "plug and play" grinding units and bulk terminals

Environment Control

In the past, technology advancements for environment control have been focussed on dust suppression. Traditionally, the cement industry has been considered as a dust-emitting industry, both stack and fugitive.

Technology advancement in environment control in cement production technology, in the near future, is likely to focus on control of gaseous emissions. These will include:

1) Gaseous Emission

a) CO2 : the cement industry contributes about 8% of global CO2 emissions and is the third largest polluter in terms of CO2 emissions. It is estimated that for every tonne of clinker produced about 1 tonne of CO2 is released. The scope to reduce CO2 is limited by the fact that the basic raw material in Portland cement is limestone, and also that calcination takes place at higher temperatures of 1,400-1,500 degree Celsius.

Presently, research in the field is mainly targeting CO2 emission on two fronts, carbon capture and alternate cements.

Production of alternate cements utilising substitutes for limestone that give out lower CO2, and materials which get calcined at lower temperatures, are being studied. Production of alternate cements using existing Portland cement manufacturing technologies would be an added advantage.

Various technological advancements envisaged in the future for CO2 emission control are:

i) Carbon capture and storage (CCS)
ii) Alternate cements

- (1) Calera process
- (2) Novacem
- (3) Calix
- (4) Geopolymer cement
- (5) Aether
- (6) Limestone Calcined Clay Cement (LC3)

iii) Clinker substitution
iv) Alternate fuels
v) Non fossil fuel base power
vi) Energy efficiency

b) SOx

i) Raw Mix optimisation
ii) AI based process control
iii) Injection of hydrated lime to the kiln feed or directly in the second stage cyclone riser
iv) Gas suspension absorber

c) NOx

i) Low NOx burner
ii) Non-contact combustion in calciner
iii) SNCR

d) Non-conventional energy

2) Green Plants

a) Vertical Gardens
b) Elephant Grass
c) Zero-energy treated water curtaining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Plant Maintenance

Whereas process control and automation ensures quality product, maximised production, and production at optimum cost, plant maintenance ensures that the plant actually operates and does so efficiently, effectively and economically.

Generally, the technological advancements in plant maintenance have been driven by low MTTR, higher MTBF and condition monitoring.

It is expected that future technology advancements in plant maintenance will be driven by need for low MTTR, higher MTBF, AI-based diagnostics and cloud-based monitoring. Some of the likely changes include:

1) New generation of condition monitoring sensors with wireless communication protocol interfaced with plant control and automation system, production planning, and inventory

2) AI-based diagnostics & failure prediction

3) Cloud-based monitoring by OEM with real-time solutions

Conclusions

In the past, technological advancements in cement production were mainly driven by the singular focus of improving energy efficiency. However, future technology advancements are also likely to be shaped by operational optimisation, quality control, and statutory regulation related to environment control.

The horizon for commercial usage of new technologies will be strongly influenced by cost-return economics and stringent statutory regulations.