Plant of
the Future
Industry 4.0 for cement
& building material manufacturers

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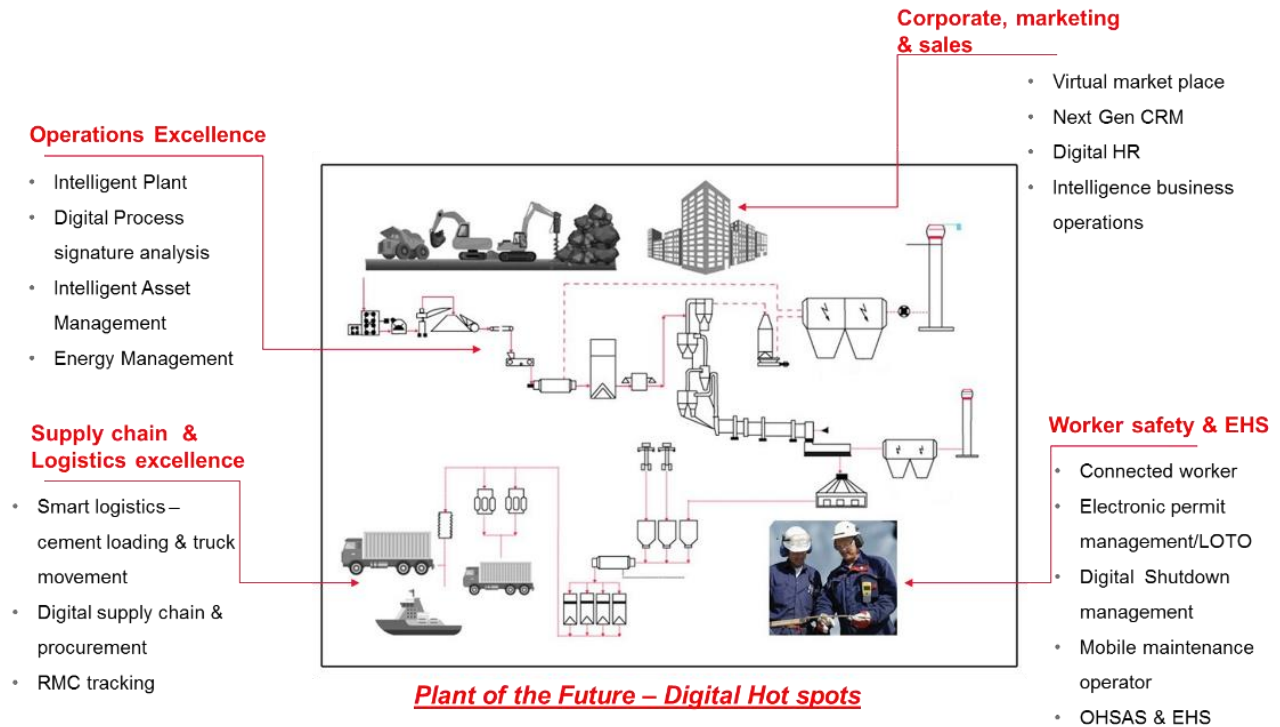Principal consultant, Process - Manufacturing

Cement and building material industry is asset intensive and energy intensive associated with high levels of emission. Cement and building material producers can better handle rising cost challenges related to energy consumption, process complexities, maintenance complexities, EHS & other regulatory compliance etc.by leveraging Industry 4.0/smart manufacturing principles i.e. *interoperability, information transparency, technical assistance and decentralised decision making* .

Applying the above mentioned Industry 4.0 principles along with new age technologies will lead to Manufacturing excellence in cement ,gypsum & other building material production in following ways-

- Adoption of data backed decision making culture rather than depending upon past experience / plant engineer's gut feeling. This can be achieved by leveraging *Internet of Things (IOT), Artificial intelligence (AI)/Machine learning (ML)/Deep learning (DL) techniques* for analysing process complexities in pyro processing, grinding , mining and quality predictions.

- Asset life extension and efficiency in plant maintenance function using **IOT, Analytics & Mobility** for predictive asset maintenance, planning & scheduling effectiveness and workforce utilization. Paradigm shift from conventional time based / condition based maintenance to intelligent asset management and performance improvements.

- Enhanced compliance on employee safety & occupational health leveraging **Wearables (smart helmet, smart tags/watch etc.)** for tracking field work force while working at confined spaces, hazardous environments etc. for their safety & productivity. Digital LOTO (Lockout/Tagout) ,Mass evacuation in case of emergency.

- Address Knowledge management risks with in enterprise due to ageing work force and on job training of new joinees related issues through **Virtual Reality (VR)** technique. Improve the work efficiency of field work force and reduction of rework using **Augmented Reality (AR).** Cross functional & remote collaboration for critical work are key success factors for efficient work managemen.

- Efficient supply chain, collaboration, transparency & visibility across partner eco system – Raw material suppliers, logistics providers, distributors & consumers (B2B/B2C) leveraging **Blockchain & IOT** .

- Leveraging **Robotic Process Automation (RPA)** to automate all back-office operations across the S2P value chain.

The **Plant of the Future** will be *approx.15-20 %* more efficient than conventional cement plant by adopting below mentioned "**digital hotspots** " -

Plant of the Future – Digital Hot spots

The following labels appear around the diagram:

Operations Excellence
- Intelligent Plant
- Digital Process signature analysis
- Intelligent Asset Management
- Energy Management

Corporate, marketing & sales
- Virtual market place
- Next Gen CRM
- Digital HR
- Intelligence business operations

Supply chain & Logistics excellence
- Smart logistics – cement loading & truck movement
- Digital supply chain & procurement
- RMC tracking

Worker safety & EHS
- Connected worker
- Electronic permit management/LOTO
- Digital Shutdown management
- Mobile maintenance operator
- OHSAS & EHS

Intelligent Plant:

Integration of plant floor to enterprise applications across value chain (from mines, pyro processing to cement/gypsum production) for real time visibility/feedback across enterprise for effective decision making in real time. Intelligent plant will provide single source of truth on plant performance Key performance Indicators like how much limestone is mined, stacked & yard, plan vs actual, mining equipment status , stocks of raw meal ,clinker & cement along with bad actors. Intelligent plant will allow to focus on how effectively lime stone mined, crushed, ground & clinker /cement produced rather than how much quantity mined & produced.

Energy cost is major cost component of total cement production cost and is approx 45 % of TCO. Intelligent plant allows cement manufacturers to monitor the different sources of energy (coal, alternate fuels etc.), consumption, losses along with process variations to effectively control & optimize the consumption.

Digital Process signature analysis:

Cement & building material production process is very complex. Vast set of process variables like raw material quality i.e. Limes stone, Gypsum & other additives, coal chemical properties / other fuel properties, equipment conditions etc. play key role in achieving desired quality of clinker / end product- OPC/PPC/PSC at optimal cost. Conventionally   Plant managers work to optimize these variables at each stage in the process based on experience and prior knowledge. This approach has its own limitations.

The digital process signature analysis is digital representation of entire production process including equipment behaviour from the data collected from various physical sensors and soft sensors(derived /calculated values) and define "golden batch – ideal operating envelop" using AI/ML/DL techniques. This will help in predicting the quality of clinker /cement in real time manner, which allows to control the impacting parameters for maintaining the quality in optimal conditions.

Ex: In one of our recent engagement with leading cement manufacturer, we come across peculiar problem of abnormal exit gas temperatures at TA duct & heat loss challenges in one of cooler. Client has 2 lines of clinkerization and having KHD-PFC 862 cooler at both lines. In one line, cooler Exit gas temperature is in the range of 340-350°C where as temperature should be in the range of 280-290°C as per design. Since ESP (Electro Static Prespitator) can't handle such high temperature gases, water spray is used to control the temperature. This is leading to heat loss of approx.10 kcal/kg of clinker. But this is not case for same make & type cooler operating in line-2 of same plant. Such problems can addressed by digital process signature analysis by carefully analysing the vast set of pyro process parameters using AI/ML and identifying the bad actors / anomalies.

Predicting the clinker / cement quality in real time and control, Energy optimization, recipe management etc. are typical use cases for digital process signature analysis.

Intelligent Asset Management:

Monitoring the asset condition monitoring & operating parameters to predict the asset deterioration & remaining useful life (RUL) of the equipment/component , develop proactive Asset strategy & performance management leveraging IOT, Machine learning(ML) & Deep learning (DL) algorithms. Using this information, companies can proactively schedule maintenance during times of least impact and avoid unexpected & costly downtime. Link the asset condition to MRO inventory /spares management & Design out maintenance for optimizing the MRO spend as well as asset life extension. Leverage Augmented Reality & mobility for timely execution of maintenance activities, minimizing the re-work and addressing the challenge of skilled worker shortage. Paradigm shift from conventional time based maintenance to predictive & prescriptive maintenance.

IAM, if implemented correctly can bring the benefits – improving the OEE/plant availability by 10-15 %, extending the asset life by 15-25 % there by reducing the maintenance capex costs and reduction in MRO spend by 10-20%.

Digital shutdown Management:

Although this is regular phenomena, execution of shutdown as per schedule & cost in safe & reliable manner is challenging task for plant managers. Integrated shutdown management solution with functionalities – Theory of constraints (TOC) based planning + connected worker(IOT/wearable) + analytics for real time monitoring of shutdown activities will help cement plant managers in timely completion of shutdown in safe & reliable manner , controlling the costs , monitor worker productivity , monitor the contractor performance and manage the contractor billings effectively.

Tech Mahindra helped leading cement manufacturers and petrochemical companies in optimizing their shutdown schedule & cost up to 25% through integrated shutdown management & TOC approach.

Connected worker /Digital worker:

Leveraging Wearables like smart watch, body sensors, gas analysers for workers working at remote places like mines, confined spaces like mill inside, cyclones, inside silo and at elevator pits for their safety & security. Additionally monitoring of their productivity. In case of contractor workforce, link this to invoices & contractor billing & payments.
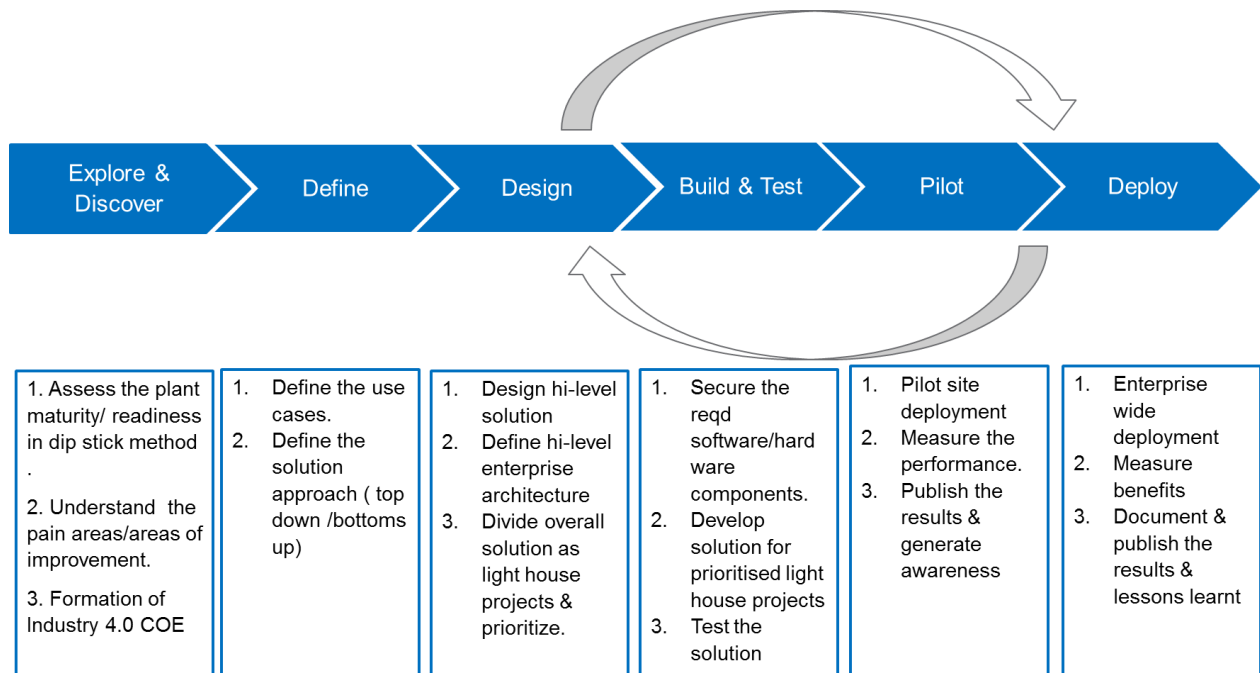
RMC Tracking:

Ready mix concrete is highly perishable nature; agility holds the key to deliver quality RMC as buyers are not only time sensitive but also spread across multiple locations. Leverage IOT+ scheduling solution to addresses all aspects of RMC supply chain i.e. Order management, Job Scheduling, routing to complete monitoring of the process - loading of the concrete mix to the delivery at the customer site. Monitor the location & speed of the vehicle, RPM of the Drum of the Transit Mixer, Water Level inside the Drum of the Transit Mixer.

Tech Mahindra has built end to end RMC tracking solution for leading cement manufacturer. This solution helped the customer in improving on time deliveries by 16% and reduction in pilferages and quality rejections.

Putting "Plant of Future" into Practice

Main challenge for the organizations is where do start this industry 4.0 adoption journey. Organizations having multiple plants having different levels of plant maturities in terms of automation, business practices & work culture. Success of such transformation programme will critically depend upon how we can able to bring all these plants to common level of maturity & understanding.

Suggested approach for "Plant of the Future" across enterprise having multi-site /Geography is

Explore & Discover	Define	Design	Build & Test	Pilot	Deploy
1. Assess the plant maturity/ readiness in dip stick method . 2. Understand the pain areas/areas of improvement. 3. Formation of Industry 4.0 COE	1. Define the use cases. 2. Define the solution approach (top down /bottoms up)	1. Design hi-level solution 2. Define hi-level enterprise architecture 3. Divide overall solution as light house projects & prioritize.	1. Secure the reqd software/hard ware components. 2. Develop solution for prioritised light house projects 3. Test the solution	1. Pilot site deployment 2. Measure the performance. 3. Publish the results & generate awareness	1. Enterprise wide deployment 2. Measure benefits 3. Document & publish the results & lessons learnt

This should be achieved through top-down approach (peculating down the organization strategy) and bottom-up approach (addressing stakeholders challenges/ focus areas/ aspirations etc.) in hybrid manner leveraging Design thinking Principles.

Design Thinking plays key role in aligning the divergent stakeholder point of view and converging the " Plant of future" initiatives to " day in life" challenges of different function stakeholders like operations, quality, maintenance, mining, SCM & logistics etc.

Tech Mahindra Industry 4.0 COE has defined robust industry 4.0/ plant of future maturity assessment model to identify the potential areas & "low hanging fruits" for adopting plant of future digital hot spots for quicker return on investments (ROI). Author has conducted such assessments and defined roadmap for leading process manufacturing clients including cement & chemical companies.

About the Author:

Rajesh is Industry 4.0 solution architect and lead consultant with hands on experience in designing and implementing manufacturing industry specific solutions leveraging domain expertise and digital technologies. Worked with Accenture, IBM, TCS, SKF & Lafarge in various capacities as COE lead, practice head, program manager & solution architect. Currently working as industry solution architect –Manufacturing in Tech Mahindra.