

AI in Cement manufacturing – Holistic approach

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Abstract - The cement industry contributes significantly to global CO2 emissions and energy consumption. This paper investigates the potential of a holistic AI-driven approach to enhance sustainability and improve maintenance strategies within this sector. By integrating foundational process improvements with advanced AI technologies like Machine Learning-based Model Predictive Control (ML-MPC) Digital Twin, Predictive Maintenance and AI powered Safety Alarm based on Video analytics, we aim to optimize operations, reduce energy consumption, and minimize environmental impact.

This holistic approach emphasizes a strong foundation of process and operational improvements prior to AI implementation. This ensures optimal baseline performance, maximizing the impact of subsequent digital optimization efforts, including predictive maintenance strategies. The integration of a Digital Twin, evolving through stages from asset modeling to a connected system of interconnected models, facilitates visualization, predictive analytics, and seamless optimization of complex processes, enabling proactive maintenance interventions, and improving overall operational reliability.

ML-MPC leverages data-driven models to overcome limitations of traditional MPC. Its key advantages include:

- Adaptability to dynamic conditions
- Improved accuracy in complex systems
- Reduced model complexity
- Enhanced computational efficiency

A real-world case study demonstrates the application of these AI techniques in a cement factory, focusing on kiln and grinding circuit optimization with a sustainability emphasis and its impacts on maintenance strategies and outcomes. The study addresses critical challenges, including data quality, model training, and interdisciplinary collaboration between AI experts and industry professionals.

Results demonstrate significant improvements in energy efficiency and emissions reductions, along with substantial economic benefits, including reduced downtime through optimized maintenance scheduling. This research highlights the transformative potential of AI in revolutionizing the cement industry, making it more sustainable, economically viable, and improving overall operational reliability.