Alternative Fuels, Boosting TSR and Efficiency in Cement Plants Using CFD-Based Engineering

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Abstract - The cement industry is increasingly driven to reduce cost, energy consumption, and carbon emissions, primarily through the replacement of fossil fuels with alternative fuels (AF). However, the transition to higher thermal substitution rates (TSR) introduces complex challenges, including process instability, variability in product quality, increased CO and NO_x emissions, and reduced operational efficiency. Additionally, the heterogeneity and inconsistent availability of AFs pose significant issues on combustion behavior.

To address these challenges, existing process equipment—originally designed for fossil fuels and low TSR combustion—requires adaptation to accommodate altered flow and combustion dynamics. Advanced Computational Fluid Dynamics (CFD) is a critical tool in this context, offering predictive capabilities to analyze heterogeneous flow fields, temperature distributions, and chemical reactions within kilns, calciners, and preheaters.

This study presents several industrial case studies with major cement producers where Advanced CFD was employed to identify performance-limiting phenomena and develop targeted process modifications. These modifications, often low in capital expenditure, enabled improved combustion stability, reduced emissions, and increased TSR. The results highlight the effectiveness of Advanced CFD-assisted process engineering in optimizing cement production under alternative fuel regimes, emphasizing the need for tailored models based on specific fuel properties and operational constraints.