BI-OBJECTIVE OPTIMIZATION OF A TUNNEL KILN OPERATION FOR CERAMIC ROOF TILE PRODUCTION

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ABSTRACT

Clay ceramics have traditionally been used as building materials for centuries. Their applicability is highly dependent on the microstructure and composition of the raw material, which typically contains clay, quartz, sand, lime, feldspars along with other minerals [1]. Clay ceramics are aesthetic, hard and highly durable materials with thermal insulation properties. These technical properties result from a series of physicochemical transformations and sintering that take place inside the material during the firing process [2,3]. The firing process holds paramount importance in the ceramic industry, playing a pivotal role in developing the desired mechanical strength and establishing the final product quality. However, this process requires subjecting the ceramic products to high temperature treatment, rendering the ceramic industry as a highly energy intensive sector. Notably, it is estimated that 55% of the total thermal energy used in the ceramic industry is consumed in the firing process [4].

This study employs a model-based, multi-objective optimization approach to examine strategies for energy-efficient production of ceramic roof tiles in an industrial-scale tunnel kiln. The study introduces a systematic methodology to generate trade-off solutions between kiln productivity and thermal energy consumption in the burners of the kiln, thereby producing a set of non-dominated solutions. These solutions aim to enhance kiln efficiency and lay the foundation for a more sustainable ceramic roof tile production process. A notable aspect of this study is the incorporation of clay material densification, with the establishment of its sintering kinetics mechanism based on firing tests conducted on a laboratory-scale oven. The integration of the sintering kinetics model into the optimization problem ensures that the maximization of objectives does not compromise the quality of the firing process. This approach provides a more comprehensive perspective on tunnel kiln optimization, offering practical relevance to the derived results. The proposed optimization framework may serve as a valuable tool to assist operators in the intricate decision-making process, presenting optimal operating policy choices in response to changing production demands.

KEYWORDS: optimization, trade-offs, ceramic roof tiles, sintering, kiln.

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