

# Product quality driven design of bakery operations using dynamic optimization

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## Abstract

Quality driven design uses specified product qualities as a starting point for process design. By backward reasoning the required process conditions and processing system were found. In this work dynamic optimization was used as a tool to generate processing solutions for baking processes by calculating optimal operation strategies which give a basis for process and unit operation design. Two different approaches for dynamic optimization had been applied: calculation of continuous trajectories based on the calculus of variations (1) and calculation of switching trajectories by using control vector parameterization (2). Optimization of bakery processes was performed for different product specifications and by using different heating sources: convective, microwave and radiation heating. Moreover, effects of variations in dough properties on the optimal processing system were also evaluated. The results showed that dynamic optimization procedures were versatile tools to achieve a better and a more flexible design by generating a number of solutions from the specified final product qualities. Furthermore, the results underpinned the well known empirical fact that different final product specifications require different baking strategies. It was also shown that the initial dough properties have significant effect on baking procedures, and that combining several heating inputs improved the flexibility of the process operation. In addition, optimization for continuous trajectories gave overall a better result than using the switching trajectories.

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## 1. Introduction

During their passage through a chain of processing equipment, raw food materials are transformed into the final products. Product quality develops due to the process conditions and treatments to which the raw materials are exposed. At the end of the chain the product quality should meet the product specifications.

The standard procedure for process design starts from the raw materials, for which a number of unit operations are put in the required sequence. The conditions are chosen

in such way that the required product qualities are more or less obtained. This approach is mostly driven by experience and knowledge of the equipment.

In contrast to the standard design procedure, product quality driven process design starts from the specified product quality and searches in the backward direction using a systematic approach towards for a processing route and process conditions that satisfy the requirements. In this approach knowledge of the fundamental process underlying product (trans) formations is a main factor. To support the backward reasoning procedure, a solution generator is required, i.e. an algorithm that searches for the best process conditions throughout the equipment to obtain the product quality attributes.

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