Contribution ID: **51** Type: **not specified**

Cost-Efficient Experimental Planning for Optimizing Multistage Processes: An Application to the Production of Potato Fries

Design of experiments (DoE) is a cornerstone methodology for optimizing industrial processes, yet its application to multistage processes remains underdeveloped, particularly in cost-constrained contexts. We present a methodology for cost-efficient experimental design tailored to such contexts, illustrated through a case study in potato fry production.

Potato fry production involves a series of interdependent stages. This study examines three critical stages: the two boiling steps and the frying step. Temperature and residence time are the key factors studied in each of these stages, as they not only significantly impact product quality but also determine the time required for each run of the production process. Notably, cooling transitions take longer than heating, and residence time defines the run length, making time the primary constrained resource.

Our approach integrates DoE principles with optimization algorithms to generate designs where run costs vary dynamically based on selected factor levels, creating experimental designs that maximize resource efficiency without compromising statistical efficiency. Moreover, these designs offer enhanced adaptability to the unique requirements of diverse experimental settings, thereby accelerating the integration of DoE into multistage industrial applications.

Our preliminary results demonstrate substantial gains in cost-efficiency and statistical performance, evidenced by optimized budget utilization and enhanced precision in parameter estimation. Our ongoing research focuses on validating and further developing this methodology at the UGent Veg-i-Tech pilot plant and with the support of the Belgian potato industry. Beyond food production, our methodology offers broad applicability to industries with variable run costs, such as chemical manufacturing, energy production, and pharmaceutical development.

Special/ Invited session

Classification

Both methodology and application

Keywords

Design of Experiments, Multistage Optimization, Food Industry

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Track Classification: Design of Experiments