

Hybrid modelling of Ohmic Heating system dynamics by integrating mathematical and physical components in MATLAB (Simscape)

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Food processing industry is a major manufacturing sector that is considered to be largely responsible for energy consumption and greenhouse gas (GHG) emissions. Therefore, alternative technologies to conventional heating methods are being developed for deployment in the food processing industry. Ohmic Heating (OH) is one of the volumetric heating technologies that uses Moderate Electric Field (MEF) processing system for heating food products effectively using electricity only. This can provide a solution to the food and drink industry to improve energy efficiency and decarbonise their food manufacturing processes. Various mathematical ohmic heating models have been developed to investigate and study the effect of numerous parameters on different types of food products over the years. However, not much attention has been paid to physical model-based designs of these Ohmic Heating systems. A model-based design can more accurately reflect the physical characteristics (such as, convective currents during the flow, product mixing, backflow, etc.) that are challenging to model mathematically. Hence, physical model-based simulations are essential to analyse the impact of processing dynamics in MEF-based Ohmic Heating. In this research, a model in MATLAB using the Simscape toolbox is developed to study the effects of MEF heating technology with respect to various physical conditions of the food product. Furthermore, the model is validated against an established mathematical model and a commercially designed continuous ohmic heater with mean square error value of ± 0.4 . The validated model can effectively simulate temperature variations with the change in thermophysical properties of the food product. It also allows to evaluate system dynamics in real-time scenarios. Moreover, the developed model is capable of investigating the effects of several significant characteristics on MEF-based Ohmic Heating of food products, such as the electrical conductivity, product temperature, density, flow rate, and magnitude of the applied electric field. Therefore, this simple but effective physical model is an optimal approach that can be used in model-based control system design to improve the performance and energy efficiency of the Ohmic Heating processes.