Modelling and Simulation of Multiphase Pulsed Electric Field (PEF) Applications

Tobias Horneber, Cornelia Rauh
Department of Food Biotechnology and Food Process Engineering, Berlin Institute of Technology
tobias.horneber@tu-berlin.de, cornelia.rauh@tu-berlin.de

Abstract

For several years, the technology of pulsed electric fields (PEF) is used in the food industry for tasks of product-friendly disinfection, as well as disruption of intact biological cells and tissues for ingredient release. Depending on the field of application (treatment of fruit juice, mash, or whole fruits like apples or tomatoes) various flow treatment chambers have to be optimised from lab scale up to industrial scale (mass flows up to 4 t per h). Amongst other things the flow profile, a homogeneous distribution of the electric field, total energy intake, and inactivation of microorganisms are optimisation criteria. Based on previous work (Krauss et al. 2011, Meneses et al. 2011) the C++ open source framework OpenFOAM was used and modified for the coupling and solving for the balancing equations of thermo-fluid dynamic (mass, momentum, energy) and electrostatic (charge conservation) by a finite volume technique. All material parameters (density, viscosity, thermal and electrical conductivity,. . .) are temperature dependent. Different treatment chambers are compared and characterised (collinear, coaxial, plate-plate). Additionally, for the case of the treatment of whole fruits (e.g. tomatoes, apples) a multi-physics solver (solid and fluid) was implemented which enables the detailed analysis of local effects regarding electric field strength and temperature. Finally a transport equation for the survival rate of e.g. cell stability or enzymes is coupled to the solver predicting the effect of the pulsed electric field on the product.

References

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