Using Moving Particle Simulation approach to investigate mechanical and thermal stress profile in a twin screw extruder

ELLWANGER F. (1), PERNICE L. (1), KARBSTEIN H. (1), EMIN A. (1)
1 Karlsruhe Institute of Technology, Karlsruhe, Germany

Current trends in the food industry and research are focused on the development of sustainable and functional foods, such as meat substitutes. Twin screw extruders are frequently used here to mix the raw materials used with water and to functionalize, shape and texture the matrix. The properties of the resulting products are influenced, both, by the mechanical and thermal stress profile in the screw section and the flow conditions in the die section. While the various influencing parameters are known, a fundamental mechanistic understanding of the processes in the extruder is lacking. Accordingly, product and process development in industry is largely based on the trial-and-error principle, which requires a high level of resources and usually offers no solution for complex food systems.

In this work, we address this problem by applying numerical simulation methods that allow a detailed analysis of process conditions. The advantage of this approach is that properties relevant to food systems can be determined, some of which are not measurable in experimental investigations.

We present a Moving Particle Simulation (MPS) model that we set up to examine the flow of a protein-water mixture through a laboratory scale extruder. The MPS model was used to establish a relationship between residence time and degree of filling. By varying the screw configuration under otherwise constant process conditions, a different degree of filling was realized. It was found that the mechanical stress history experienced can be related to the degree of filling in the extruder. In addition, the thermal stress history in the extruder could also be considered using the energy equation.
The results obtained help to build a fundamental mechanical understanding of the processes in the extruder. Furthermore, the data can be used to perform a targeted scale-up.