

9th World Congress on

MATERIALS SCIENCE AND ENGINEERING

June 12-14, 2017 Rome, Italy

Computational investigation of the kneading process of bread dough

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A key step in the production of bread is the kneading process. The aim of this process is to form the gluten network and to bring air into the dough. While too little kneading results in dough with limited gas storage capacity, too much kneading can destroy the gluten network, impairing the dough's ability to rise. There is a connection between the rheological properties of kneaded dough and the final quality of bread. Since scientific basis is lacking, the industrial kneading process is currently controlled using visual and haptic information from experienced personnel. Therefore, the goal of this project is to investigate the kneading process using CFD. For the rheological description of the dough, we used a new model developed by Tanner et al. (2011). We determined the exact values of the model parameters by fitting the model to small amplitude oscillatory shear, stress relaxation, transient simple shear, and uniaxial compression data. In the dough model, a so-called damage function is used to describe the partial degradation of the starch and the proteins during the deformation. We have slightly modified this function to prevent a drastic decrease in the moderate deformation range. With the help of this modification, we obtained an excellent agreement with the experimental data (see Fig. 1). Due to its complexity, the dough model has not yet been solved for an inhomogeneous flow field. In this talk, we will present the first results of such a simulation, performed in the annular gap between two eccentric cylinders. This benchmark geometry is an idealized form of a kneader. We will discuss the numerical solution strategy that we have implemented in OpenFOAM. A further focus will be the relative influence of the rotational speed on the shear and extensional deformations.

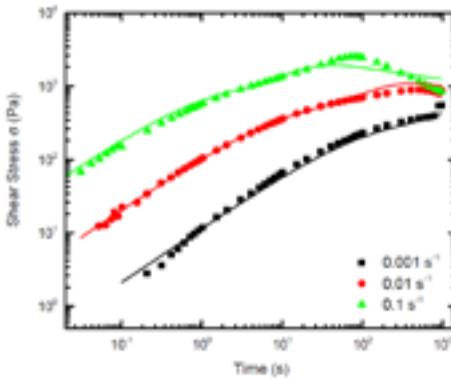


Fig. 1. Startup of simple shearing flow performed at a constant shear rate $\dot{\gamma} = 0.001$, 0.01 , and 0.1 s^{-1} . Comparison between experimental data (symbols) and model predictions (solid lines).

Biography

N German research group focuses on the rheology, i.e., the flow behavior, of viscoelastic fluids that are of industrial relevance. The reason for the unusual rheological properties of viscoelastic fluids is their microstructural dynamics. To establish a more fundamental understanding of viscoelastic fluids, her research group investigates the relationship between their rheology and their microstructure. The research approach combines thermodynamic modeling and numerical simulation with laboratory experiments. Professor German studied food science at ETH Zurich. In 2011 she received a PhD from the same institution. From 2011 to 2014 she worked as a researcher and lecturer at the University of Delaware, USA. Since 2014 she has been assistant professor for fluid dynamics of complex biosystems at TUM. She has acquired international experience in the USA (University of Delaware), Australia (University of New South Wales), and Japan (National Food Research Institute).

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