Modeling of Coupled Mass and Heat Transfer and Expansion During Baking of Bread in a Mould

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Abstract

Introduction:
Bread is a food product which various complex physico-chemical phenomena occur during the cooking process. Thus, phenomena of heat and mass transfer are coupled to the deformation. In addition, bread is a multiphase product (solid, liquid and vapor) and composed of various components (dry matter, water, air and carbon dioxide). This model will permit to have a better knowledge and comprehension of the main phenomena and their relative weight occurring during the baking process. Finally, modeling the cooking step can control and optimize the industrial process.

Use of COMSOL Multiphysics®:
A 2D model is developed with COMSOL Multiphysics® 4.3b witch simulate 30 minutes baking. Taking into account principal phenomena (molecular diffusion, convection, evaporation-condensation and deformation) during cooking makes a complex and strongly coupled model. Indeed, the calculated states variables are liquid water, liquid carbon dioxide and dry air contents, solid volume fraction, temperature and the velocity field witch appear in PDE system. Algebraic equations corresponding to thermodynamical equilibrium are used to calculates vapor water and carbon dioxide contents. The algebraic differential equations system use a moving mesh ALE.

Results:
Solving the system of equations is done in 2 hours calculation (Figure 1). The temporal evolutions are compared with experimental data for temperature (Figure 2), mass loss of water, mass loss of carbon dioxide and deformation. In addition, spatial dependences of the variables are observed and analyzed (Figure 3).

Conclusion:
The model implemented with COMSOL Multiphysics® allows to simulate the baking of bread in a mould. The comparison with experimental data allows to advance on the model validation. The next step of this study is to use the model to explore new heating modes (low temperature baking).

Figures used in the abstract

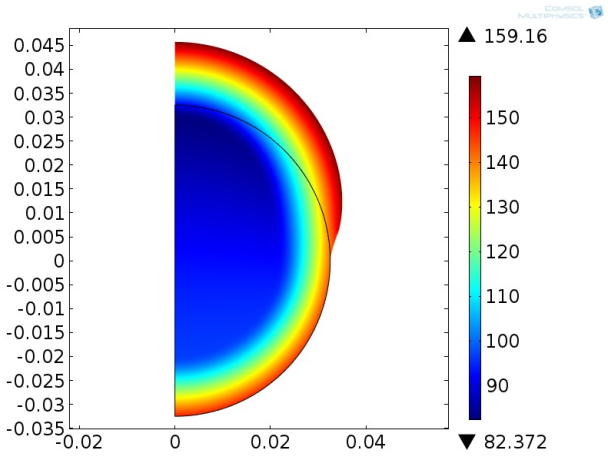

Figure 1: Temperature field at 2700s simulation.

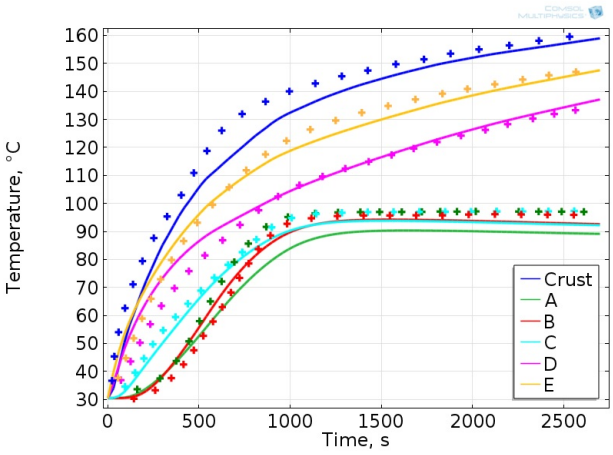

Figure 2: Temperature evolution with time.

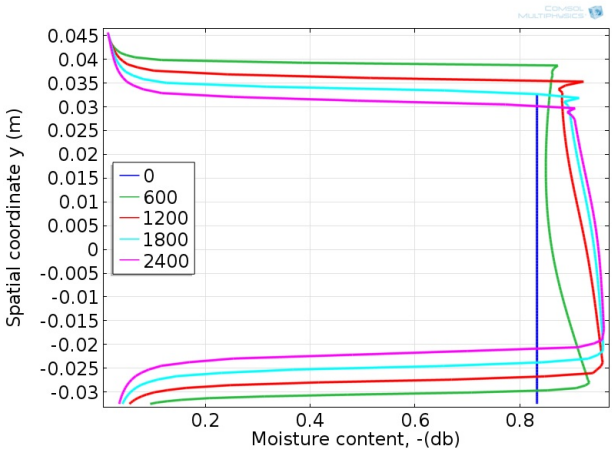

Figure 3: Moisture content evolution with space at different time.