Numerical Model for Predicting Heat and Mass Transfer Phenomena during Cake Baking

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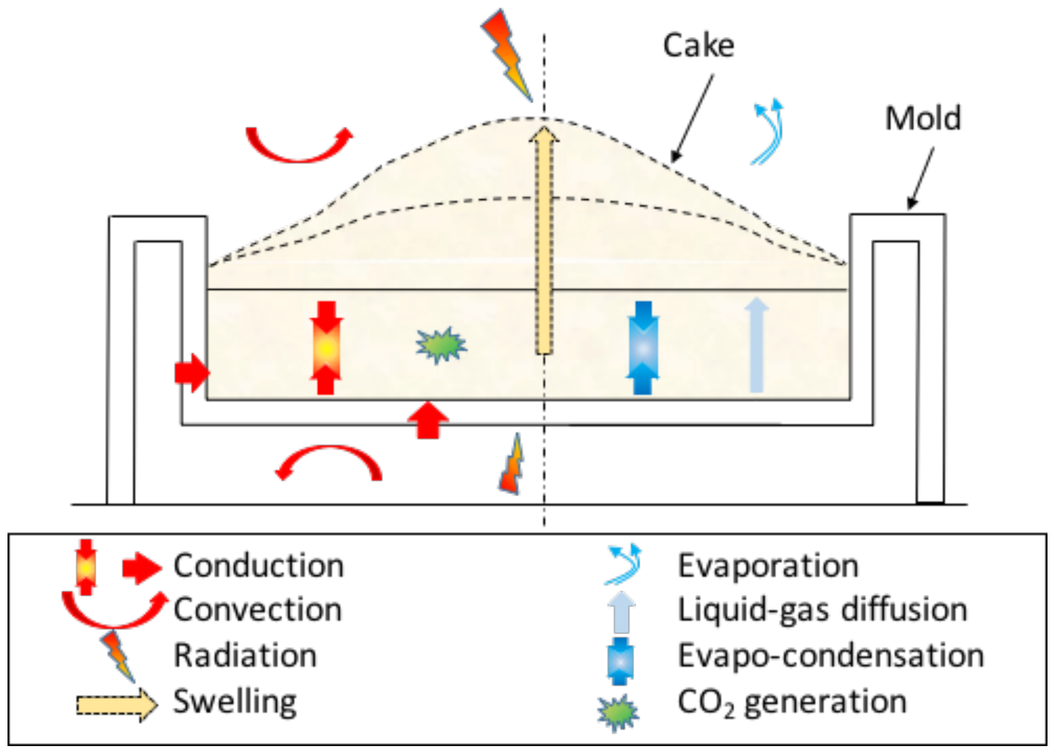
Introduction

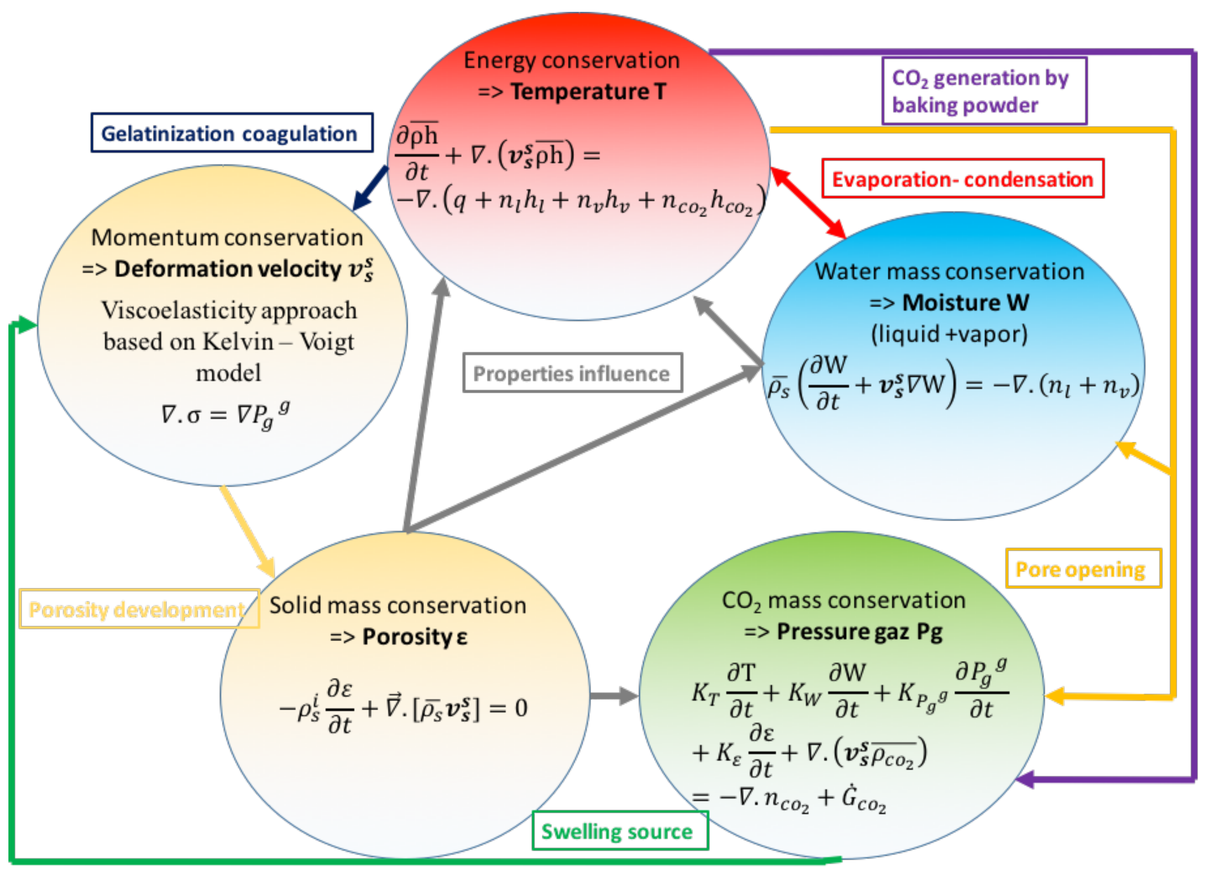
The aim of this study is to provide a numerical model for predicting heat and mass transfers phenomena as well as the swelling encountered during the baking of cake contained in mold.



Physical phenomena during baking stage

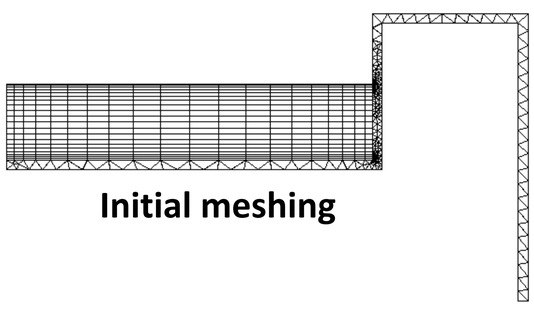
Governing equations

A transient two-dimensional axisymmetric model is implemented to simulate temperatures, moisture contents distributions and cake swelling caused by the leavening agent, Temperatures in mold are also computed. In this approach, the medium is assumed to be a deformable porous medium containing three phases: solid (dough), liquid (water) and gas. Gas phase includes two species, water and CO_2.



Governing equations and coupling

Geometry & Model implementation

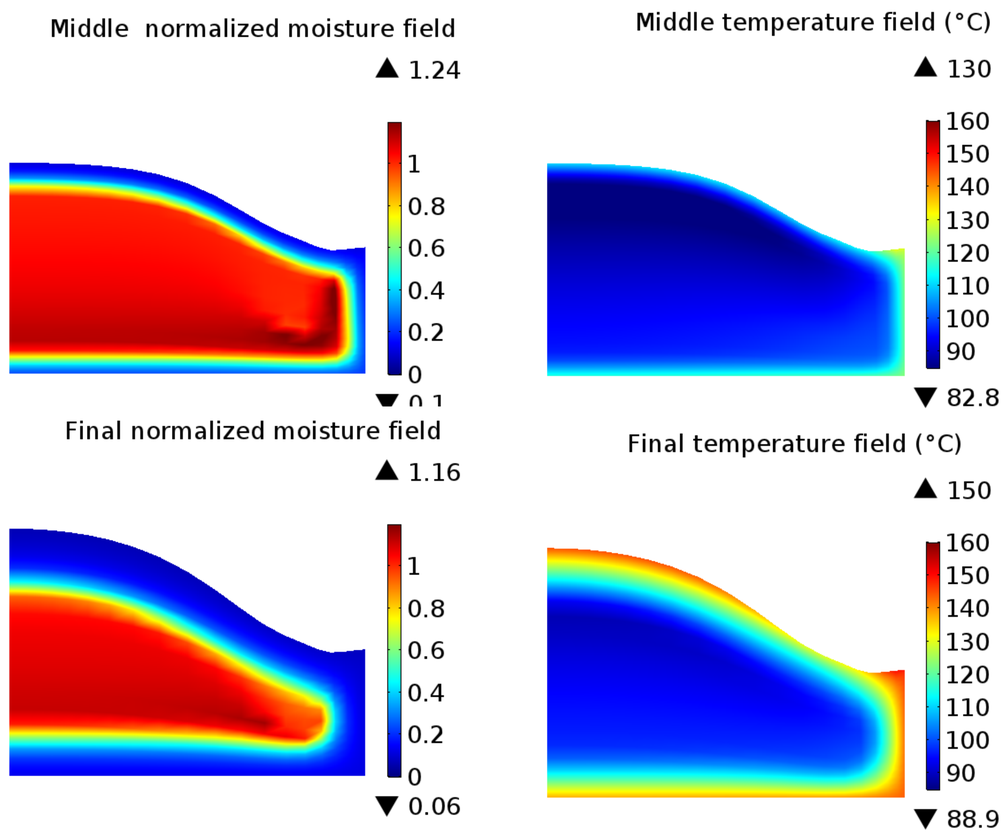


Initial meshing

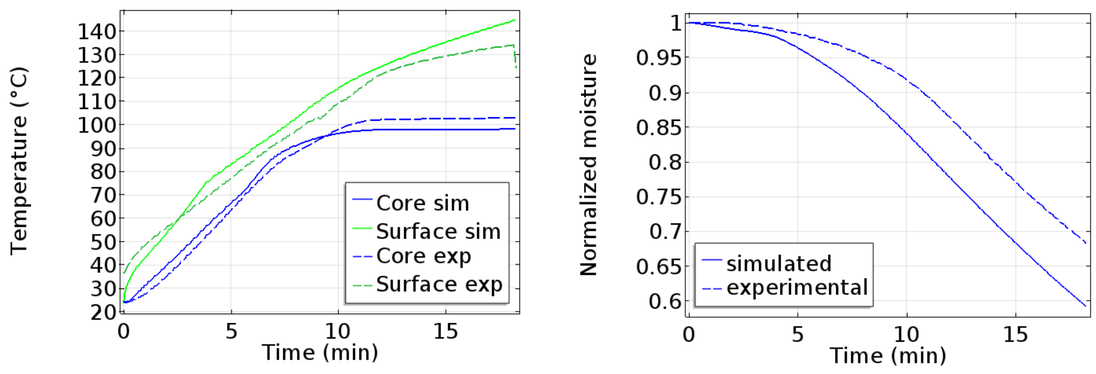
- Comsol Multiphysics 5.2
- Structural Mechanics Module
- 714 mapped and triangular elements
- ALE formulation

Results

Simulated results are compared to experimental data recorded during a typical baking stage. The studied product is baked for 18 min in an oven whose floor wall temperature is set at 175° C and top wall temperature is set at 195° C.



Temperature and normalized moisture fields at intermediate and final time



Comparison Simulation / Experience: Temperature and average normalized moisture content

Final deformed meshing and real geometry

Conclusions

- The implemented model predicts temperatures, moisture contents fields and global deformation.
- Differences between simulated and observed data are noted.
- Mass transport properties (notably, mass diffusion coefficients) must be more precisely known.
- Other mechanical constitutive laws will be tested.

Acknowledgements

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