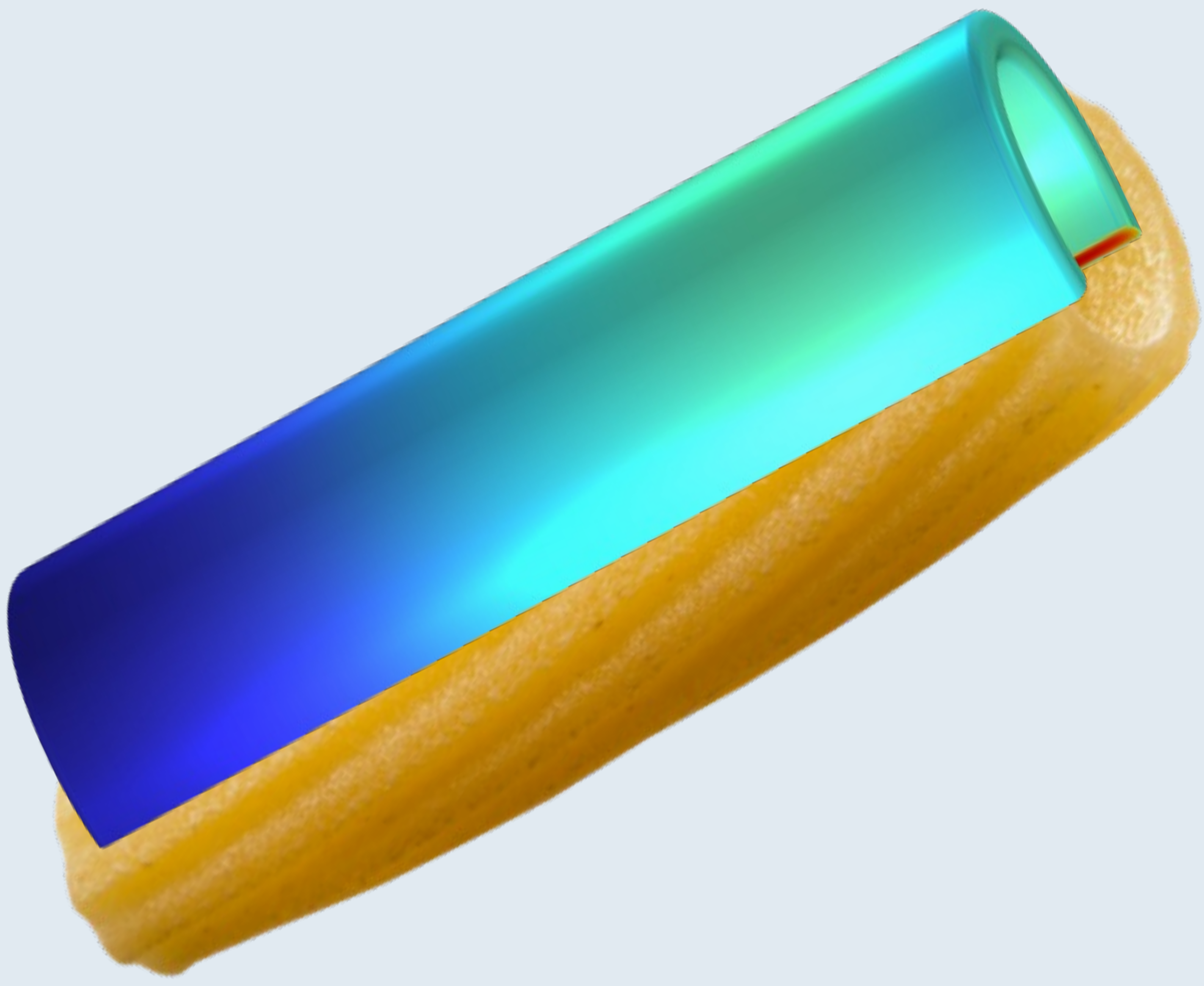

Comprehensive Analysis of Transport Phenomena Developing in a Pasta Drying Chamber

Development of a physical-mathematical model for predicting temperature, moisture distribution, and structural changes in pasta during drying under turbulent airflow.

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Abstract

In pasta drying, the process of trials needed to identify the optimal operating parameters to obtain a constant and high-quality product is often time and energy consuming. The process of forced convection consists of several phases, with air temperature and relative humidity varying within 40 °C - 90°C and 40%-85% . Air velocity also fluctuates significantly. The drying time depends on these parameters and can extend over several hours [1,2]. This study presents the development of a physical-mathematical model for predicting temperature and moisture distribution during the drying of pasta in turbulent air conditions. The model aims to optimize drying processes to ensure high product quality and safety while minimizing energy consumption. The model implements the pasta glass transition and shrinkage during drying. Simulations are carried out in a 2D geometry representative of the volume/surface ratio of a real "tortiglione".

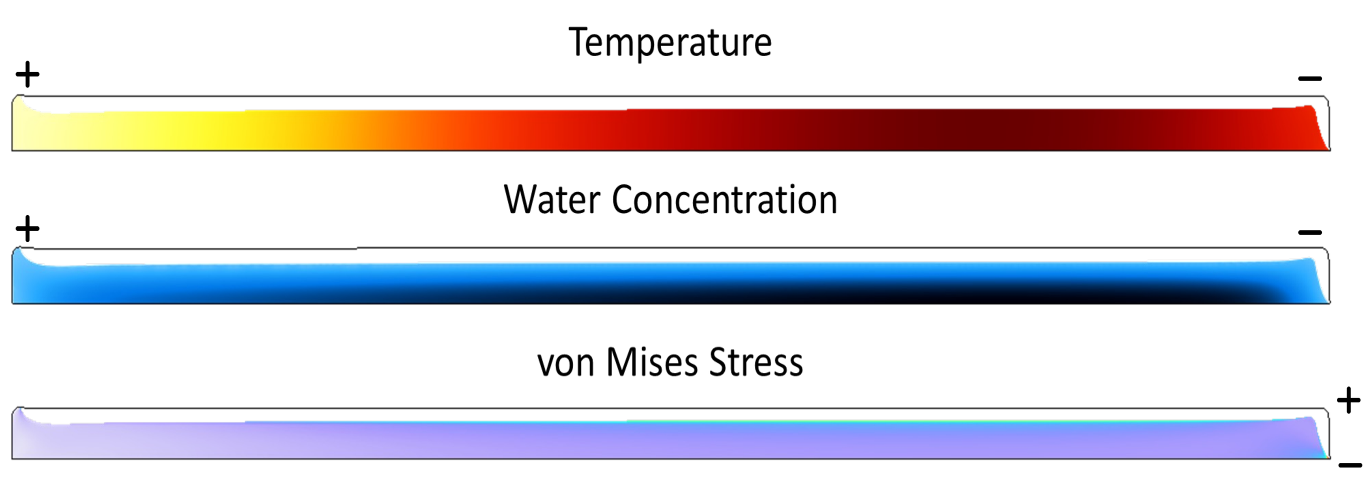

FIGURE 1. Temperature distribution, moisture content distribution and von Mises stresses within the sample. The 2D geometry is representative of the volume/surface ratio of a real "tortiglione".

Methodology

This study employs a two-domain modeling approach to estimate the temperature and moisture evolution in pasta samples during turbulent drying. The model couples heat and mass transfer equations, discretized using the finite element method in COMSOL Multiphysics. Boundary conditions are established based on the continuity of temperature and fluxes at the pasta-air interface, while transport coefficients are disregarded [3]. The model incorporates glass transition effects on the food matrix's properties [4] and accounts for food shrinkage during drying. Numerical simulations are parameterized to reflect typical industrial conditions.

Results

The model was validated by replicating the drying process in a lab-scale static drying cell, equipped with an air temperature and relative humidity control system, where a quantity of pasta was distributed over a series of stationary perforated plates. The experimental tests were performed in triplicate to ensure consistency and reliability, and the drying time was chosen to allow the system to reach a plateau in moisture removal. The models' data are in excellent agreement with the experimental results. In both the tested drying conditions, the model results give a mean relative error of less than 9%.

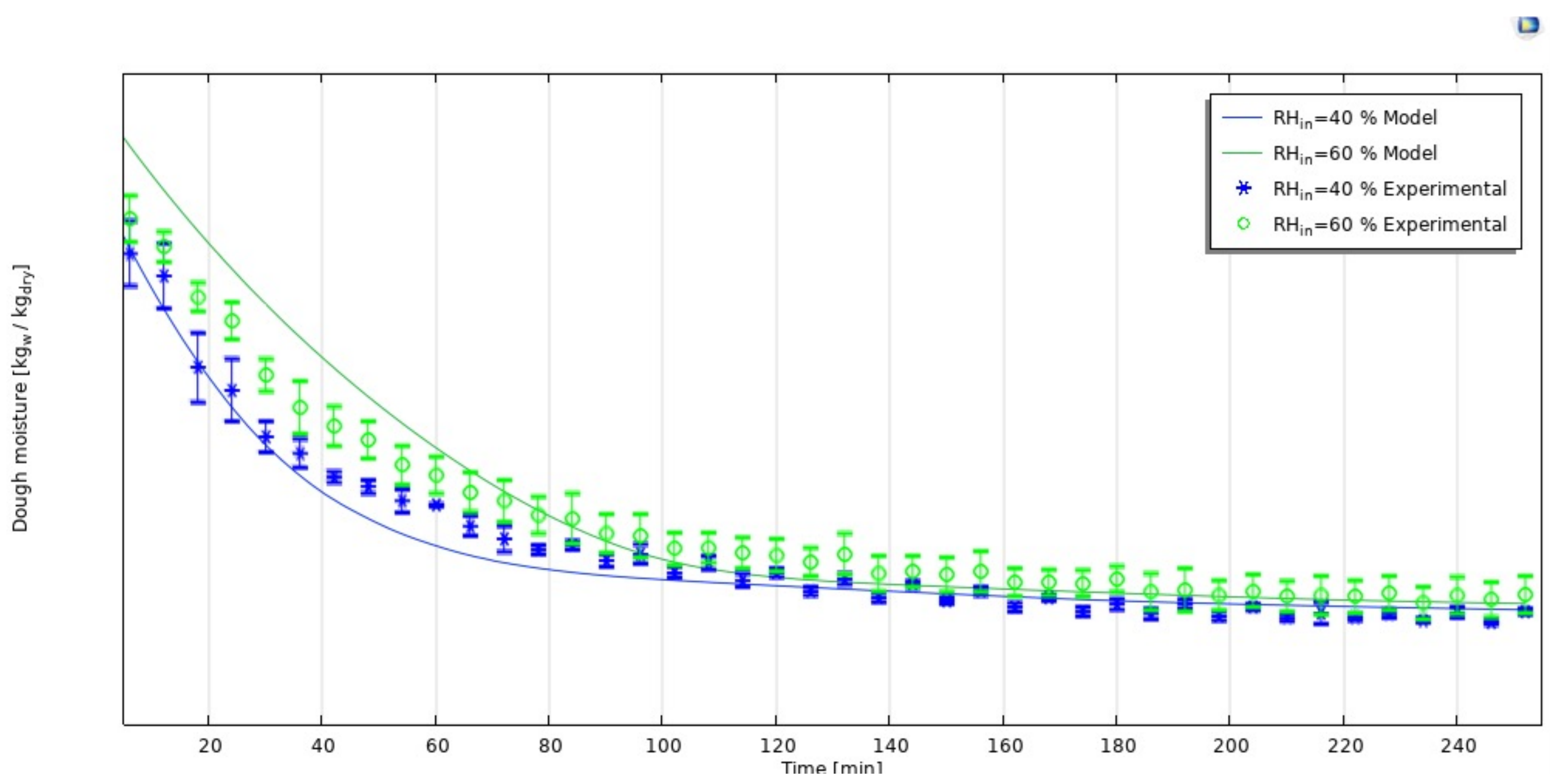

FIGURE 2. Pasta water content variation over time: experimental results versus model prediction for air relative humidities RH= 40% and RH=60% and air temperature T=90°C.

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