Multiphysics Approach of the Performance of a Domestic Oven

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Introduction: In the present study thermal analyses to improve the energy efficiency of the domestic ovens are performed and compared to experimental results. The final target of the development of the theoretical model is to better understand the heat transfer processes occurring during the oven operation [1].

Figure 1. Brick position in the UE Normative [2] for energy consumption in domestic ovens

Computational Methods: A Finite element 3D model of the heating and evaporation processes is developed using “Heat and Mass Transfer” and “Transport of Dilute Species” modules, solving the following equations [3]

$$\rho C_P \frac{\partial T}{\partial t} + \nabla \cdot (-k\nabla T) = Q$$

$$\frac{\partial c}{\partial t} + \nabla \cdot (-D\nabla c) = R$$

The main elements of the oven are represented in a three dimensional geometry that is grouped in several clusters.

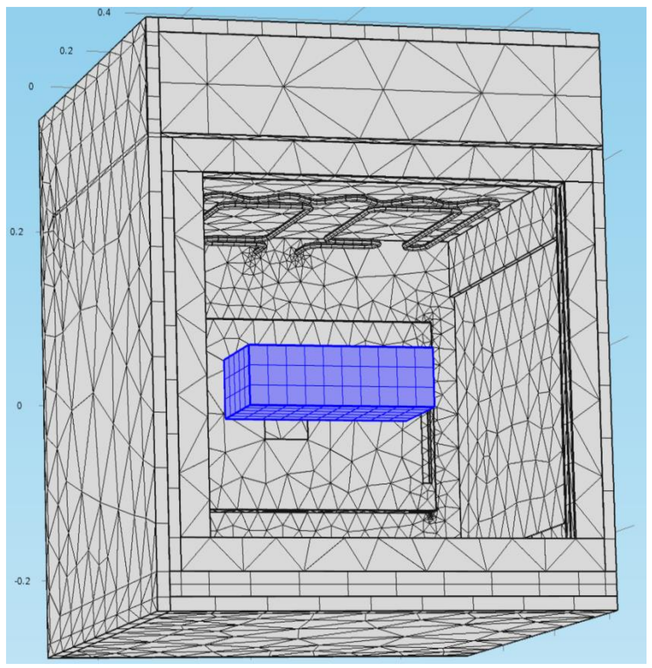

Figure 2. View of the model Finite Element grid

Results: The FEM model provides the predictions for the transient values of temperature and concentration for all the elements of the oven. The evolution of the brick temperature is validated with the experimental results of the standard energy consumption test.

Figure 3. Surface temperature predictions in the oven

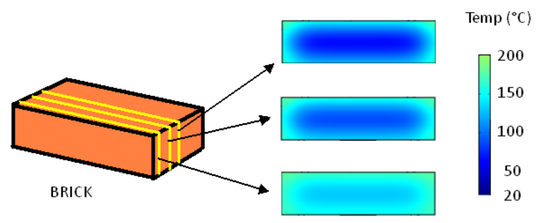

Figure 4. Predicted profiles of temperature in the brick

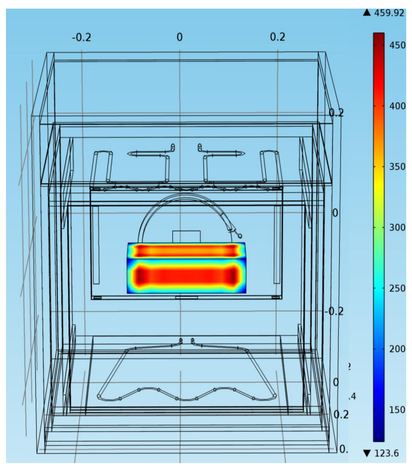

Figure 5. Predicted moisture concentration (mol/m^3)

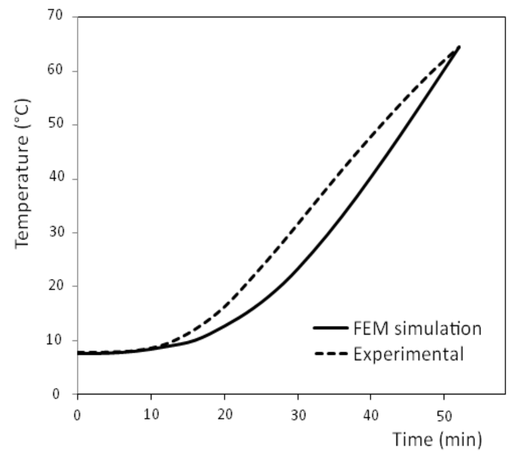

Figure 6. Brick temperature evolution: predictions vs tests

Conclusions: In this study a finite element model coupling different physics of a domestic oven is experimentally validated. This model makes possible to further study different strategies to reduce the energy consumption of an oven without decreasing the final quality of the product.

References:

1. www.iapp-greenkitchen.eu
2. CENELEC, Electric ovens for household use of methods for measuring the energy consumption, pr EN 50304 (1998).
3. A. Niro, Modelli e Simulazioni MultiFisica a Supporto della Descrizione dei Fenomeni e dei Processi che Avvengono in un Forno di Cottura. Politecnico di Milano. (2012).

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