CFD/Electromagnetics Interactions Via Realistic Heat and Mass Transfer to Moist Substrates

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Abstract

Localized convection heat and mass transfer can be intensified and optimized by providing exposure to electromagnetic energy. The rate and efficiency of heat and mass transfer can be controlled by using air jet impingement in appropriate configurations. Transient distributions of temperature and residual moisture are analyzed in this work by means of a 3-dimensional numerical model, featuring heat conduction, moisture diffusion, flow field effects and volumetric heat generation as resulted from application and solution of coupled energy, Fick's, Navier-Stokes and Maxwell's Equations.

Conjugate heat and mass transfer are configured by solving the momentum, heat and mass transfer simultaneously in both solid (substrate, comprising of a two-phase chemical species) and fluid (auxiliary air) phases. In this way the heat and mass fluxes vary seamlessly through the phases interface, and the solutions for temperature and concentration are determined with no need for empirical assumptions at the free surface.

After proper validation with the correspondent experimental results, the complex geometry and thermal-fluid dynamics parameters and their interdependence are scrutinized. Sample results for the electric field, the air flow field and the temperature in the substrate are reported in Figs. 1, 2 and 3, respectively. The exposure to microwaves may increase treatment throughput, and improve energy consumption and product quality. These good, positive outcomes should encourage operators to embrace microwave-enhanced jet impingement technology.

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Figures used in the abstract

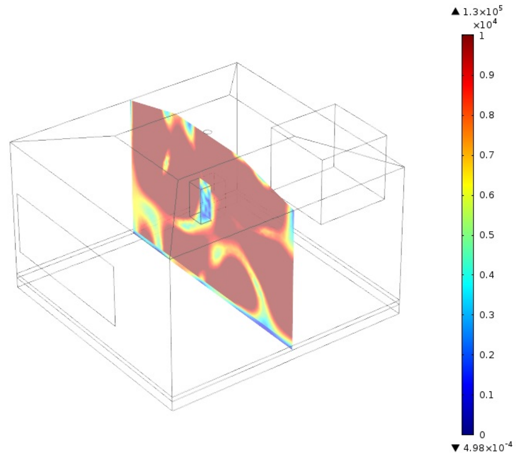

Figure 1: The electric field distribution in the sample and in the process cavity [V/m].

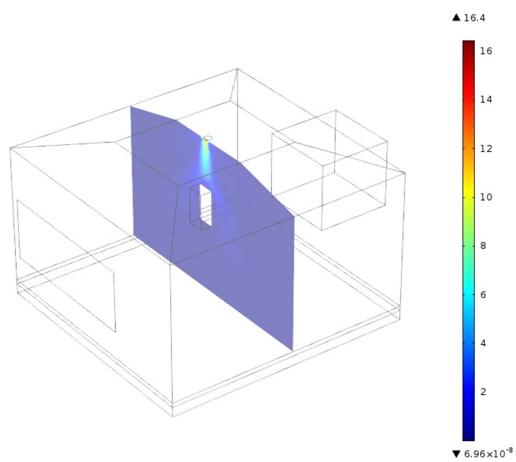

Figure 2: The air velocity field in the process cavity [m/s].

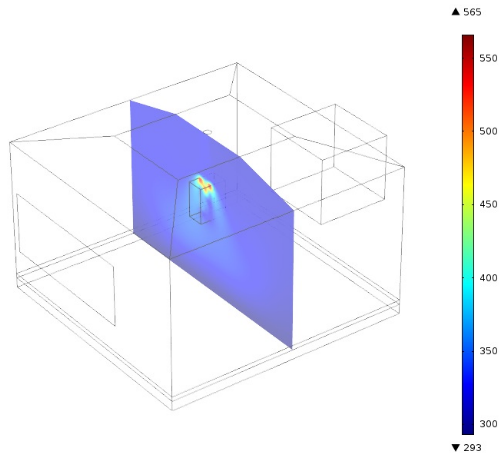

Figure 3: The temperature field in the sample and in the process cavity [K].