Microwave Radiation to Cure Cork Stoppers Using a Conventional Turntable Configuration

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Introduction

This work presents an alternative method for curing cork stoppers based on microwave radiation, which is energetically more efficient, where it is possible to accelerate the reaction rate and therefore reduce the cure time comparatively with conventional curing methods.

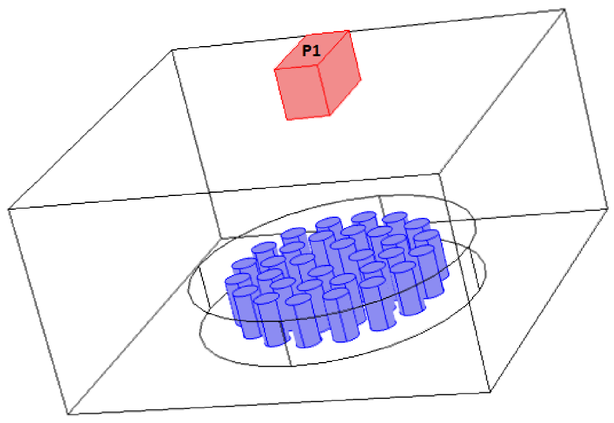

Figure 1. Microwave oven configuration 42 × 39 × 21 cm, where it was placed 32 cork granulate composite samples with $\varepsilon_r^* = 3.8903 - 0.2745i$ and $\rho = 240$ kg.m^{-3} in a rotating PEEK Ketron® mold.

Computational Methods

The microwave radiation is inserted in the cavity by a rectangular port labeled P1 with a power of 1 kW, at 2.45 GHz. The electric field vector is calculated by,

$$\nabla \times \mu_r^{'-1}(\nabla \times E) - k_0^2 \left(\varepsilon_r^{'} - \frac{i\sigma_{ac}}{\omega\varepsilon_0}\right) E = 0$$

The relation between electromagnetic and thermal distribution is given by,

$$\rho C_p \frac{\partial T}{\partial t} = k\nabla^2 T + Q$$

The absorbed power density in the material, with a complex permittivity, $\varepsilon_r^* = \varepsilon_r' - i\varepsilon_r''$ can be expressed by,

$$\mathrm{P} = \frac{1}{2}[(\sigma_{dc} + \omega\varepsilon_r^{''})\mathrm{E}^2 + \omega\mu_r^{''} H^2]$$

The effect of rotation of the turntable was modeled using 'Translation Motion' available in the Microwave Heating module. The object was rotated according to,

$$vx = -2\pi y N$$

$$vy = 2\pi x N$$

where N is the number of turns per second, 0.1 s^{-1} and x and y are the position coordinates of the rotating object.

Computational Results

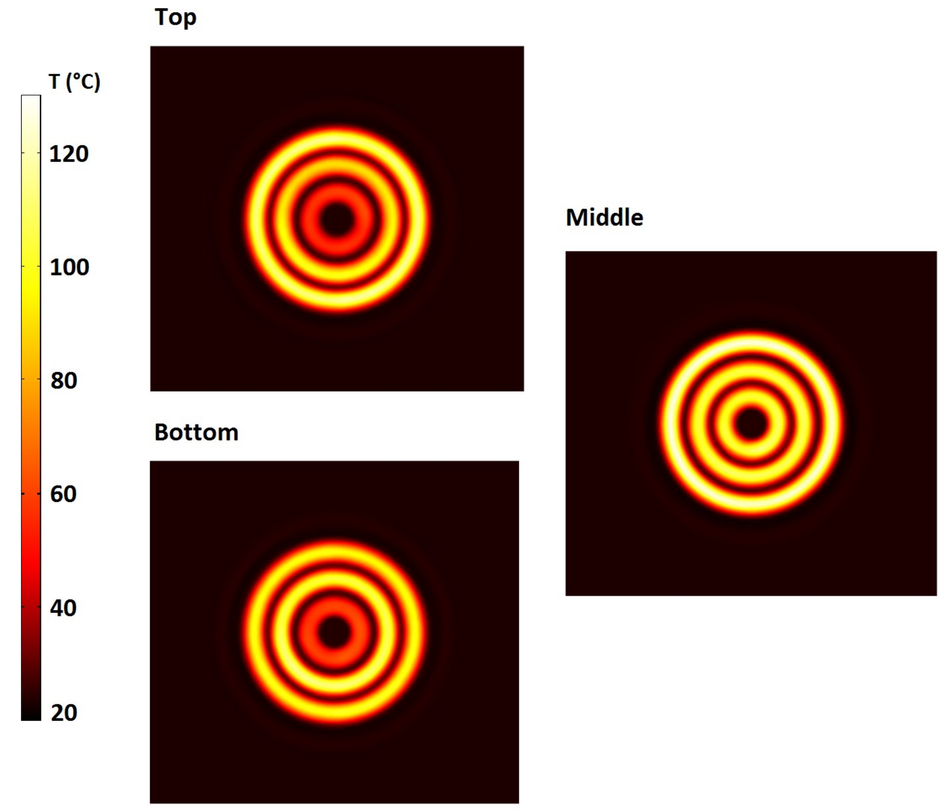

Figure 2. Thermal distribution profiles after 50 seconds of microwave heating.

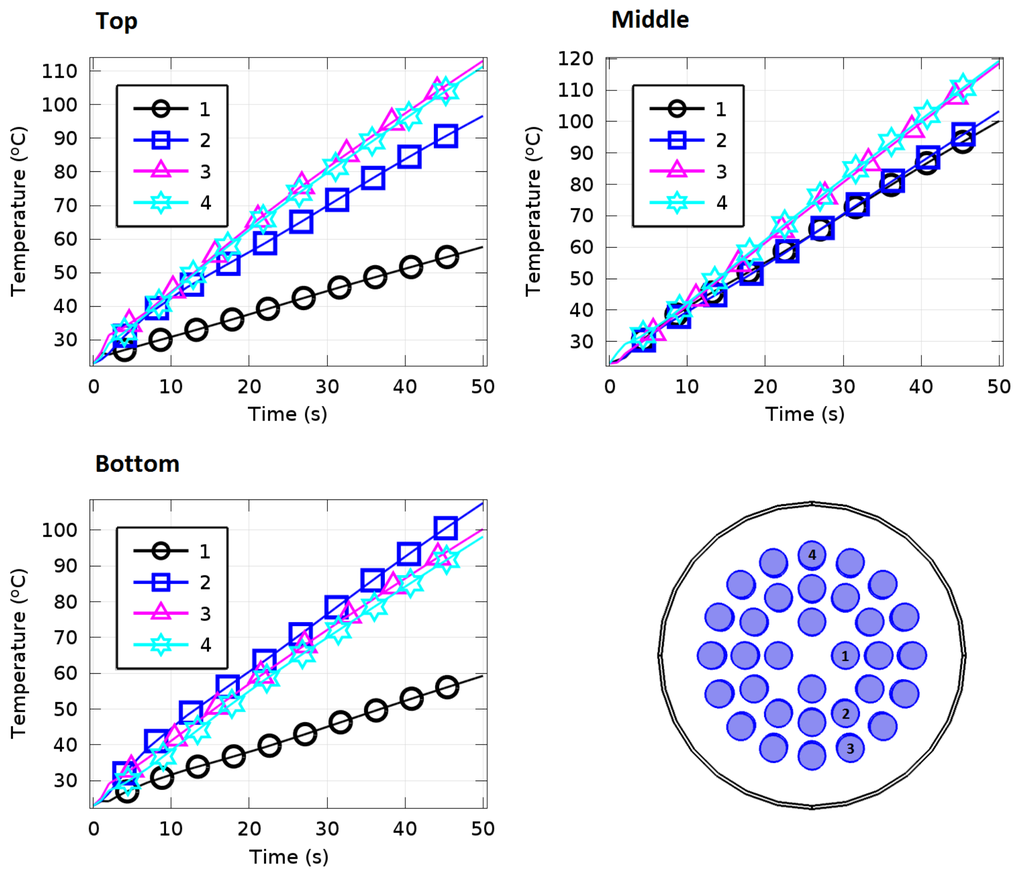

Figure 3. Temperature profiles at the top, bottom and middle layers for 4 different samples during the heating process.

Conclusions

With this system, it is possible to cure cork stoppers in a shorter period of time, over 50 seconds comparatively to the 45 minutes required in conventional heating, demonstrating that the microwave radiation is a very good alternative to the conventional technology. However, moveable platforms may not be practical or adequate in many applications, as in tunnel ovens, once they add complexity on the design. Thus, it is imperative the study of others approaches to accomplish our main objective, changing the setup.

Acknowledgments
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