# Modeling Microwave Heating During Batch Processing of a Liquid Sample in a Single Mode Cavity

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## Abstract

The use of microwaves for heating purposes of dielectric materials is encountered in many industrial applications (food processing, chemistry, material engineering and medical applications). In most of these thermal applications, the prediction of the temperature evolution within the processed materials is of primary interest in order to optimize the treatment (Chandrasekaran et al., 2013). In this study, the objective is to model the microwave heating process of a liquid sample in the fundamental mode, denoted TE10, operating at a frequency of 2.45 GHz.

A dielectric material, consisting of pure water, is placed within a monomode applicator at a location where the electric field strength is set at its maximum amplitude. The bottom ended of the rectangular waveguide consists in a water load which absorbs the transmitted microwave power throughout the waveguide.

The sample is settled on a Teflon® support plate which fills the section of the rectangular waveguide. The support is located between the inlet and the absorbing water load.

The first part of the numerical study deals with the modeling of the microwave propagation into the waveguide without any sample into the Teflon® mold. Microwave interactions with Teflon® are studied from the electric field distribution (stationary study in frequency domain).

A COMSOL Multiphysics® model is used to solve the coupled equations when the dielectric material is inserted within the Teflon® support. The model considers the coupling between the fluid flow (natural convection in laminar flow using the CFD Module), electromagnetic field (frequency domain with RF Module) and thermal kinetics during the process (using the Heat Transfer Module).

For all of these transient state simulations, thermophysical and dielectric properties of water are considered as temperature dependent.

The microwave input power is fixed at a constant value and the process is stopped as soon as the maximum temperature reaches approximately 80°C within the water sample.

The convective flow of water due to microwave heating within the Teflon® mold is analyzed in terms of 3D distributions of temperature and fluid motion (Figure 1). The temperature evolution within water issued from the model is also compared to experimental measurements performed under similar operating conditions.

From an energy point of view, results are analyzed following the forward, reflected and absorbed microwave power within the waveguide. 3D temperature distribution maps within the dielectric material are quantified following the dielectric properties evolution and as a function of processing time (Zhang et al., 2000).

As a whole, the study highlights both the complexity of physical phenomena and a high computational demand in order to model microwave interaction within a liquid sample in a batch configuration. This study will also help for the future design of a microwave applicator in order to prevent the hot and cold spots that may occur during such a thermal treatment.

## Reference


1. S. Chandrasekaran et al., Microwave food processing-A review. Food Research International, 52, 243-261 (2013).

2. Q.O. Zhang et al., Numerical modeling of microwave induced natural convection. International Journal of Heat and Mass Transfer, 43, 2141-2154 (2000).

## Figures used in the abstract

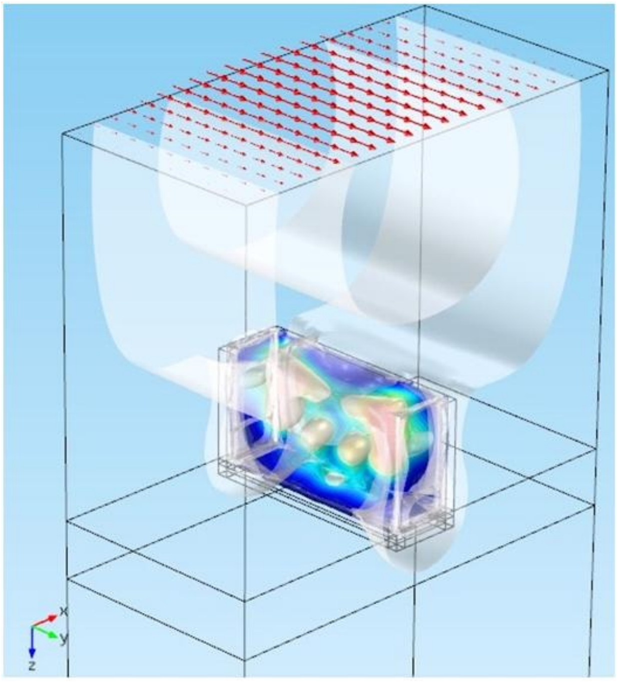


**Figure 1**: 3D simulation of microwave heating for a liquid sample attached with Teflon® plate within a single mode applicator.

**Figure 2**

**Figure 3**

**Figure 4**