Simulation of a Microwave Applicator for the Treatment of Petroleum Emulsions

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Introduction: In Mexico, there is a decline in the production of oil deposits due to the lack of effective treatment of oil emulsions, this generates a problem in the reinjection of emulsified water, transport of oil with high water content and corrosion in the oil refineries. Through the simulation in COMSOL Multiphysics® software, specifically the modules of RF, heat transfer and the materials library, it was possible to simulate a microwave applicator with different geometries to find the ideal geometry where there is a greater energy absorption leading to a better heating oil and contribute to a better separation.

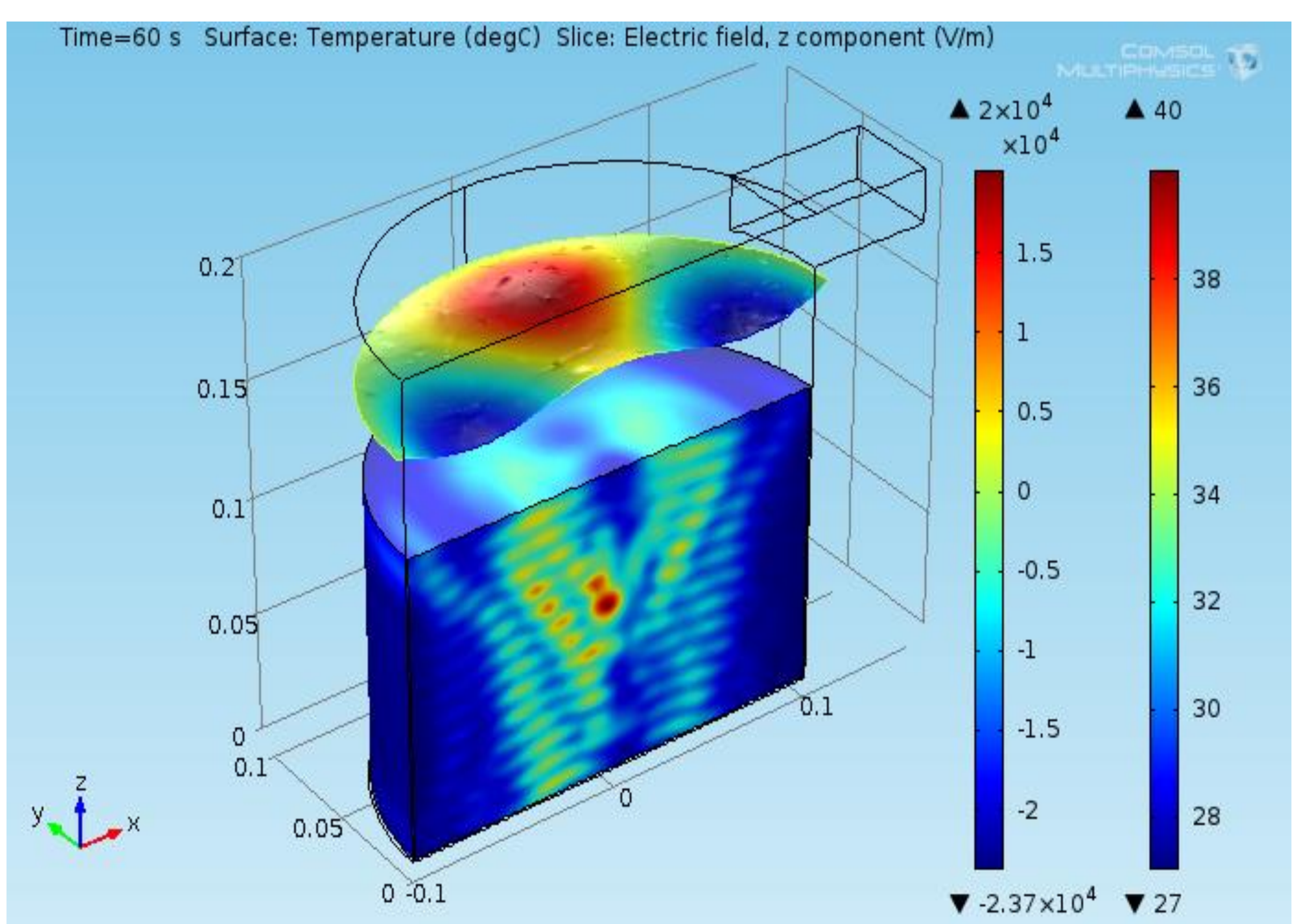


Figure 1. 3D visualization of a resonant cavity with cylindrical geometry radiating 4 l of a crude-water sample for 60 seconds.

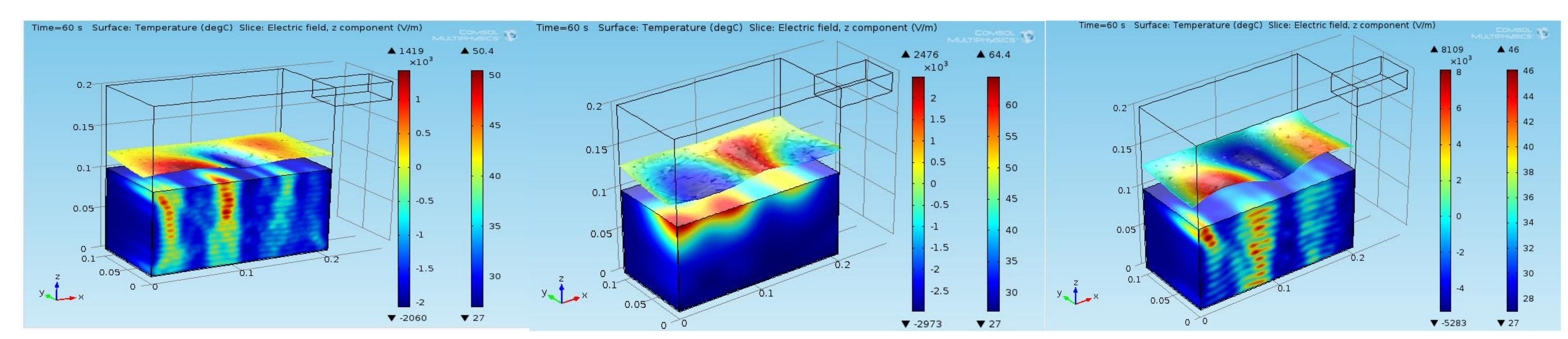
Computational Methods:
Wave Equation, Electric (1):

$$\nabla \times (\mu_r^{-1} \nabla \times \mathbf{E}) - k_0^2 \varepsilon_{rc} \mathbf{E} = 0$$

The Heat Equation (2):

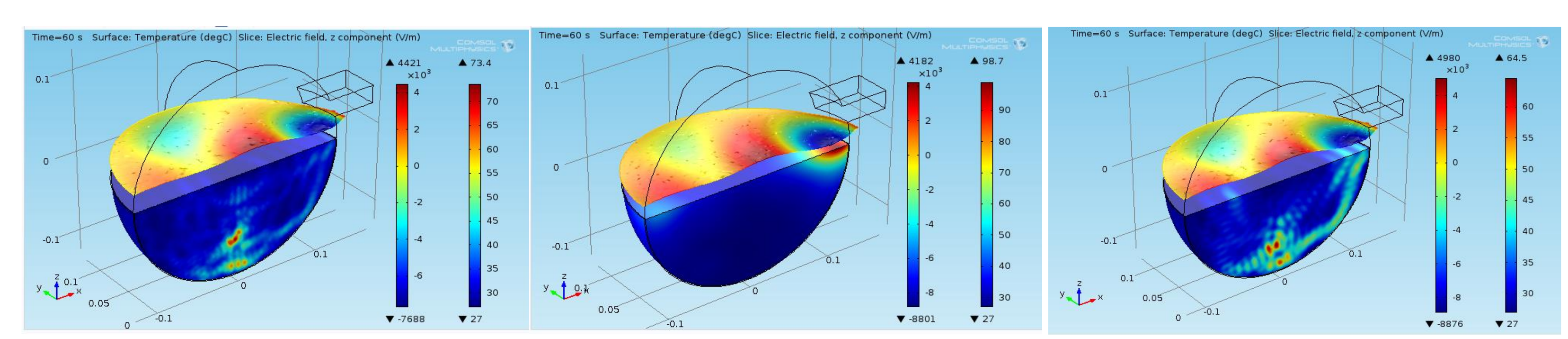
$$\rho C_p \frac{\partial T}{\partial t} + \nabla \cdot (-k \nabla T) = \mathbf{Q}$$

Results: Figure 2 shows the simulation of a resonant cavity with a cubic geometry of 200 mm. Figure 3 shows the simulation of a resonant cavity with a spherical geometry of 125 mm radius. Figure 4 shows the simulation of a resonant cavity with a cylindrical geometry of 100 mm radius and 200 mm high.



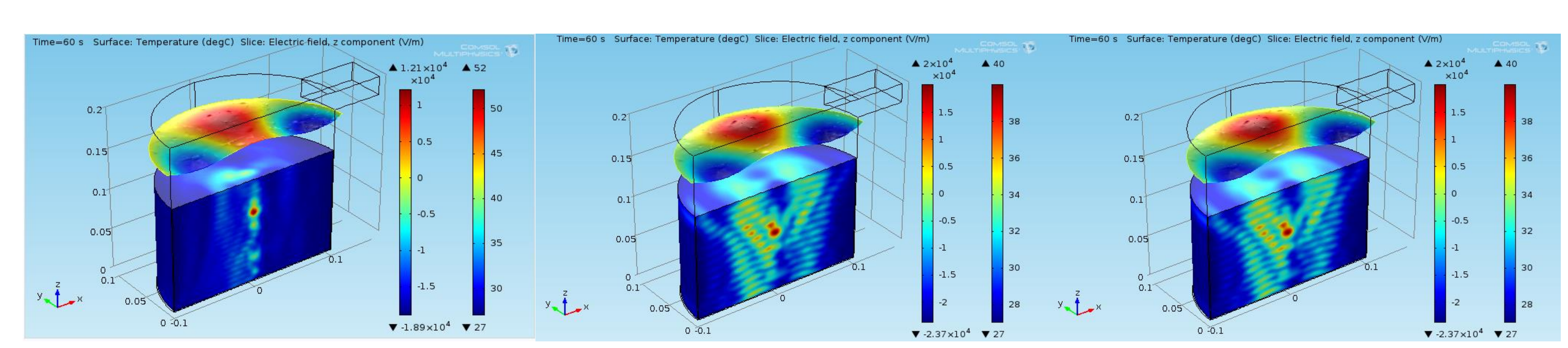
(a) (b) (c)

Figure 2. Resonant cavity with cubic geometry radiating for 60 s to 4 l of a sample of: a) Distilled water, b) Crude and c) Water-crude.



(a) (b) (c)

Figure 3. Resonant cavity with spherical geometry radiating for 60 s to 4 l of a sample of: a) Distilled water, b) Crude and c) Water-crude.



(a) (b) (c)

Figure 4. Resonant cavity with cylindrical geometry radiating for 60 s to 4 l of a sample of: a) Distilled water, b) Crude and c) Water-crude.

Conclusions: It will be concluded that the construction of a microwave applicator with cylindrical geometry will be the most stable to obtain a better distribution of the electric field and a better control of the temperature inside the resonant cavity.

References:

1. RF Module, the Electromagnetic Waves, Frequency Domain Interface, Wave Equation, Electric, 70 – 109, (2013)
2. Heat Transfer Module, Theory for Heat Transfer Interfaces, 31-67, (2013)