Design Optimization of Waveguide Applicator for Microwave Hyperthermia Cancer Treatment

Pankaj Kumar[1] Shifali Kalra[2] Anupma Marwaha[3]
[1, 2]M.Tech Research Scholar, [3]Associate Professor
Department of Electronics & Communication, SLIET Longowal, Punjab, India.

Introduction: This poster presents the optimized design and simulation of a waveguide applicator has been presented for superficial microwave hyperthermia. The 3D modeling of the waveguide applicator is performed and the performance is verified by analyzing the resistive heating and temperature distributions in muscle like phantom.

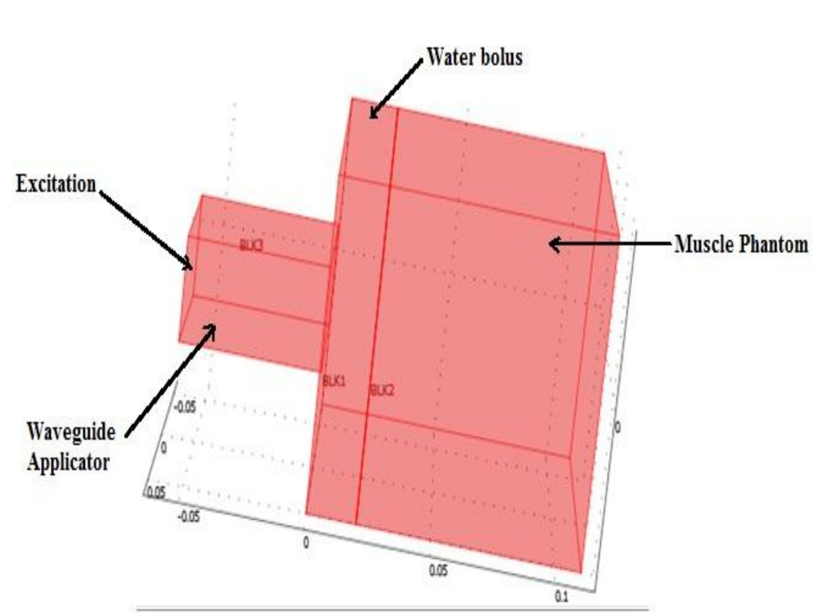

Fig. 1. Labeled diagram of 3D Hyperthermia System

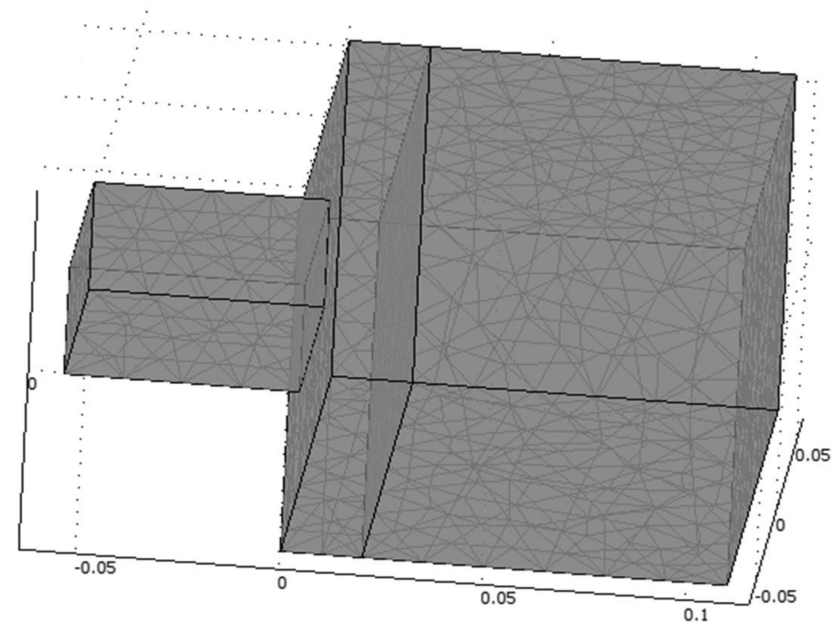

Fig. 2. Mesh plot of the hyperthermia system

Computational Methods:

Waveguide design equations:

$$a = \frac{1}{2f_c\sqrt{\mu_0\mu_r\varepsilon_0\varepsilon_r}}\ ;\ b = \frac{a}{2}\ ;\ \lambda = z = \frac{1}{f_c\sqrt{\mu_0\mu_r\varepsilon_0\varepsilon_r}}$$

SAR(Specific Absorption Rate):

$$\mathrm{SAR} = \frac{\sigma\, E^2}{\rho} \quad (\mathrm{W/kg})$$

Bio-heat equation:

$$\delta_{ts}\rho C\frac{\partial T}{\partial t} + \nabla.\,(-k\nabla\,\mathrm{T}) = \rho_b C_b\omega_b(T_b - T) + Q_{met} + Q_{ext}$$

Modeling in COMSOL Multiphysics:

The dimensions of the waveguide are 60 x 30 x 58 mm. A water bolus which is 20 mm thick is placed between the waveguide and the surface of agar jelly muscle phantom.

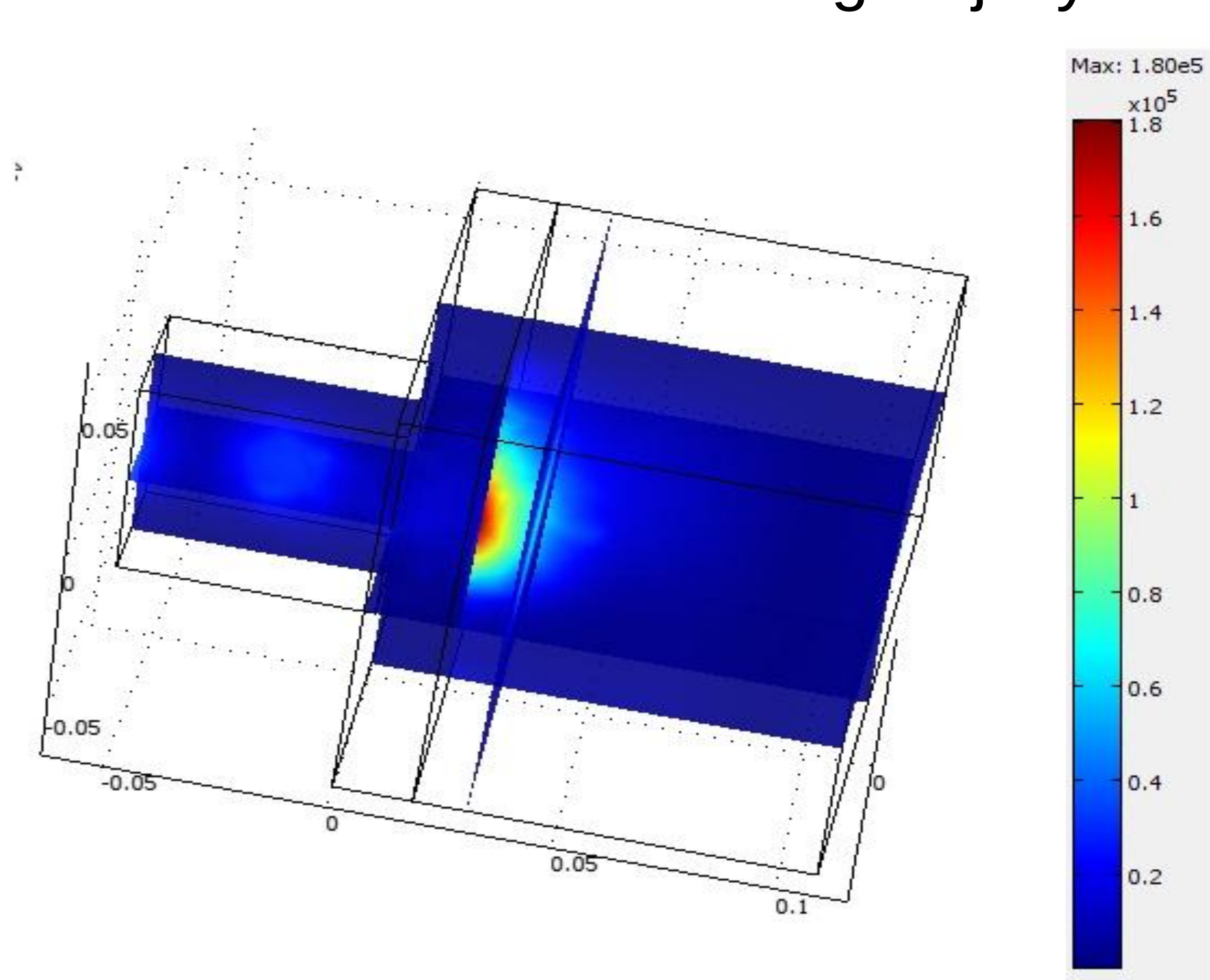

Fig. 3. Heat distribution plot of waveguide applicator

Results:

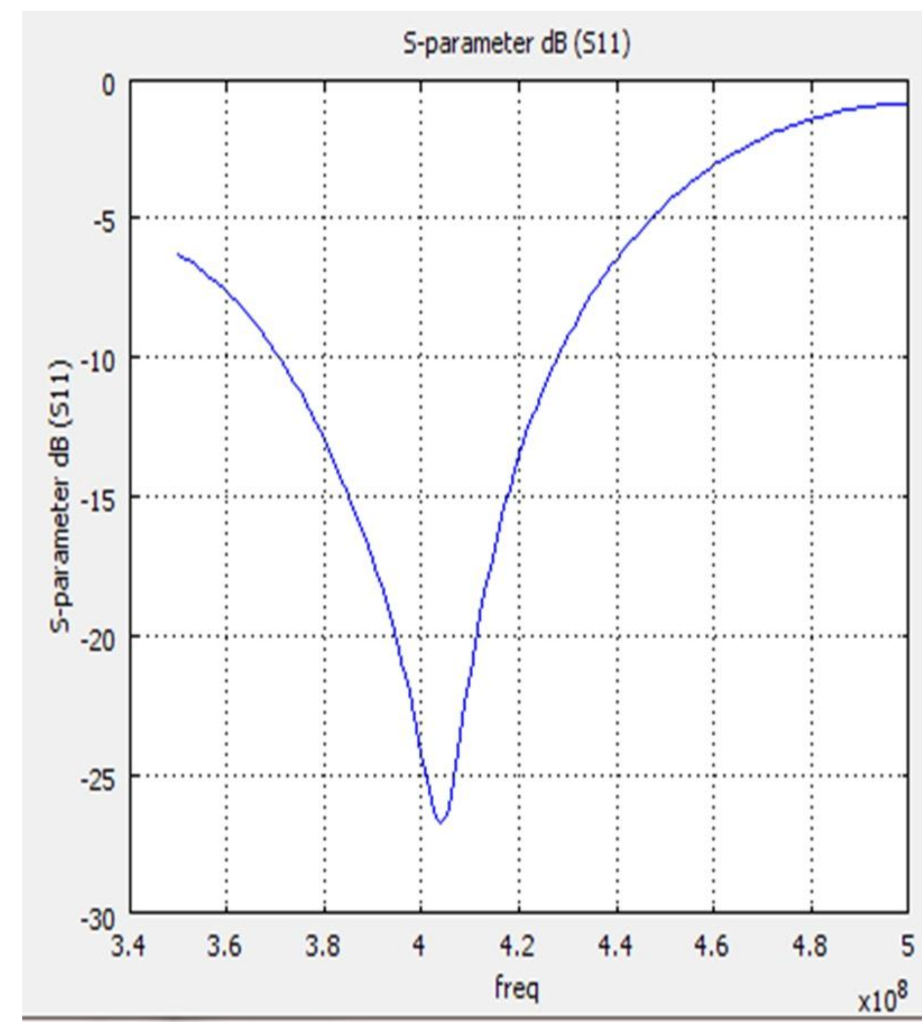

Fig. 4. Impedance matching of waveguide applicator

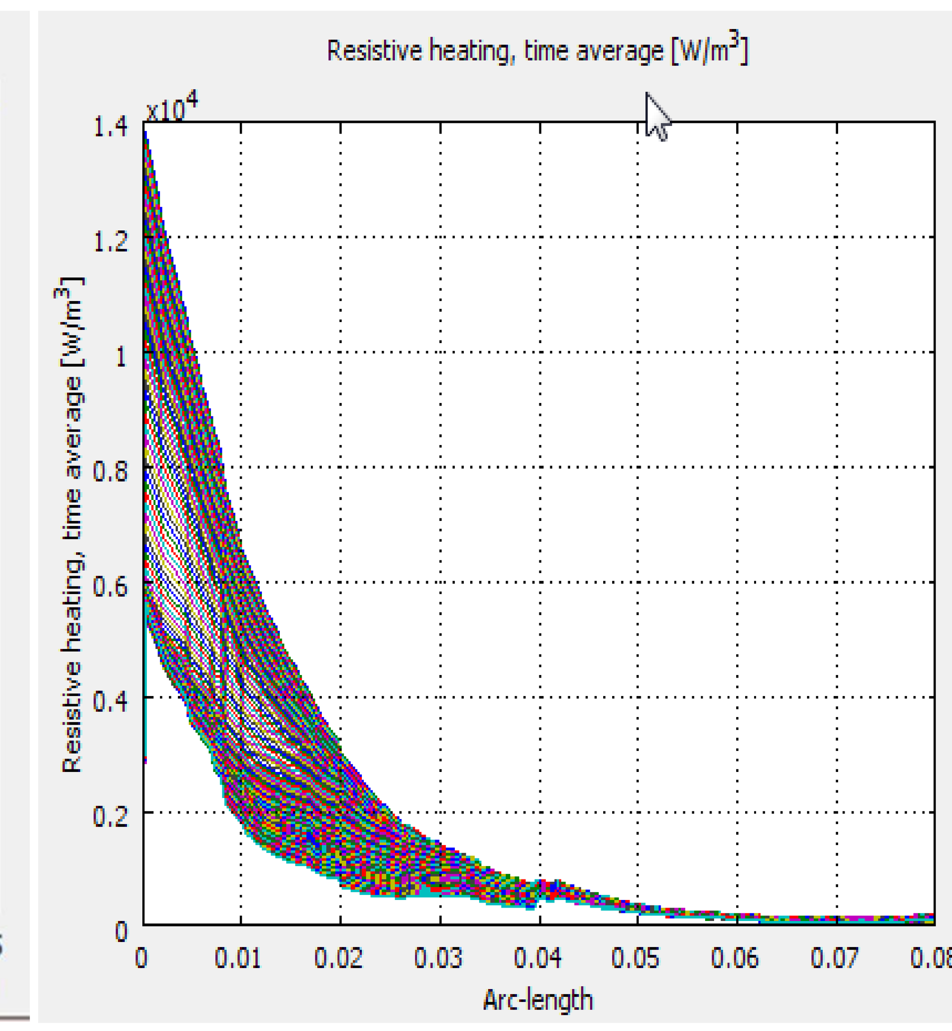

Fig. 5. Resistive heating plot

At operating frequency of 404 MHz S_{11} reaches a minimum of -26.7 dB indicating good impedance matching. The applicator frequency bandwidth (S11 < -10 dB) is 57 MHz (from 371 MHz to 428MHz)

Conclusions: A 3D model of waveguide applicator presented here for hyperthermia treatment also performs the analysis of the distribution of electric field along with the resistive heating distribution. Finite element full-wave modeling has been performed to predict to a high degree of accuracy the performance of 3D model of the applicator. In the next step of research the formulation of 3D model will be done for several tissue types.

References:

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