Design and Analysis of Microwave Antenna for Cancer Ablation
Kapil Allawadi¹, Kumar Saurabh²
*Mtech Scholar, Asst. Prof.
ECE department, Om Institute of Technology and Management, Hisar.
¹kapilallawadhi5@gmail.com
²saurabhoitm@gmail.com

Abstract— The Cancer is the second leading cause of death in the world only after coronary diseases. It is estimated that within the next 30 years, it will become the main reason for death. This bothersome statistic result not from an increase in incidences of cancer, but because deaths from heart disease could be reduced to nearly half, while the number of cancer-related deaths remains about the same. A new microwave antenna is proposed and analysed using various power and parameters.

Keywords— Microwave, Temperature, Electric Field, Damaged Tissue.

I. INTRODUCTION
The Electromagnetic heating emerge in a wide variety of engineering problems and is preferably suited for modeling in COMSOL Multiphysics since of its multiphysics capabilities. This comes from the area of hyperthermic oncology and it representation the electromagnetic field coupled to the bioheat equation. The modeling issues and method are generally applicable to any problem involving electromagnetic heating. In hyperthermic oncology, cancer is treated by applying localized heating to the tumor tissue, often in combination with chemotherapy or radiotherapy. Various of the challenges connected with the selective heating of deep-seated tumors without damaging surrounding tissue are:
• Control of heating power and spatial distribution
• Design and placement of temperature sensors
Among possible heating techniques, RF and microwave heating have engrossed much attention from medical researchers. Microwave coagulation therapy is one such technique where a thin microwave antenna is inserted into the tumor. The microwaves heat up the tumor, producing a coagulated region where the cancer cells are killed.

II. MODEL DESIGN
The antenna geometry consists of a thin coaxial cable with a ring-shaped slot measuring 1 mm cut on the outer conductor 5 mm from the short-circuited tip. Antenna geometry for microwave coagulation therapy. A coaxial cable with a ring-shaped slot cut on the outer conductor is short-circuited at the tip. A plastic catheter surrounds the antenna. For hygienic purposes, the antenna is enclosed in a sleeve (catheter) made of PTFE (polytetrafluoroethylene). The following tables give the geometrical dimensions and material data. The antenna operates at 2.45 GHz, a frequency widely used in microwave coagulation therapy.

Table 1: Geometry Dimensions.

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of the central conductor</td>
<td>0.29 mm</td>
</tr>
<tr>
<td>Inner diameter of the outer conductor</td>
<td>0.94 mm</td>
</tr>
<tr>
<td>Outer diameter of the outer conductor</td>
<td>1.19 mm</td>
</tr>
<tr>
<td>Diameter of catheter</td>
<td>1.79 mm</td>
</tr>
</tbody>
</table>

Figure 1: Antenna Geometry.
III. GEOMETRY MODELING

To draw the antenna geometry shown in figure 1, following steps are required:

- Liver model width of 20 mm and height of 80 mm.
- Antenna of height 70 mm and width of 0.3 mm is inserted in the liver shown in blue color.

The proposed antenna has cuts on both sides by which surface area of surface is increased and which can produce larger heating surface.

IV. APPLYING PHYSICS

After planning the model we are able to apply the specified physics i.e. electromagnetic wave frequency domain and heat transfer. That facilitate us in obtaining the specified results.

V. RESULTS AND DISCUSSION

We the proposed design is analyzed for various values of input power i.e. 5 W, 10 W and 20 W and various parameters like temperature, electric field and damaged tissue.

1) 5 W Geometry

Parameters of the liver tissue for an input microwave power of 5 W are as follows:

- Electric Field
Figure 4 shows the resulting steady-state temperature distribution in the liver tissue for an input microwave power of 5 W. The temperature is highest near the antenna i.e. 65 °C. It then decreases with distance from the antenna and reaches 37 °C closer to the outer boundaries of the computational domain. The perfusion of relatively cold blood seems to limit the extent of the area that is heated. Temperature variation with respect to time at 5mm (blue), 10mm (green), 15 mm (red) and 20mm (sky blue) are shown in figure 5. Temperature above 20mm remains at 37 degC.

Tumor upto 5mm is cured in 5 minutes. Effect of heating damages 20% of cells till 20 mm in 10 minute but in two minutes it is nearly zero.

2) **10 W Geometry**

Parameters of the liver tissue for an input microwave power of 10 W are as follows:

Electric Field

Figure 8 shows the electric field produced by the antenna during input microwave power of 10 W. The maximum value of electric field is given by 31.8 MW/m$^3$.
Figure 9 shows the resulting steady-state temperature distribution in the liver tissue for an input microwave power of 10 W. The temperature is highest near the antenna i.e. 93.2 °C. It then decreases with distance from the antenna and reaches 37 °C closer to the outer boundaries of the computational domain. The perfusion of relatively cold blood seems to limit the extent of the area that is heated. Temperature variation with respect to time at 5mm (blue), 10 mm (green), 15 mm (red) and 20mm (sky blue) are shown in figure 10. Temperature above 20mm remains at 37 degC.

Figure 11 shows the distribution of the microwave heat source. Clearly the temperature field follows the heat-source distribution quite well. That is, near the antenna the heat source is strong, which leads to high temperatures which is sufficient to kill the tumor cells, cells till 10 mm are killed completely and it effect the cells till 20 mm. while far from the antenna, the heat source is weaker and the blood manages to keep the tissue at normal body temperature.

Tumor upto 5mm is cured in 2 minutes and upto 10 mm is cured in 8 minutes. Effect of heating damages 30% of cells till 20 mm in 10 minute but in two minutes it is nearly zero.

3) **20 W Geometry**

Parameters of the liver tissue for an input microwave power of 20 W are as follows:

- **Electric Field**
  
  Figure 13 shows the electric field produced by the antenna during input microwave power of 20 W. The maximum value of electric field is given by 63.7 MW/m³.
Figure 13: Electric field 20W.

Figure 14: Temperature 20W.

Figure 15: Temperature Curve 20 W.

Temperature variation with respect to time at 5mm (blue), 10mm (green), 15 mm (red) and 20mm (sky blue) are shown in figure 15. Temperature above 20mm remains at 37 degC.

Figure 16 shows the distribution of the microwave heat source. Clearly the temperature field follows the heat-source distribution quite well. That is, near the antenna the heat source is strong, which leads to high temperatures which is sufficient to kill the tumor cells, cells till 15 mm are killed completely and it effect the cells till 25 mm. while far from the antenna, the heat source is weaker and the blood manages to keep the tissue at normal body temperature.

Figure 16: Dead Cells

Figure 14 shows the resulting steady-state temperature distribution in the liver tissue for an input microwave power of 20 W. The temperature is highest near the antenna i.e. 149 °C. It then decreases with distance from the antenna and reaches 37 °C closer to the outer boundaries of the computational domain. The perfusion of relatively cold blood seems to limit the extent of the area that is heated.
Figure 17: Dead Cells Vs Time Curve 20W.

Tumor upto 5mm is cured in 1 minutes, upto 10 mm is cured in 3.5 minutes and upto 15mm is cured 10 minutes. Effect of heating damages 40% of cells till 20 mm in 10 minute but in one minutes it is nearly zero.

VI.

CONCLUSION

The temperature field follows the heat-source distribution quite well. That is, near the antenna the heat source is strong, which leads to high temperatures which is sufficient to kill the tumor cells, cells till 5 mm are killed completely and it effect the cells till 10 mm. while far from the antenna, the heat source is weaker and the blood manages to keep the tissue at normal body temperature. At 5W power tumor upto 5mm is cured in 5 minutes. Effect of heating damages 20% of cells till 20 mm in 10 minute. At 10W power tumor upto 5mm is cured in 2 minutes and upto 10 mm is cured in 8 minutes. Tumor upto 5mm is cured in 1 minutes, upto 10 mm is cured in 3.5 minutes and upto 15mm is cured 10 minutes.

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