

# International Journal of Innovative Research in Science, Engineering and Technology

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## Design and Analysis of Two Slot Antenna for Microwave Ablation

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**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 2 slot 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. RELATED WORK

The design of a single slot antenna for hepatic MWA using COMSOL MULTIPHYSICS 4.3b software has been done. After designing 140 antennas models out of which one was selected based on the variation in its reflection coefficient, total power density and Specific Absorption Ratio. These three antennas have different geometry parameters which relates to the effective wavelength of microwaves that is at 2.45GHz. Perfect electric conductor (PEC) boundary conditions were used to model the inner and outer conductors of antenna. For determining the antenna efficiency the antenna model was stimulated at different discrete lengths. The antenna has a reflection coefficient as low as -44.67618 dB, with a corresponding total power dissipation of 9.47744 W at slot size 3.5 mm. The antenna operates with low reflection coefficient which at high power levels prevents overheating of the feedline this has been shown in the results. overheating may damage the coaxial line, thereby making it is suitable for ablation of hepatic and other tumors. There were a few problems which are needed to be resolve, Following are the major area of concern.

- ▶ Microwave generate high temperature which influence healthy blood cells
- ▶ Power requirement are high as compare to the size of tumor.
- ▶ Radiation from the antenna around the tumor are scattered
- ▶ Time taken to complete destruction of tumor is quite large

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## III. COMSOL DESIGNING

### A. MODEL DESIGN

The tool used for designing antenna is COMSOL. 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.

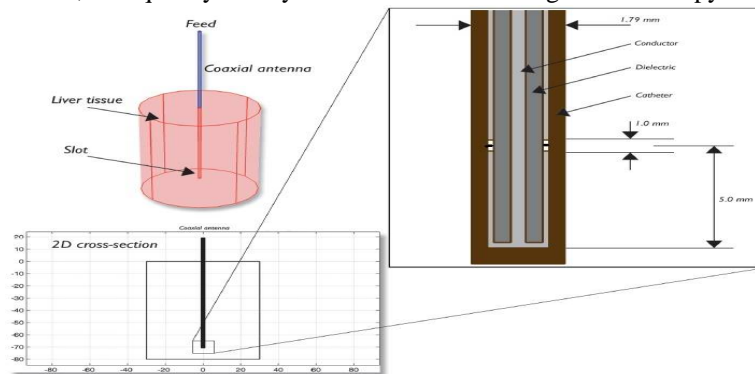


Fig.1 Antenna Geometry

TABLE I  
GEOMETRY DIMENSIONS.

PROPERTY	VALUE
Diameter of the central conductor	0.29 mm
Inner diameter of the outer conductor	0.94 mm
Outer diameter of the outer conductor	1.19 mm
Diameter of catheter	1.79 mm

TABLE III  
MATERIAL PROPERTIES.

PROPERTY	INNER DIELECTRIC OF COAXIAL CABLE	CATHETER	LIVER TISSUE
Relative permittivity	2.03	2.60	43.03
Conductivity			1.69 S/m

### B. GEOMETRY MODELLING

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.

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Vol. 6, Issue 7, July 2017

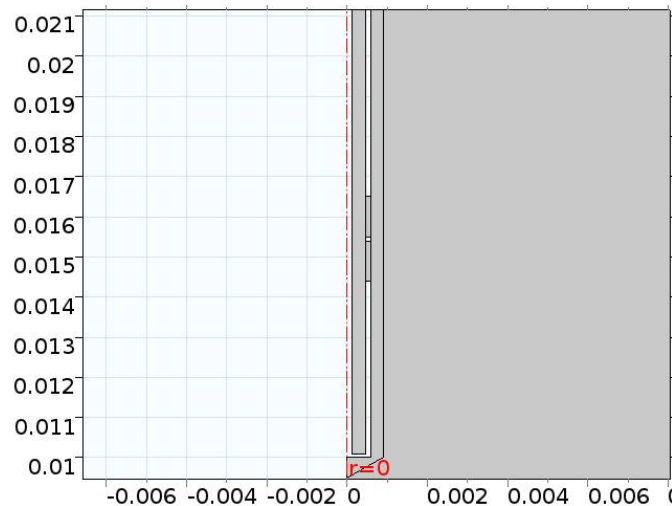


Fig.2 Proposed Antenna.

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

## C. APPLYING PHYSICS

After planning the model we are able to apply the specified physics i.e. electromagnetic wave frequency domain and heat transfer. That facilitates us in obtaining the specified results. It will describe the physical nature of the liver tissue

## IV. EXPERIMENTAL RESULTS

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) 5W Geometry:

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

- Electric Field

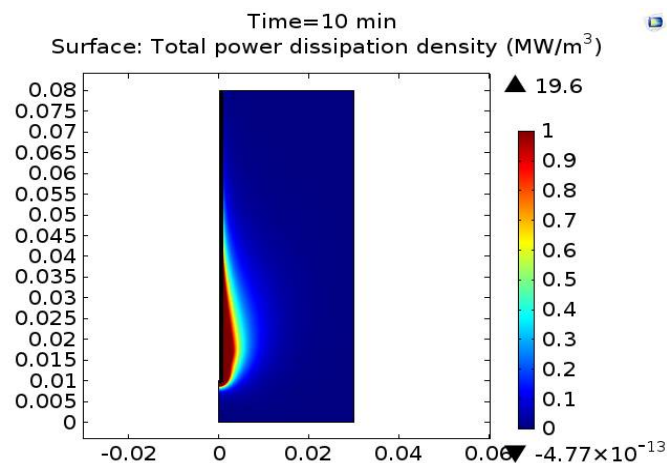


Fig.3 Electric Field 5W.

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Vol. 6, Issue 7, July 2017

Figure 3 shows the electric field produced by the antenna during input microwave power of 5 W. The maximum value of electric field is given by  $19.6 \text{ MW/m}^3$ .

- Temperature

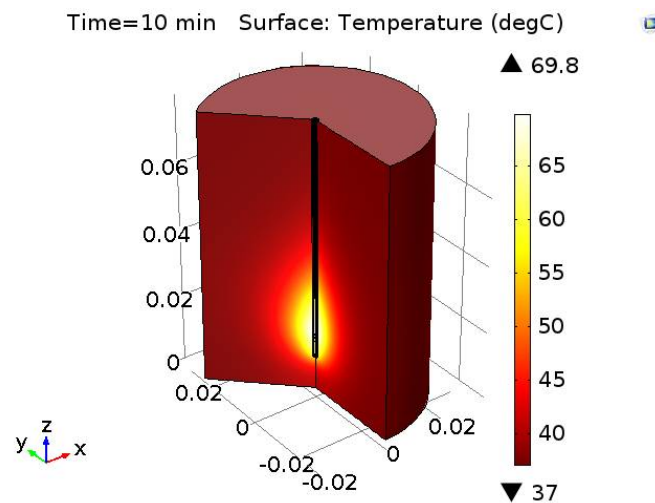


Fig.4 Temperature 5W.

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.  $70^\circ\text{C}$ . It then decreases with distance from the antenna and reaches  $37^\circ\text{C}$  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.

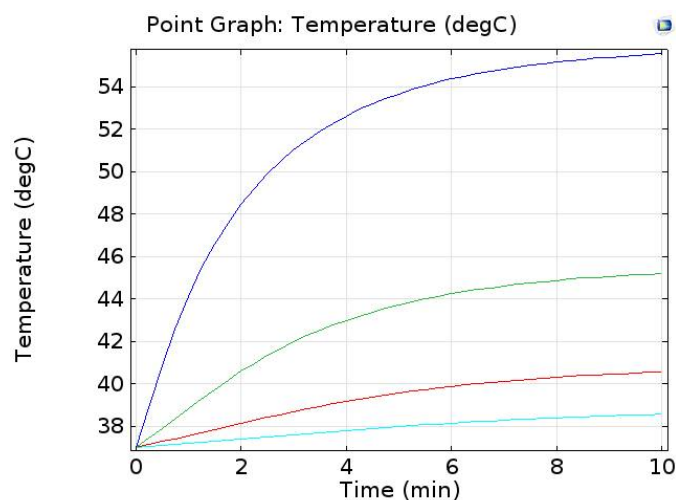


Fig.5 Temperature curve 5W.

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  $37^\circ\text{C}$ .

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Vol. 6, Issue 7, July 2017

## • Damaged Tissue

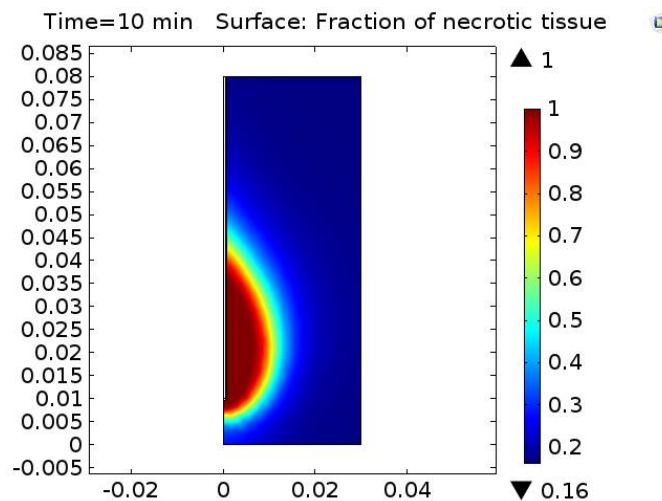


Fig.6 Dead cells

Figure 6 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 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. Tumor upto 5mm is cured in 4 minutes. Effect of heating damages 20% of cells till 20 mm in 10 minute but in two minutes it is nearly zero.

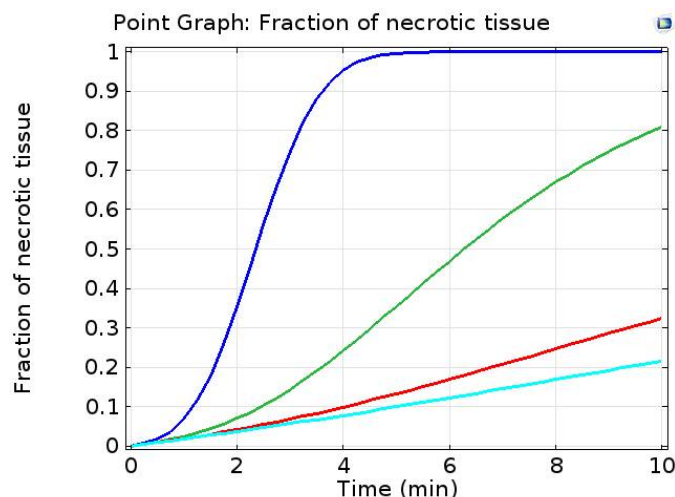


Fig.7 Dead Cells Vs Time Curve 5W.

## 2) 10W Geometry:

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

- Electric Field

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Website: [www.ijirset.com](http://www.ijirset.com)

Vol. 6, Issue 7, July 2017

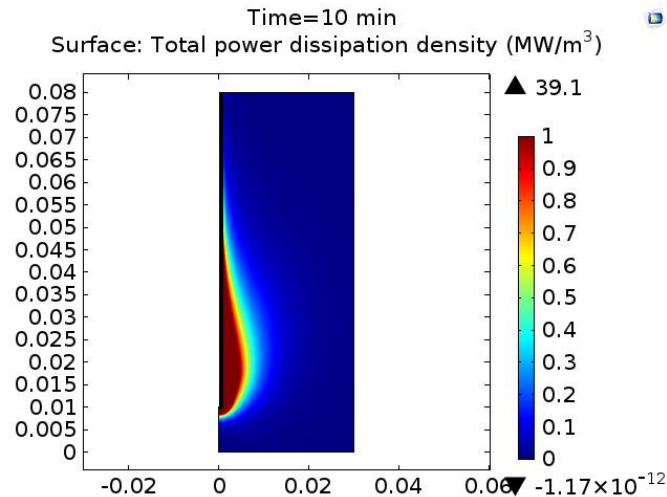


Fig.8 Electric Field 10W.

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 39.1 MW/m<sup>3</sup>

- Temperature

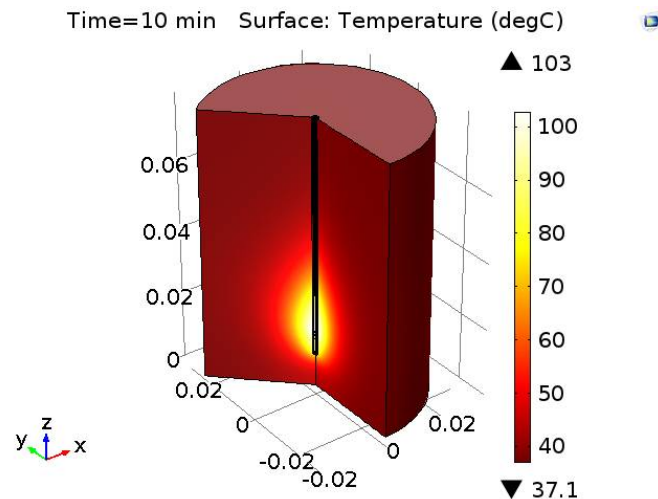


Fig.9 Temperature 10W.

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. 103°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.

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Vol. 6, Issue 7, July 2017

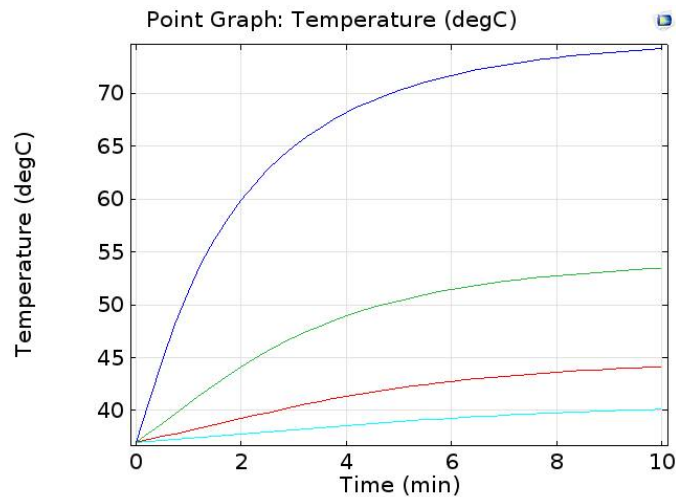


Fig.10 Temperature curve 10W.

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

- Damaged Tissue

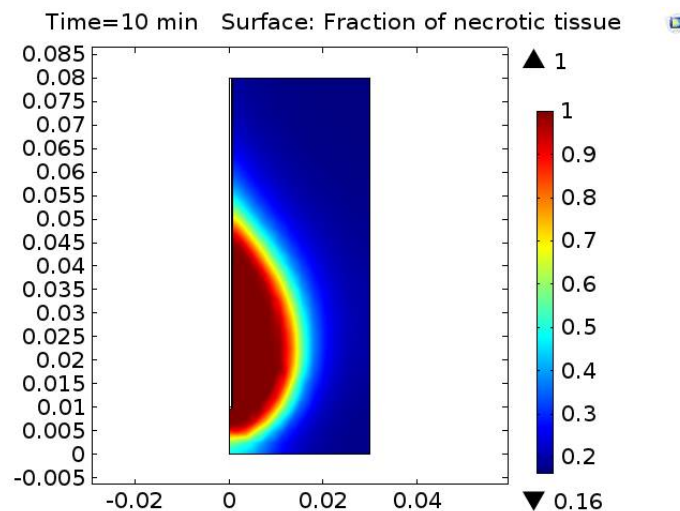


Fig.11 Dead cells



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Vol. 6, Issue 7, July 2017

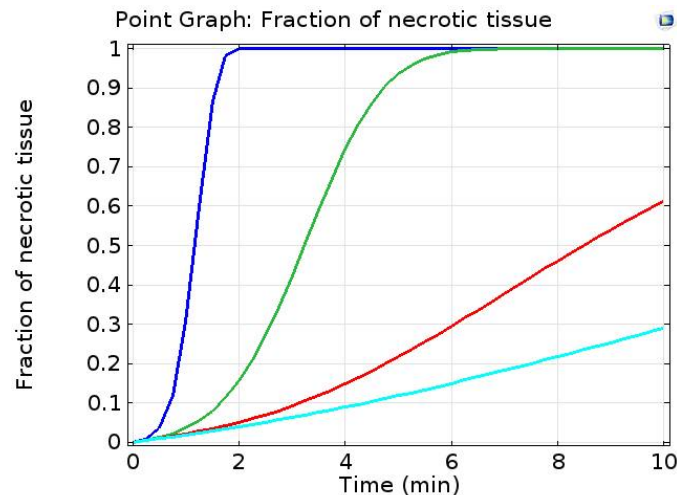


Fig.12 Dead Cells Vs Time Curve 10W.

Figure 12 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 6 minutes. Effect of heating damages 30% of cells till 20 mm in 10 minute but in two minutes it is nearly zero.

### 3) 20W Geometry:

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

- Electric Field

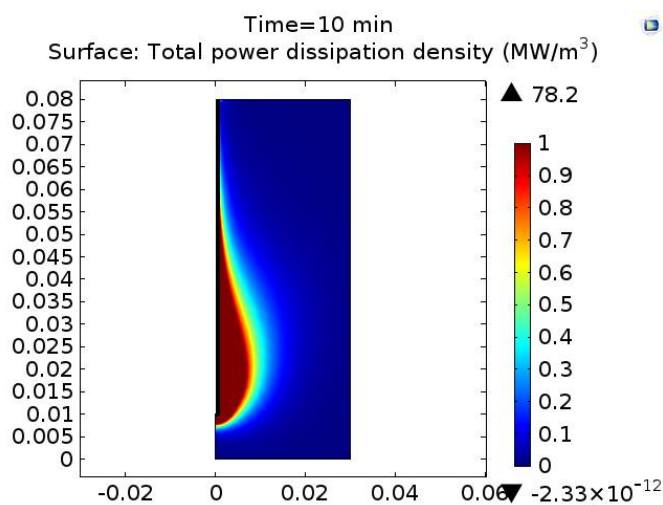


Fig.13 Electric Field 20W.

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 78.2MW/m<sup>3</sup>.



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Vol. 6, Issue 7, July 2017

- Temperature

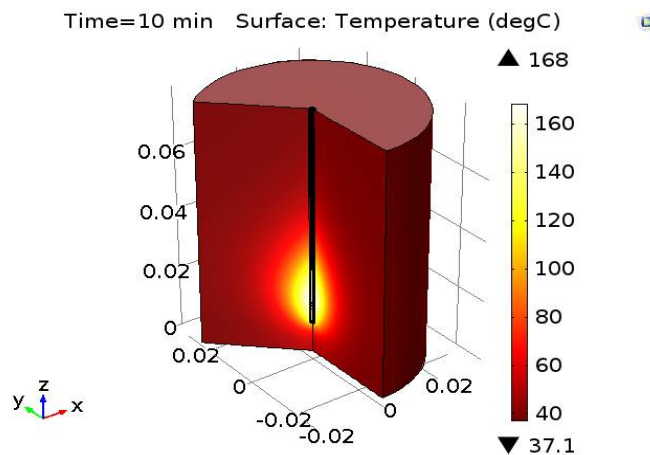


Fig.14 Temperature 20W.

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. 168°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.

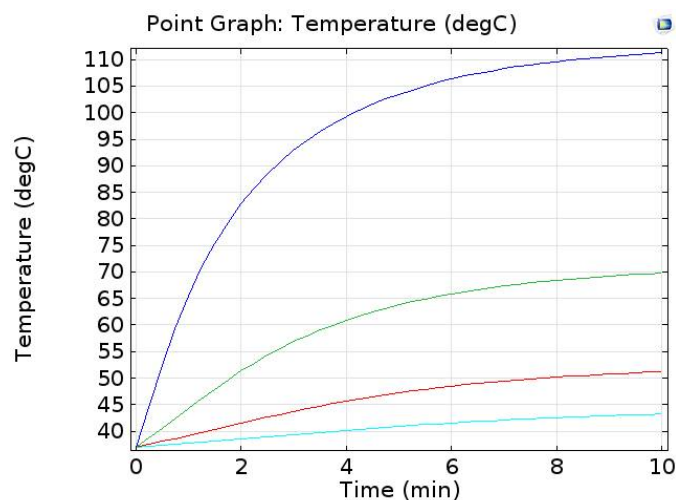


Fig.15 Temperature curve 20W.

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.

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Vol. 6, Issue 7, July 2017

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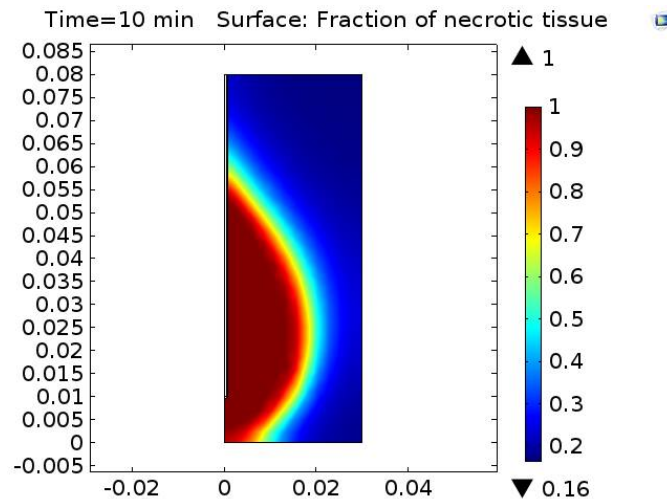


Fig.16 Dead cells

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 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.

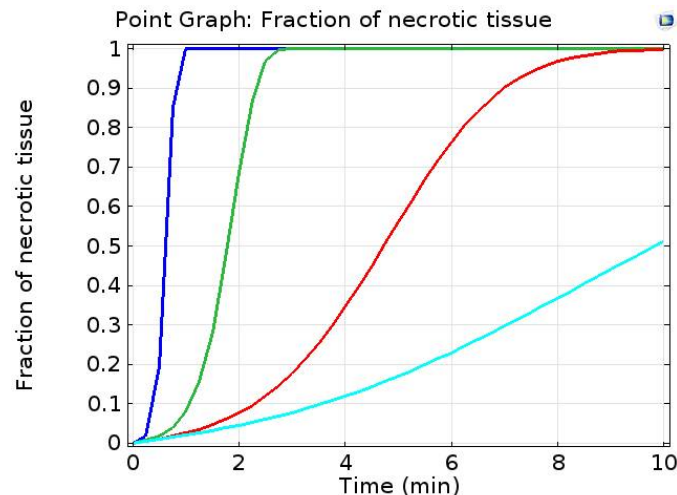


Fig.17 Dead Cells Vs Time Curve 20W.

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

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Vol. 6, Issue 7, July 2017

TABLE IIIII  
RESULT OF THE MEASURED ABLATION DIAMETER WITH TIME AT DIFFERENT POWER FOR TWO SLOT ANTENNA

Diameter (mm)	Power in Watt		
	5W	10W	20W
10	330	180	60
20	1800	480	402
30	5280	2100	660
40	7200	5760	2340
Time in seconds			

We have studied different temperature , power distribution and dead cell graphs and above are the values which we have obtained for ablation diameter with time at different power , in this a tumor of 10mm diameter is killed in 330 seconds when we apply 5W power to it and it takes only 15 seconds to kill the same tumor by applying 100w power . whereas if we talk about 40 mm tumor , the time take for dissertation is 510 seconds when a power of 50W is applied.

## V. 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 4 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 6 minutes. Tumor upto 5mm is cured in 1 minutes, upto 10 mm is cured in 2 minutes and upto 15mm is cured 9 minutes.

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