Effects of Cell Phone RF Radiation on Human Testes

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Abstract: The purpose of this feasibility test was to determine how the thermal effects of electromagnetic radiation from cell phones can affect male fertility. By creating a model of testes, two legs, and a cell phone in HFSS, we were able to simulate this. By then converting the amount of energy imposed upon the testes from the cell phone signal to heat, we discovered that having a cell phone in your pocket will increase the temperature of the nearest testicle by .00102 ^{o}C per hour. We determined this not to be a substantial enough amount to lead to male infertility.

I. Problem

Wi-Fi, FM radio, microwave ovens, cell phones: over the past two centuries humans have dedicated a tremendous amount of effort into surrounding ourselves with electromagnetic radiation. And as this technology became more and more prominent in our culture, the concern for people's health naturally arose. As it turns out, exposing biological tissues to electromagnetic radiation have both thermal and nonthermal effects, with the former being the largest concern and the subject of this report.

While microwaves and car radios have already been thoroughly tested and deemed safe years ago, cellular phones are still a relatively new technology. It's because of this, that our group decided to examine the thermal effects of a cellphone's radiofrequency radiation on one part of the human body particularly valuable to any man, or any woman looking to have kids with a man. Of course it is now well known that an excessive increase to the temperature of human testes could be a cause of male infertility. So, since everyday many men walk around with a cellphone in the front pocket of their pants, the question has to be asked: "Is my cellphone going to prevent me from having kids?"

II. Goals

In order to properly assess the thermal effects of a cellular radio waves, our group needs to simulate the specific absorption rate of human testes, originating from a source of radiofrequency radiation having similar characteristics to that of a modern cell phone. The specific absorption rate (SAR) will provide us with the amount of energy that absorbed the tissue. From that information, a few simple formulas could be used to derive the change in temperature the tissue would undergo over some period of time. We would be able to estimate how much heat the tissue would absorb over any period of time. One hour, eight hours, even a whole day of having testes exposed to a cellular signal.

However, the accuracy of our simulated SAR will depend on the accuracy of our cellular signal, and of our human model. Both of these elements will be limited, in majority, by our lack of 3D modeling skill. The intricate geometry of the human body, and the complexity of a modern day cell phone will force our group to simplify this model wherever we can, reducing the phone to a simple antenna and the body to its most basic shapes. However, we expect these simplifications to have relatively little effect on our overall results, and simulating the design in Ansoft HFSS should provide with sufficiently accurate data.

The situation being proposed is that a human man has a cell phone in his pants pocket, radiating energy in the form of cellular data transmission. By modeling this geometry, and simulating at the most "extreme" frequency and power level of a typical, modern-day cell phone, the resulting SAR reading will allow us to calculate the testes' increase in temperature. Finally, after all of this is achieved, we should be able to accomplish the ultimate goal: to determine if this temperature increase would have any realistic effects on the man's fertility.

III. Solution

The first step of our solution was to build a model of the region that would be representative of the average male. We made four cylinders to represent the average thighs and femurs with length 48 cm and diameter of 14.5 cm and 2.34 cm respectively[3][4]. Then we created two spheres to represent the testes using the average dimensions once again[5]. We then created new materials for bone, muscle, and testes to assign to the proper geometries. Each material needed the relative permittivity, bulk conductivity, dielectric loss tangent, and mass density which we found online[1][9].

Next we built the antenna that would represent our cell phone antenna. We built it out of a copper ground plane with dielectric in between that and a cylinder of copper. We used a lumped port for excitation as we discovered that a waveport would not work inside the 3D geometry. The length of the cylinder is 7.9cm which is a sufficient length for the signals cell phones receive[10]. The antenna was placed next to the thigh at a height that would be similar to where a cell phone sits while in someone's pocket. This was chosen because it is the most typical scenario and the one which would result in the most exposure to the studied area. To finish the model we enclosed everything in an air box with radiation boundaries as we have learned to do in previous labs. Pictures of this model can be seen in Figures 1-3.

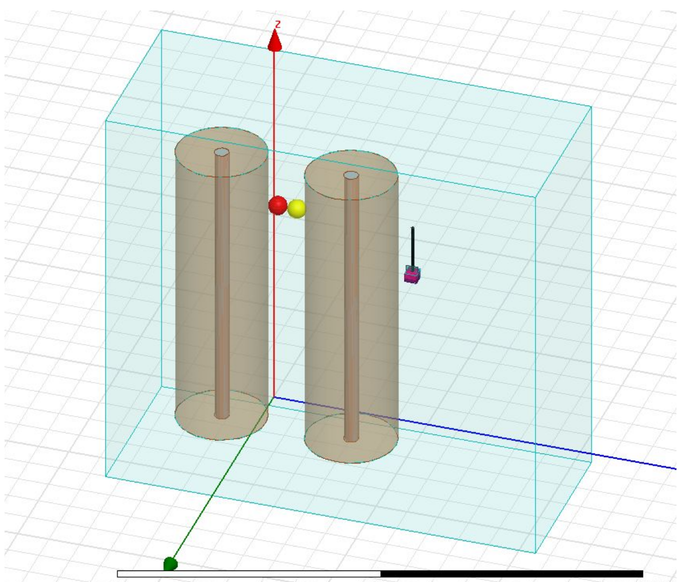

Figure 1:Trimetric view of model

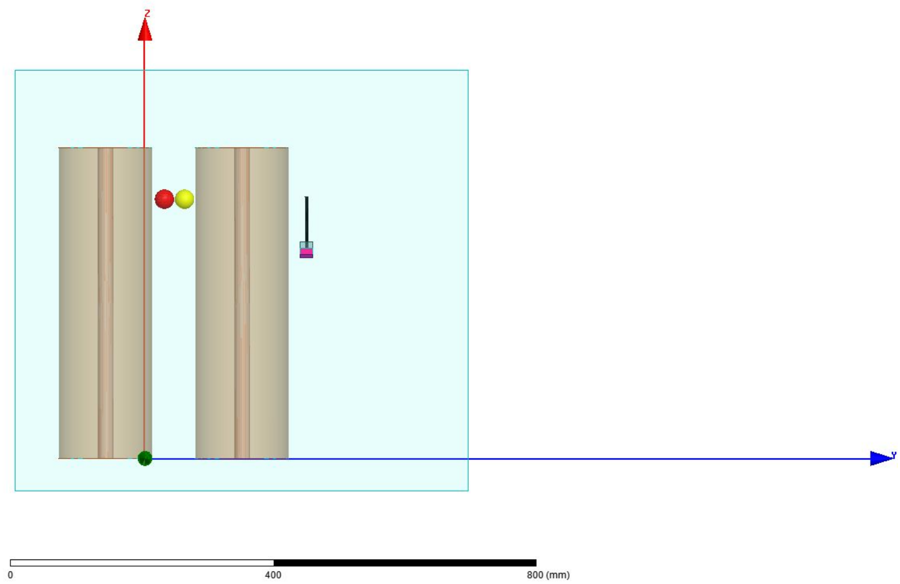

Figure 2: Front view of model

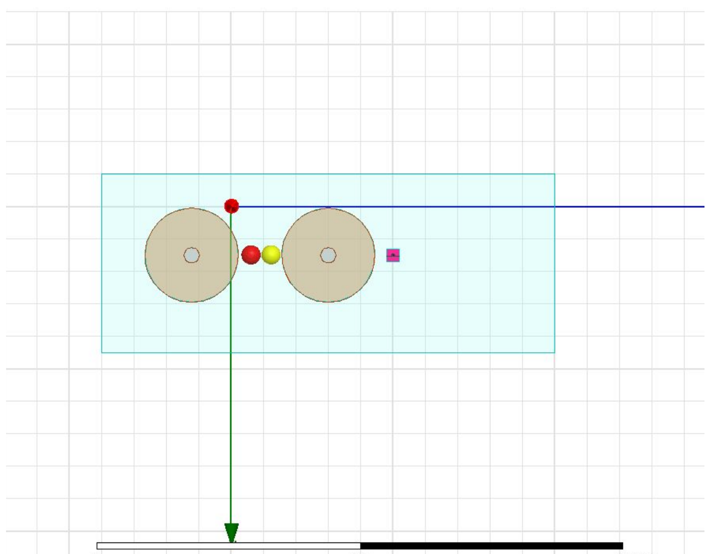

Figure 3: Top view of model

We then needed to find the characteristics of a cellphone signal to properly simulate the scenario. We decided to go with the highest frequency they use because we expected it to have the most penetration. This is desirable since we are looking for the typical scenario with the greatest effect on the tissue. For the same reason we used the highest power at that frequency. As a result our antenna used a frequency of 1900Mhz and a power level of 1W[6][11].

IV. Results

We ran our simulation at the single frequency of 1900Mhz. It took a relatively short time to simulate which is due to the simple geometries we chose. This let us know that it would have been possible to use a more accurate and hence more complex model to try to obtain more accurate results. However, we were satisfied with the accuracy of our model for the project's specifications.

The relevant field for this experiment is the Specific Absorption Rate “which is a measure of the amount of radio frequency energy absorbed by the body when using a mobile phone.”[12] Figure 4 shows this field applied to our model’s interior. As you can see the signal propagates directly towards the testes which revealed it was a good location for the antenna because it’s a use case with high likelihood and the highest likely effects. The SAR quickly decreases as it penetrates the thigh and it is clear that the signal level as it reaches the inside of the thigh is orders of magnitude less than that immediately next to the antenna. We did not consider the possible heating effects on the thigh because it is not nearly as sensitive to the testes, and would require much more heat to have any detrimental effects.

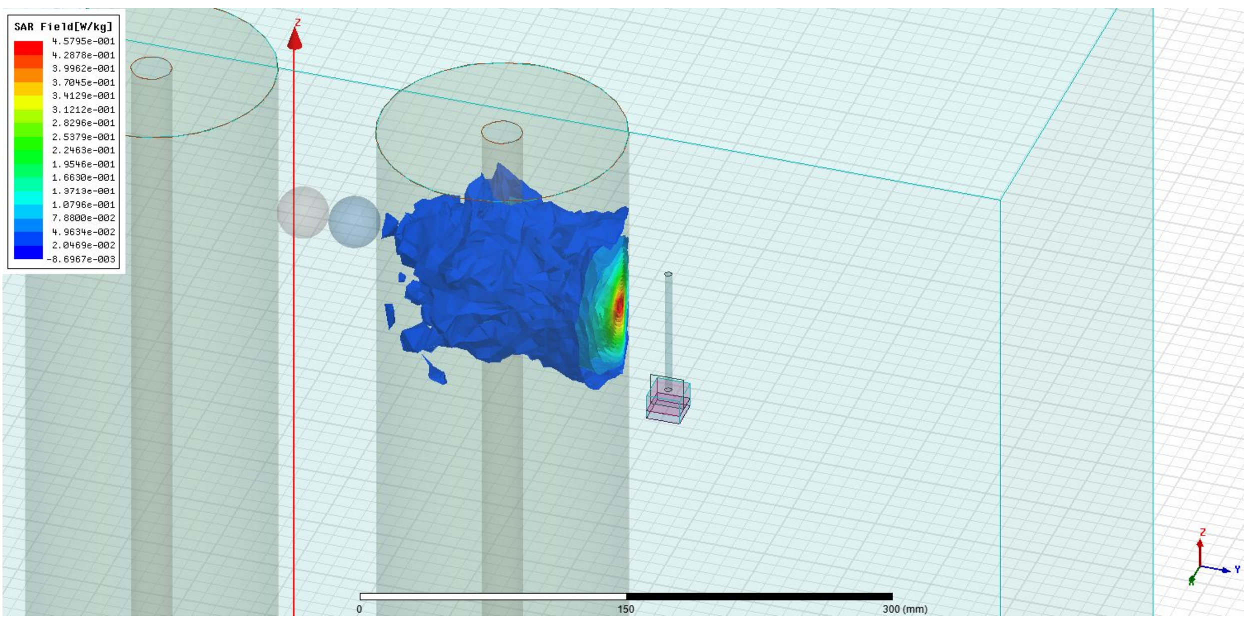

Figure 4: SAR field on the model

Figure 4 did not show any field on the Testes because it was relatively much lower than that in the thigh and thus did not make the scale. So we plotted the field just on the nearest sphere to see the results. We only did our tests on the nearest because it would be the one most affected, so the other results weren’t relevant to our goals. Figure 5 shows the results plotted only on the surface of the sphere because it showed the results more clearly and we did not need to see the same penetration as in the thigh. We can see from the scale the SAR is considerably lower than that in Figure 4. We hypothesize it is stronger at the top of the testicle because there is empty space in our model above the thigh. In future experiments a geometry representing the hip area could be added to test this.

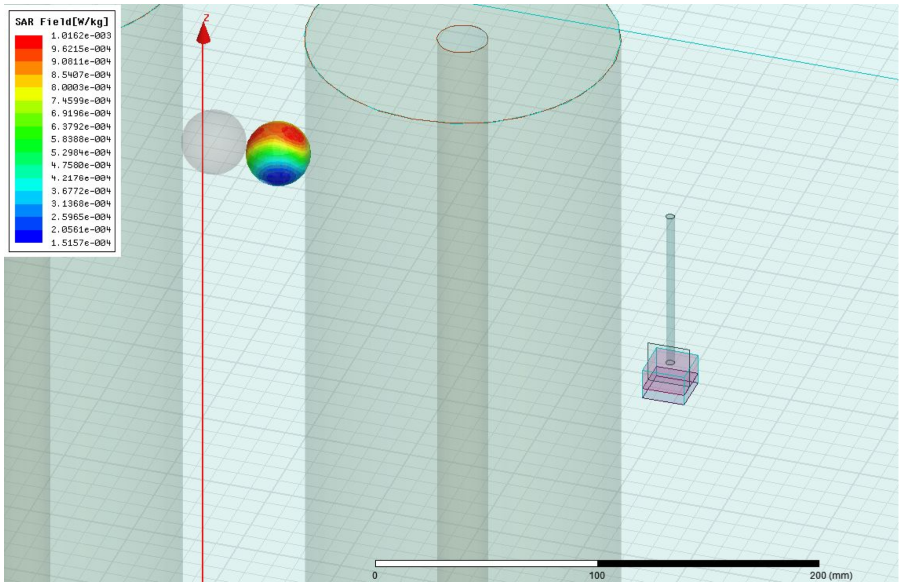

Figure 5: SAR field on nearest testicle model

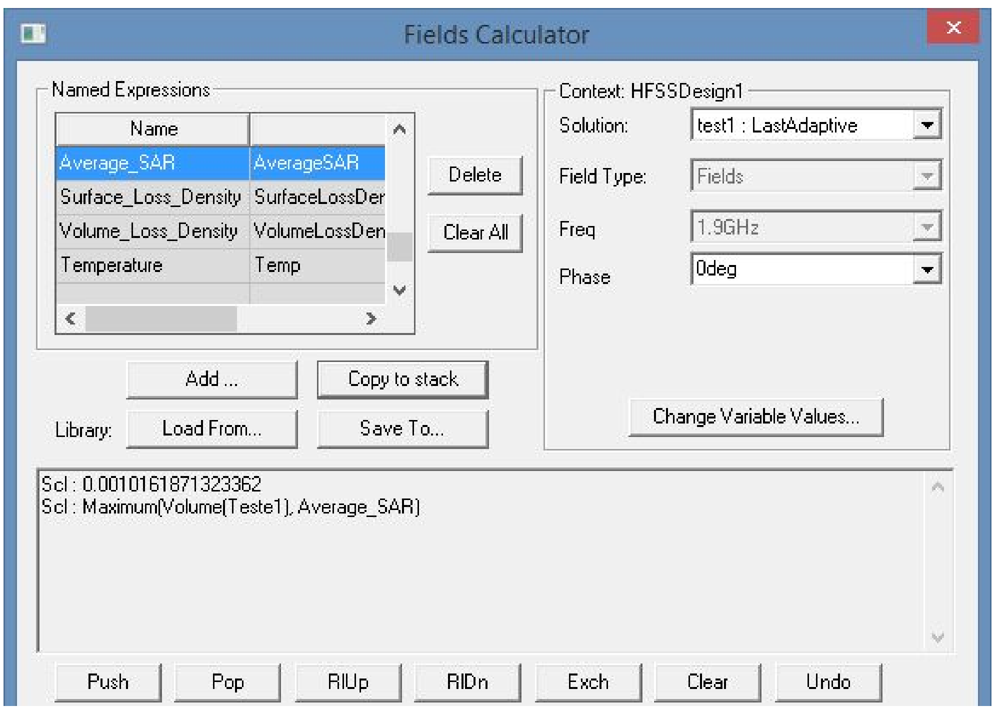

Figure 6: Field calculator results of SAR on Testicle

$$SAR = W/kg \tag{1}$$

$$P = Work/Time \tag{2}$$

$$Q = c_p * m * dt \tag{3}$$

Our final step to obtain the desired results was to calculate the heat dissipated in a single Testicle. We found the maximum average SAR using the fields calculator (Figure 6) which turned out to be .001016. We used the maximum because once again we are looking for the most effect possible. From equation 1 we know that the SAR is W/kg so we multiplied our number by the mass of our testicle (.06456 kg) to get a power of .066 mW[9]. We now had a level of power and used equation 2 to solve for work (energy)[2]. We used a time of 3600 seconds which is equal to one hour. We used one hour because it is a long enough time that we though it may have some effect on temperature, and is short enough to be a realistic time for leaving your phone in your pocket. Finally we plugged this value (.2361 J) in for Q in equation 3 which is the equation for relating change in temperature to energy in a system. C_p is the specific heat of of the material and we used that of muscle because it was the closest value we could find for our tissue (3.59 kJ/kg^{o}C)[8]. M is the mass so it is now simple to solve for the change in temperature of the tissue. Our result was an increase of .00102 ^{o}C.

V. Conclusion

The results of this feasibility study show that the electromagnetic radiation from a cell phone will not lead to infertility. The signals from a cell phone will increase the temperature of a testicle by .00102 ^{o}C per hour. According to Parenting Weekly[7], increasing the temperature of testes by 1^{o}C will reduce sperm count by approximately 40%. We find these results to be valid because of the low amount of energy coming from the cell phone signal. In running this simulation, we set the power from the antenna to be approximately 1 W, which would allow the amount of power reaching the testicles to be very low. As the testicular temperature increase from a cell phone is so little, this feasibility study can not conclude that a cell phone causes infertility.

References

1. http://niremf.ifac.cnr.it/tissprop/
2. http://www.engineeringtoolbox.com/heat-work-energy-d_292.html
3. http://dtic.mil/dtic/tr/fulltext/u2/a433581.pdf
4. http://www.orthopaedicsone.com/display/Review/Femur
5. http://www.theaveragebody.com/average_testicle_size.php
6. https://en.wikipedia.org/wiki/Cellular_frequencies
7. http://www.parentingweekly.com/preconception/preconception_information/heat_and_male_infertility.htm
8. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2278909/
9. https://en.wikipedia.org/wiki/Testicle

10. http://denbeste.nu/cdmafaq/antenna.shtml
11. https://en.wikipedia.org/wiki/DBm
12. https://www.fcc.gov/encyclopedia/specific-absorption-rate-sar-cellular-telephones