MOBILE PHONE EM EXPOSURE STUDY ON INHOMOGENEOUS HUMAN MODELS CONSIDERING DIFFERENT HAND POSITIONS

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Abstract

The goal and the novelty of the proposed research is to study Mobile phone EM exposure influence upon the inhomogeneous child and woman models in case of different hand and finger positions at the 900 MHz, 1900 MHz and 3700 MHz frequencies. Numerical simulations are carried out using FDTD method to estimate the specific absorption rate (SAR) and temperature rise caused by absorption of EM field energy in the human tissues. There were also studied SAR and temperature rise dependence on S11 radiation parameter of mobile phone antenna for different distances.

1. INTRODUCTION

A tremendous increase of mobile phones and other wireless communication systems are observed during past years. Their EM radiation can be dangerous for human health. In this way the study of their EM exposure influence on the human body is very actual problem nowadays. The antenna of a mobile phone is located in a close proximity to the user's head and hand. Both are a dielectric object with high loss dielectric parameters. The wavelength is comparable to the both, head and hand and they affect the radiation process. It is important detailed study these phenomena in order to obtain some general conclusions about the nature of exposure process and to elaborate some safety recommendations and standards. It is necessary find out the way how to reduce the radiation influence on human from phone antennas.

Many researches show that radiation nature and EM fields behavior is highly dependent on complex human body geometry and anatomy [1], location in an enclosed or semi-enclosed room and its wall's transparency [2,3], other objects around the user, etc.

The researches also show that absorption of radiated energy (SAR) depends on characteristics of mobile phones, antenna types and its positions or the phantom itself, and radiated power from the mobile phone [4-7]. It is important to note that the absorption may be in the device and in the human, holding the device, but here the variations in the user influence are difficult to include. This problem is avoided if the antenna is measured in the anechoic chamber including different users as it was done in [8,9].

In [10] it two types of realistic mobile phones were considered. There have been some reports about possible effect of the hand presence on the head SAR if hand phantom is included in the measurements of the head SAR compliance assessment procedure. There was shown that lower band GSM frequencies the presence of the hand decreases the SAR in head tissues up to ~70%. For the upper band GSM frequencies, the presence of the hand decreases the head SAR up to ~55%.

In spite of many publications on this topic the problem is not studied completely. Our paper focuses on detail investigation how the hand and fingers position influence on the EM field energy absorption and temperature increase in the human (woman and child) head tissues; their dependence on S11 radiation parameter of mobile phone patch antenna; also, the fields behavior in the near and far zone.

2. MODELS, METHODS AND RESULTS OF NUMERICAL SIMULATIONS

As it mentioned above, our goal is to investigate EM field exposure on human, particularly, on a woman's and child’s models, with and without considering the different hand (finger) positions and estimate SAR and temperature rise values in the head tissues. The inhomogeneous 3D models of a woman named as “Ella” and child named as “Thelonious” [11] were used with 1mm discretization.

Figure 1. Woman (Ella) head model with phone, a) without hand, b) with hand position 1, c) with hand position 2.

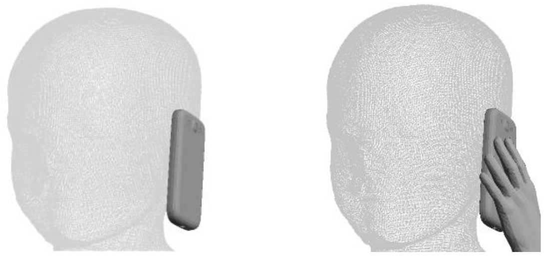
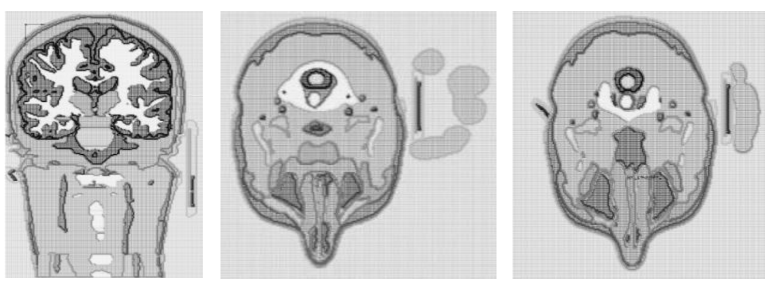


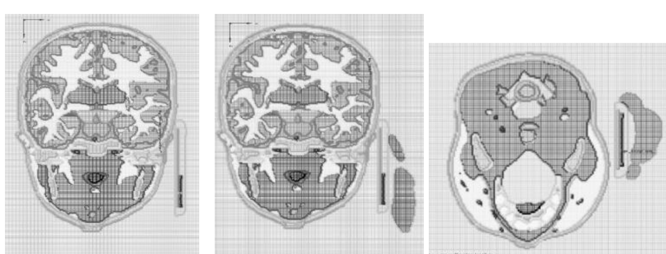
Figure 2. Child (Thelonious) 3D models with phone: a) without hand, b) with hand.

For the woman head model two hand position (Figure 1), holding the mobile phone, were selected: phone held with fingers (hand position 1) and phone held with the palm (hand position 2). For the child model, it was selected only one hand position (Figure 2b). The handset is placed from the head model at the distances 1 mm and 10 mm. For the both human model frequency dependent tissue parameters for the EM simulation and thermal tissue parameters have been used from the known database [12]. The hand models are filled with muscle material. The patch antenna is embedded in mobile phone model (Figure 2), which dimensions are 9x5x0.8 [cm]. The phone case dielectric permeability ε=2 and patch antenna dielectric is Bakelite, with permeability ε=4.8. The woman's and child's head-hand and mobile phone discrete models in different plane are presented on the figure 3 and figure 4.



a) b) c)

Figure 3. Woman (Ella) discretic model: a) without hand, b) with hand position 1, c) with hand position 2.



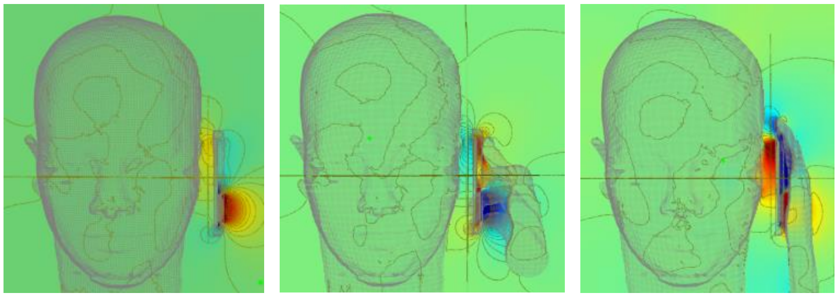
a) b)

Figure 4. Child (Thelonious) discretic head model with phone: a) without hand, b) with hand in different plane.

The numerical experiments were conducted using the EM and thermal solver, program package FDTDLab, which is developed at TSU [11, 12] and based on the FDTD method. The standard frequencies: 900, 1900, 3700 [MHz] are selected for the simulations and a sinusoidal wave signal has been used at corresponding frequency. SAR and Temperature rise in tissue were simulated due to RF exposure from mobile phone's Patch antenna placed at 1mm and 10mm distance from the head model.

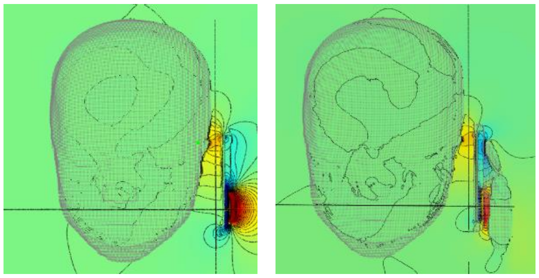
3. RESULTS AND DISCUSSIONS

Based on the above-mentioned models and parameters, we have obtained the following results. The E field distributions for the Ella and Thelonious head-hand models head-hand models are shown on figures 5, 6. It can be seen from Figures 5a, 6a, that the significant part of energy is radiated into the open space; the rest is absorbed by the head. But when we take into account hand, the most part of radiated energy is absorbed by the hand; as a result, the field values inside the head will be smaller (Figures 5b, 5c, 6b).



a) b) c)

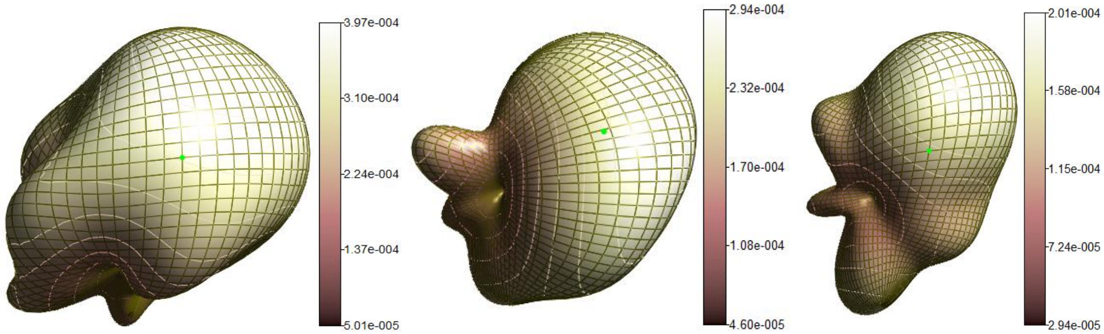
Figure 5. Near field distribution for the woman (Ella) head model at 900 MHz, a) without hand, b) with hand position 1, c) with hand position 2.



a) b)

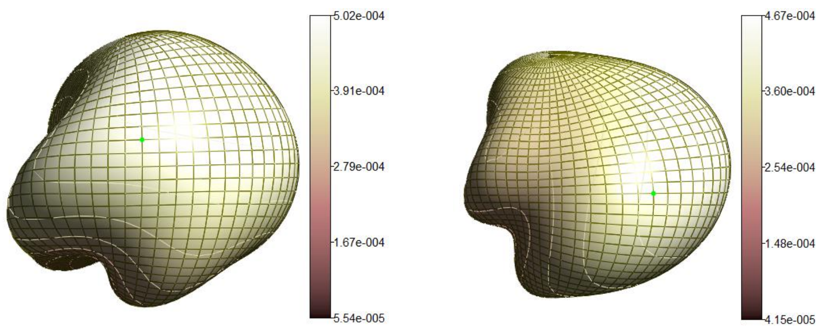
Figure 6. Near field distribution for the child (Thelonious) head model at 900 MHz: a) without hand, b) with hand.

On figures 7, 8 are presented 3-dimentional far field patterns for the both human head without hand and with different hand positions at 900 MHz.



a) b) c)

Figure 7. Far field patterns at 900 MHz for the woman (Ella) head: a) without hand, b) with hand position 1, c) with hand position 2.



a) b)

Figure 8. Far field patterns at 900 MHz for the child head: a) without hand, b) with hand.

The simulated 2-dimentional radiation patterns for different scenarios with some positions of the antenna, the head and the hand are presented on figures 9, 10. From figures it’s clearly seen, that hand presence changes the radiation pattern and its quantity. The head and hand palm (hand position 2) absorbs the most part of the energy radiated by the phone, that's why the far field pattern size is much smaller than in the case when the phone is held by the fingers (hand position 1) and than in other cases (Figure 9). We have a similar picture for the child model (Figure 10).

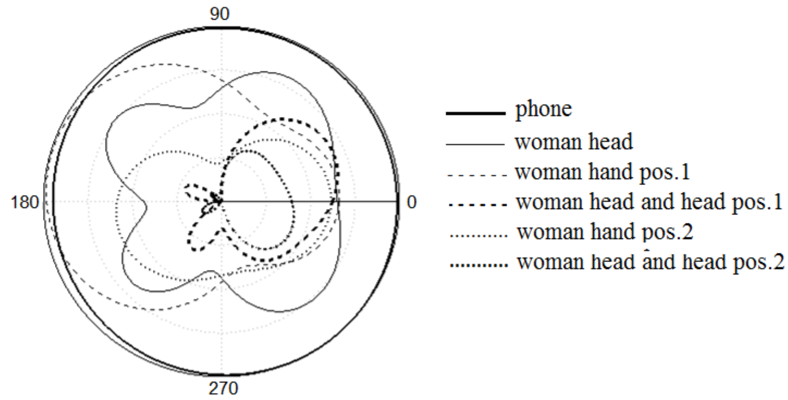


Figure.9. Radiation pattern of the woman model "head-hand" system at 900 MHz radiation Frequency.

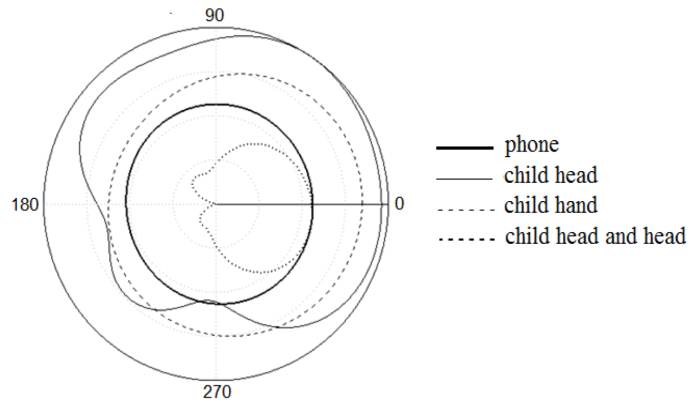
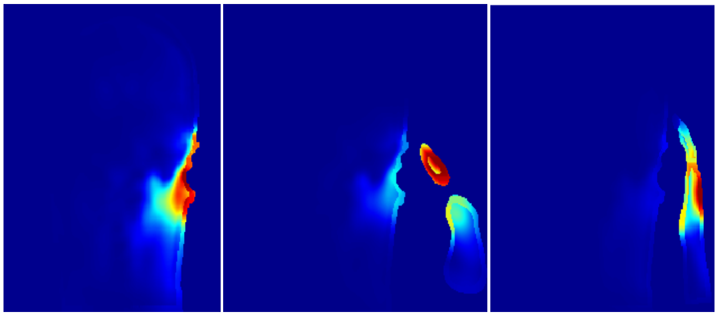


Figure 10. Radiation pattern of the child model "head-hand "system at 900 MHz radiation Frequency.

On figures 11 and 12, SAR distributions for the Ella and Thelonious head-hand models are shown at 900 MHz radiation frequency.



a) b) c)

Figure 11. SAR distribution for the woman (Ella) head and hand models at 900 MHz, a) head without hand, b) head with hand position 1, c) head with hand position 2.

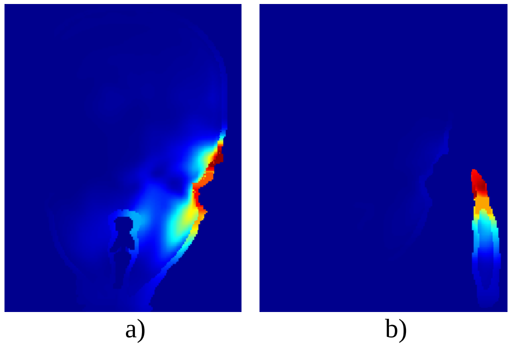


Figure 12. SAR distribution for the child (Thelonious) head and hand models at 900 MHz, a) head without hand, b) head with hand.

It can be seen that when hand is considered the peak SAR locations are shifted from the head to the hand, because hand absorbs a big part of radiated energy and as a result, the peak values of SAR in the head model are drastically reduced.

This good effect seems from the figures 13, 14 where the 10g SAR peak values for the woman and child head models without hand and considering hand different positions are given, when hand and phone are placed at 1 mm and 10 mm distances from the head model. All the obtained results are normalized for the 1W of input power.

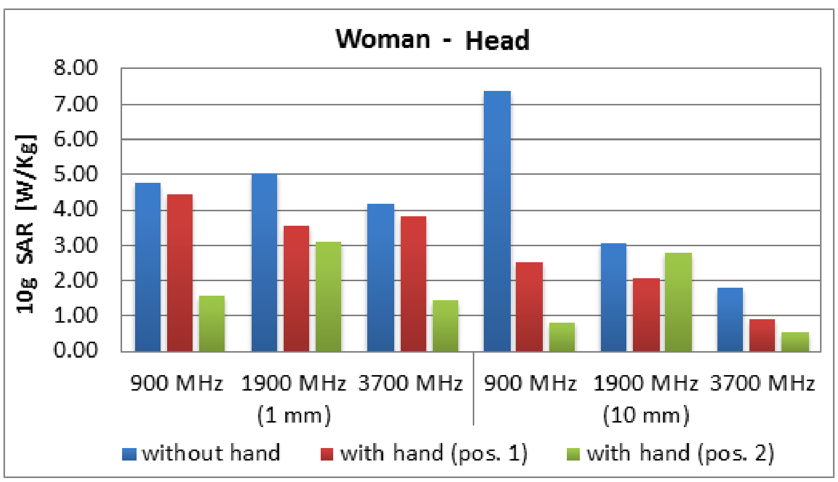


Figure 13. 10g SAR values for the woman (Ella) head model at 900 MHz, 1900 MHz and 3700 MHz, without hand and considering the hand position 1, hand position 2.

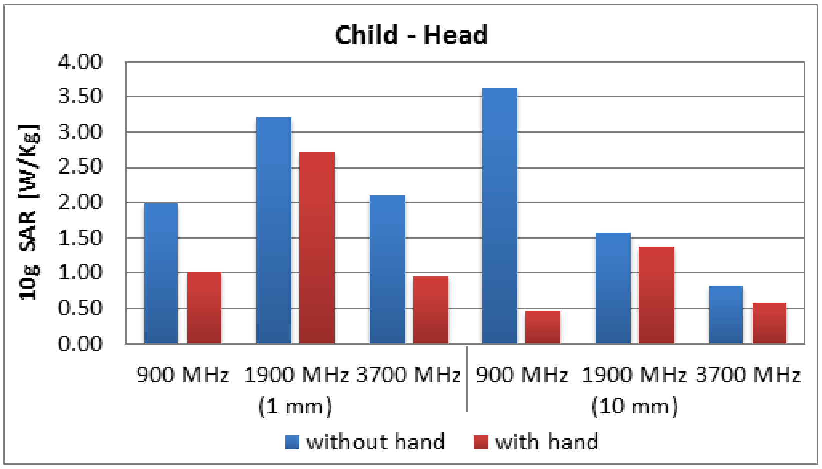


Figure 14. 10g SAR for the child (Thelonious) head model at 900 MHz, 1900 MHz and 3700 MHz, with and without hand.

According to the results, which are presented in figure 13, 10g SAR peak values in the head considering the hand position 2 are much smaller than for hand position 1.

The temperature rise peak values in the woman and child head models, for the considered head-hand models, when the distances between them are 1 mm and 10 mm, are presented on figures 15, 16.

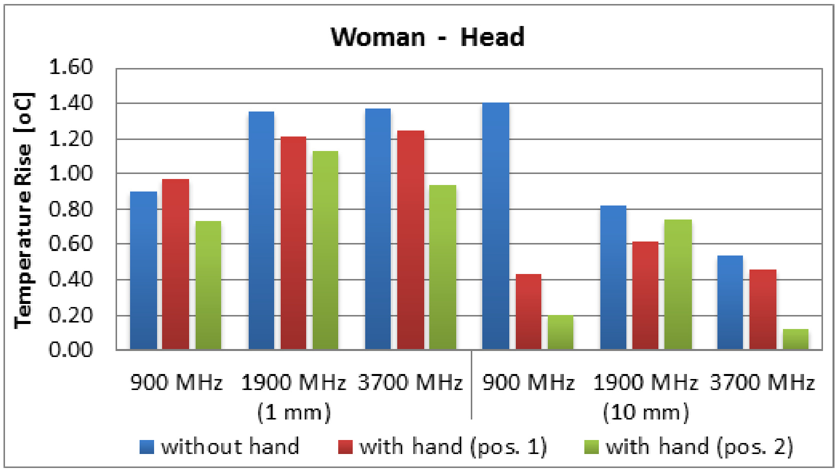


Figure 15. Temperature rise for the Ella head model at 900 MHz, 1900 MHz and 3700 MHz, without hand and for the hand position 1, hand position 2.

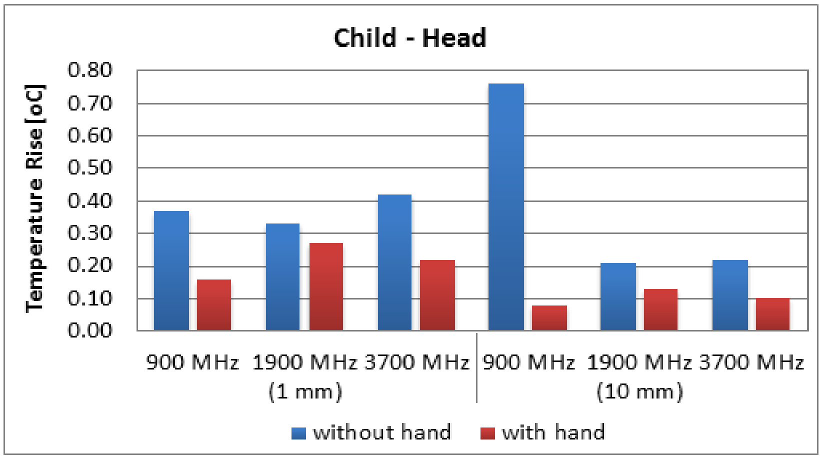
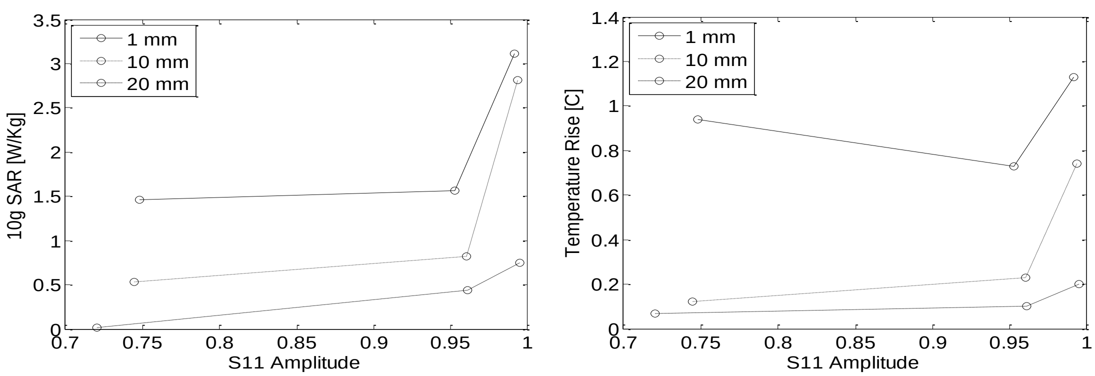


Fig.16 Temperature rise for the child (Thelonious) head model at 900 MHz, 1900 MHz and 3700 MHz, with and without hand.

All presented results show that if we take into account the hand effect, we see the reduction of SAR and temperature rise values in a woman and child head tissues. It has been also shown that if phone is held by a palm (hand position 2) SAR and temperature rise are lower than in case when phone held with fingers (hand position 1). This is explained the fact that the most part of radiation is absorbed in the palm and just a small part of radiation reaches the woman head. The SAR and temperature rise values also depend on distance between the head model and the phone with hand models. In particular, these values are higher when the radiation source with hand is close to the head (for 1 mm) than for the 10 mm 20 mm distance from it, because EM field is inversely proportional to the distance from the source. After that we have investigated SAR and temperature rise dependences on mobile phone's antenna radiation S11 parameter. The obtained results are presented on Figures 17, 18.



a) b)

Figure 17. (a) 10g SAR and (b) Temperature Rise dependences on S11 for woman head model considering hand pos. 2. SAR normalized to 1W input power.

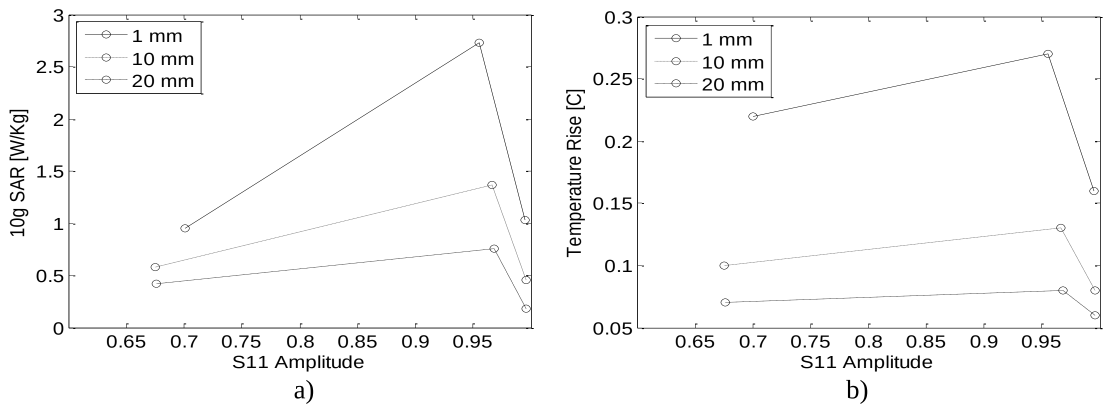


Figure 18. (a) 10g SAR and (b) Temperature rise dependences on S11 for child head model. Temperature rise normalized to 1W.

As it can be seen from figures 18a, 18b for the examined scenarios SAR and temperature rise values increase with the increase of S11 coefficient. Though it is a proofed fact, that there is a strict correlation between S11 and temperature rise. On the figures 19a, 19b we see that some points are not in agreement with previously observed dependency.

The relative position of the head, hand and handset determines the radiation condition, for some of examined scenarios the S11 close to 1.0 means, that almost nothing is radiated. Despite the fact, that the obtained results are normalized for the 1W of input power, these results where the S11 was close to 1.0 are not reliable and can be neglected. From the above stated we can conclude that the amount of energy absorbed by human tissues can be estimated by monitoring the S11 coefficient.

4. CONCLUSIONS

The effects, related to the presence of a human hand, holding the mobile phone, and the EM exposure process have been studied in this paper. It has been shown that the hand presence changes the radiation pattern, thus changing the SAR and temperature rise peak values in tissues. The peak SAR and temperature rise values in the head tissues are lower considering the hand presence. These values are even more reduced in the head tissues when phone held with a palm than in case when the mobile phone held with fingers, because most part of radiation is absorbed by palm. Also, resultant SAR and temperature rise values are decreasing by increasing the distance from the radiation source to the head. Based on the obtained results we can make the following safety recommendation. If phone hold with palm the most part of the radiated energy is absorbed in it. In this occasion, it is better not to cover the mobile antenna by the palm, because modern smartphones automatically increase the radiated power to achieve good connection, causing higher SAR and temperature rise values in the head tissues. It is better to hold the phone with finger tips as far from the head as possible in order to reduce EM field exposure. It is shown that in first approximation the peak SAR and temperature rise value depend on the S11 coefficient. And the amount of energy absorbed by human tissues can be estimated by monitoring the S11 coefficient, making the smartphones even smarter. Finally, it should be noted that every human is unique and differs in form, dimensions, weight and constitution, thus it's difficult to make general conclusions. Due to this reason, the stated problems still are topical nowadays and it requires further research.

ACKNOWLEDGEMENT

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