Numerical investigation of the influence of the handset/phantom positioning error on SAR calculations

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Abstract

Mobile phone dosimetric conformity assessment is performed by applying measurement procedures established by international standardization committees. Numerical dosimetry was essentially focused on head models but the ever increasing computing capability has now paved the way for SAR (Specific Absorption Rate) calculations using CAD (Computer Aided Design) phone models. A key issue in numerical dosimetry is the evaluation of the uncertainty associated to a given SAR calculation. A reconstructed commercial mobile phone model with a built-in antenna is herein employed to evaluate the uncertainty due to the positioning of the handset with respect to the phantom.

1. Introduction

Today the SAR (Specific Absorption Rate) conformity assessment of mobile phones is performed by applying measurement procedures which are based on international standards such as IEC [1] and IEEE [2]. The SAM (Specific Anthropomorphic Mannequin) phantom filled with the appropriate tissue equivalent liquid is used for the dosimetric measurements for several mobile phone intended use positions as shown in Figure 1. The established measurement procedure is rigorous – liquid verification, system validation and regular costly maintenance of the system are required – but proves to be time-consuming. Currently, the compliance test of a dual-band mobile phone easily requires a full day. The maximum averaged 10 g SAR value is provided with an uncertainty of up to 30 %. This figure includes typical uncertainties due to the measurement instruments employed as well as the uncertainty related to the positioning of the handset with respect to the phantom. The latter may become quite important for complex design mobile phones such as clam-shells.

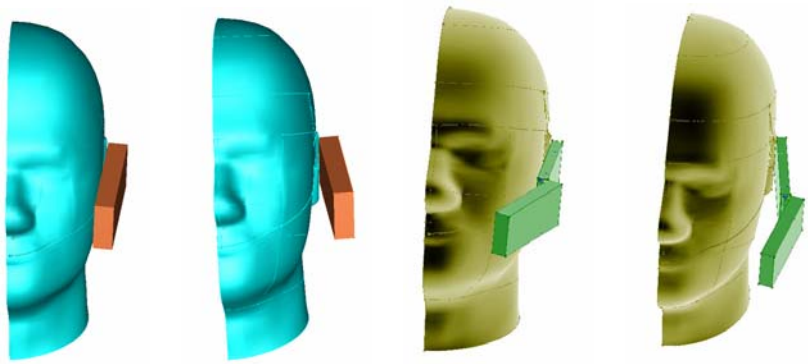

Figure 1. Handset positioning with respect to the SAM phantom from left to right : (a) barphone left/cheek, (b) barphone left/tilt, (c) clam-shell left/cheek and (d) clam-shell left/tilt.

Until recently, numerical SAR calculations were undertaken using rather simplified mobile phone models such as a monopole over a metallic box or a PIFA (Planar Inverted-F Antenna) over a PCB (Printed Circuit Board). Nowadays it is possible to run SAR calculations with CAD (Computer-Aided Design) phone models using currently available standard computers. However the complexity of full CAD models – which are initially developed for mechanical engineering purposes – does not allow a straightforward electromagnetic analysis. A simplification or reconstruction of the CAD model is often a pre-requisite prior to the numerical simulations. A previous numerical study of a commercial mobile phone shows that the results – return loss, total radiated power and SAR – obtained with the reconstructed model agree well with measurements [3]. The comparison of the return loss results showed that some specific components of the mobile phone – for example, the speaker – can induce undesired resonances which cannot be easily accounted for by the numerical modeling. The total radiated power data showed that the losses of the mobile phone were consistent with the dielectric properties employed for the different components. Finally, the maximum averaged 10 g SAR values at 900 MHz and 1800 MHz were within the 30 % uncertainty level of the dosimetric test facility. However the overall uncertainty of the numerical simulations was not assessed. As usual in numerical modeling, the suitability of the mesh density was tested through a convergence analysis of the results. Thereafter, the mesh density was then optimized to provide fast run times for efficient SAR calculations.

The study is herein extended in the aim of evaluating the uncertainty associated with the SAR derived from the numerical simulations. The focus is on the uncertainty due to the positioning of the handset with respect to the phantom. A recent international comparison on SAR calculations observed that the handset/phantom positioning may be one of the possible causes of discrepancy observed between the different participating laboratories [4]. Indeed, although most commercially available SAR calculation software packages provide an advanced graphical user interface, it still remains difficult to accurately position the handset against the phantom.

2. Numerical Modeling

Electromagnetic solvers based on the FDTD (Finite Difference Time Domain) method are usually employed for SAR calculations. A commercial package of the TLM (Transmission Line Matrix) method is herein adopted [5]. The numerical model of the reconstructed commercial mobile phone with a built-in PIFA is shown in Figure 2. The electromagnetic shields mounted on the PCB as well as the battery are modeled as rectangular metallic blocks. A dielectric material (not shown) covers the PCB and acts as a support for the antenna and the battery. The ensemble is covered by a dielectric casing.

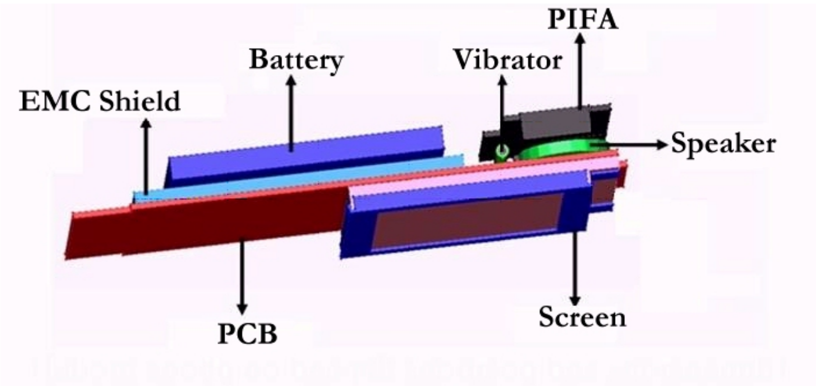

Figure 2. Numerical model of the reconstructed commercial mobile phone with a built-in antenna.

For practical reasons a flat phantom is chosen for the numerical investigations at 900 MHz. Compared to the SAM phantom, the flat phantom ensures an easier positioning of the handset as shown in Figure 3. Furthermore the regular shape of the flat phantom helps relieve the computational burden. Indeed, due to the presence of fine details, a high mesh density is required for the accurate numerical modeling of the mobile phone. In fact, a dipole antenna is also used as excitation for validation purposes. The calculated results are confronted with those obtained from measurements using a standard dosimetric test facility. In this case the SAR measurement uncertainty is reduced and the maximum averaged 10 g SAR value is expected to be within 10 % of the target value.

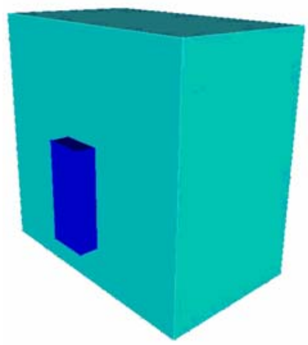

Figure 3. Mobile phone placed next to the flat phantom.

3. Results

The results obtained with the dipole antenna placed next to the flat phantom are provided in Table 1. Both the measurement and the numerical simulation results are within 10 % of the target value of 6.90 W/kg when normalized to 1 W of input power.

Table 1. Comparison between measurement and numerical simulation results for the case of a dipole antenna.

Configuration	SAR [W/Kg]
Measurement	7.30
Numerical Simulation	7.21

Table 2 shows the numerical simulation results for three configurations of the mobile phone position with respect to the flat phantom using a default mesh. Table 3 shows the results for the same configurations using a finer mesh. The first configuration wherein the mobile phone is placed parallel to the phantom constitutes the reference position. Two additional configurations are obtained by rotating the phantom – the mobile phone is not rotated to minimize staircase effects – by 1 degree either away or towards the mobile phone. For these two latter configurations, the mobile phone is first translated by 2 mm away from the reference position to avoid penetration of any part of the mobile phone inside the phantom. The variation of the distance between the mobile phone and the phantom has a first impact on the return loss of the antenna. A maximum deviation of about 5 % is observed between the three configurations whether the default mesh or a finer mesh is applied.

Table 2. Numerical simulation results for three configurations of the mobile phone with respect to the phantom using a default mesh.

Configuration of mobile phone	Return Loss [dB]	SAR [W/Kg]
Parallel to phantom	-9.73	0.86
Rotation of 1 degree away from phantom	-10.16	0.90
Rotation of 1 degree towards phantom	-9.54	0.85

Table 3. Numerical simulation results for three configurations of the mobile phone with respect to the phantom using a finer mesh.

Configuration of mobile phone	Return Loss [dB]	SAR [W/Kg]
Parallel to phantom	-7.94	0.81
Rotation of 1 degree away from phantom	-8.17	0.82
Rotation of 1 degree towards phantom	-7.7	0.77

4. Conclusion

Although the positioning is expected to be better than 1 mm when translating the handset towards the phantom, it is not necessarily the case when rotational transformations are applied. Hence the positioning of the handset can be a source of discrepancy when comparing SAR calculations between different laboratories, sometimes using the same numerical simulation software.

5. References

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