EMF hazards caused by dielectric heater - measurements and various numerical simulations

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Objectives

Presented investigations were conducted to check the possibility of the use of various software packages for modelling and assessing workers' exposure to electromagnetic fields (EMF). The software packages, which were used, based on various methods of EMF numerical simulations. The minimum requirements for numerical modelling complexity of work place models were also checked.

Methods

Simulations were carried out with the use of the following numerical methods: finite element method (FEM); finite difference time domain method (FDTD); finite integration technique (FIT). In all cases the specialised software packages for EMF simulations were used.

In all cases, various models of the same EMF's exposure source and worker's body were developed. Dielectric heater operated manually by worker was modelled as the source of 27 MHz sinusoidal EMF was. It was decided that the simplest model of work place, will allow to make comparison of the results obtained with the use of various numerical methods. Models of unshielded heater were developed as this simplest case. In consequences also the simplest model of worker's body was used – homogeneous cylindrical model.

The results of detailed 3D measurements of spatial distribution of electric field vector E (electric field strength of x, y, z spatial components) in the vicinity of real dielectric heater were used as reference data. The magnetic field strength H was found as relatively low over the worker's body position during the operation of the device and only electric component was taken into consideration.

Simulations were done for electric field spatial distribution in the vicinity of 5 models of dielectric heater, which modelled it's geometrical structure with gradually higher complexity (Model 1, 2, 3, 4, 5). Additionally, simulations for the simplest model of heater (Model 1) with the cylindrical model of worker's body (field affected by the worker's body), as well as without it (unperturbed field and), were done.

Results

Examples of obtained results of measurements and calculations will be presented. Obtained data were normalised by the value of electric field strength in reference point, which was established in front of the powered electrode, in the distance of 15 cm. The comparison of results obtained with the use of various dielectric heater's numerical models will be presented. Except the simplest model, which use results in significantly lower electric field strength in front of the heater at the place, the results are similar for other models.

The results obtained from various numerical methods are not the some, but all are relatively similar to the measurement's results.

Conclusions

The geometry of the used model of EMF's source, as well as numerical simulation's method selection can significantly influenced on the level of obtained results, however the relative spatial distribution of electric field strength could be similar. Thanks to this fact, obtained results of calculations suggest that various numerical simulations' methods could be acceptable for calculations, which were worked out for assessment the EMF occupational exposure level of 27 MHz frequency band.

The results indicate also that for the use of all methods the "calibration" of the calculation's results have to be done by the comparison with measurement's results. The decision for geometrical model and electrical properties of models and boundaries could be also crucial, but obtained results suggest that it could be standardised for typical devices existing in workplaces.

Presented investigations can support the work on the methods of the use of numerical simulations for the routine assessment of worker's exposure to EMF of intermediate frequency range. There is relatively wide gap of experience of "numerical" assessment of worker's exposure to EMF from intermediate frequency range in comparison with the huge amount of data concerning power frequency and microwave.

This work will be continued with more complex/realistic models of worker's body and devices.

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