Dosimetric analysis of occupational exposure of the hands in localized magnetic fields

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Highly localized and intense magnetic fields in the frequency range < 10 MHz occur at many workplaces in metal industry, e.g., welding, de-magnetization, induction heating, etc. In such situations Action Levels (AL) for the external magnetic fields are often substantially exceeded, hence a dosimetric exposure analysis based on numerical computations of the induced electric field strengths E_i inside the tissue and comparison with the corresponding exposure limit values (ELV) is required for a final assessment of exposure. For this purpose, however, numerical high resolution anatomical models of the hand are required, taking into account the fact that hand posture and skin modelling may have significant impact on the computational results [1].

For this purpose, three numerical hand models in three different typical working postures have been developed [2] and used for dosimetric computations of various occupational exposure situations (Fig.1a). The skin of the hand models is composed of seven layers (0.2 mm each) which can be arbitrarily parametrized with respect to their electric properties, allowing for a realistic representation of the gradually changing conductivity of real skin, starting from the innermost low conductive subcutaneous tissue, over better conductive dermis and epidermis layers, to the well insulating cover layer of stratum corneum (conductivity ≤ 0.0002 S/m).

Beside uniform magnetic field exposure (to verify the AL for limb exposure acc. to EU-Directive 2013/35/EU), several realistic occupational exposure conditions including usage of capacitor discharge (CD) stud welding guns, resistance welding devices, demagnetization units and induction heating, have been analyzed by numerical computations using the SPFD-based solvers of the SEMCAD X and Sim4Life simulation platforms.

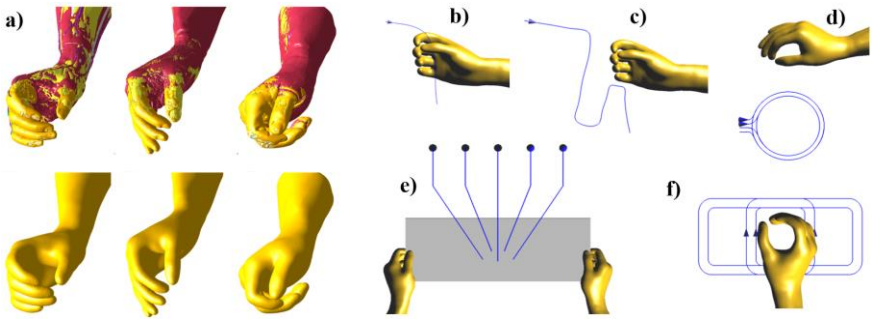

Figure 1. Hand models (a), with different versions of 16 kA CD stud welding gun (b, c), beside induction heating device (d), close to resistance welding machine holding a metallic sheet(e), and on top of a de-magnetization unit. Blue lines indicate current paths.

The results showed that, when using a realistic skin model, the AL for limb exposure acc. to 2013/35/EU can be considered conservative for the hands, i.e., when the AL is met, the ELV is not exceeded inside the hands. Highest exposure for the investigated situations was found when using the CD stud welding guns, showing induced E_i inside the tissue of more than a factor of 5 above the ELV. Moreover, the computations with the resistance welding and induction heating devices also indicated that the ELV may be exceeded under particular (but realistic) working conditions, particularly when there exists skin-to-skin contact (e.g. between thumb and index finger) or skin-to-metal contact (working without working gloves) during the magnetic field exposure.

References

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