Numerical Simulation of Large Structures with Moving Parts

Paolo Veronesi, Daniela Belviso and Cristina Leonelli

Department of Materials and Environmental Engineering, University of Modena and Reggio Emilia, Modena, Italy

The design and optimisation of large structures with multiple ports and moving parts requires significant computational efforts and the definition of the objective function should be carefully studied. In this work, three different modelling and design strategies are presented, aimed at reducing computational time and provide the best solution in terms of energy efficiency:

1. modular design
2. optimisation of the worst scenario
3. maximisation of the overall dissipated power in selected configurations

In the first case, the idea is to try to reduce the computational dimensions of a large applicator by dividing it into smaller systems having the same geometry and loading conditions (module). Then, optimisation is performed only on the single module, provided there is not a strong influence on each module from the neighbouring ones. However, even if this approach can somehow solve the problem of computational effort, still it fails to address the issue of moving parts.

In the second case, a set of preliminary simulation is performed on not yet optimised applicator geometry and the response, in terms of energy efficiency (obtained as overall SAR or by the scattering matrix of the system) is correlated to the position of the moving part(s). This allows for determining the worst scenario, which is then used as model, without moving parts, to optimise the system. The drawback of this approach is that the optimisation of the worst scenario does not implicate that the remaining scenarios are optimised at their turn.

In the third case, the geometry of the applicator with moving parts is simulated in time steps, each one corresponding to a different position of the moving part. The response of the simulation is then expressed as the overall dissipated power in the time steps, for a given applicator geometry. Optimisation is then conducted on the basis of this response, maximising the power dissipation in the load. One drawback of this approach is that the validity of the results is dependent on the time steps separation (usually the smaller, the better) and the strategy allows for the existence of configurations which could be detrimental for the system integrity (for instance, high power reflections at one port, even if only for one time step).

However, the third method provides also the response of each configuration, thus potentially dangerous conditions can be prevented by imposing constraints or simply by examining each simulation output of the optimised configuration.

Depending on the system dimensions and geometry, one of the three proposed approach can result in reduction of computation time and in the identification of the most suitable applicator geometry. However, it must be taken into account that also temperature distribution should be optimised (in particular heating homogeneity), and not only SAR or energy efficiency figures, and that the calculation should include the permittivity dependence with temperature and/or the existence of reactions inside the load which can alter temperature distribution, mass or shape of the load itself.