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Invited Talk at the CASOPT Closing Conference

The Dawn of Electric Field Simulation – a Journey through Time

Hans Steinbigler

It was a long minute of trembling uncertainty during the test procedure in the hall of the high voltage institute of the Technical University Munich, when the new facilities were tested with the limit voltage 1200 kV. This test procedure was carried out on November 19, 1963, in the presence of an outstanding audience: the bavarian minister of education, the rector of the University, representatives of industry and many other important persons. It was a strong feeling of relief, when this minute was over and no discharges appeared on the electrode system. In particular the organiser of this test, the late Professor Dr. Hans Prinz, director of the high voltage institute and responsible for the design of the system shared this feeling, because he knew that the preliminary tests for this show failed: there were in deed discharges on the surfaces of the shielding electrodes of transformers, capacitors and rectifiers. He was very lucky with this risky one minute test and he was well aware of this. From this time he supported emphatically the introduction of new design methods on the basis of digital computers. Roughly speaking this one minute in the high voltage hall of Munich was a starting shot for a new era in the design work of high voltage apparatus and systems.

Until this time the main tool for the determination of the electric field in high voltage systems were analogous methods, mainly the electrolytic tank. But now numerical methods for the calculation of the electric field as the main criterion for the design work were available. First the finite difference method, then charge simulation methods and finally the finite element method. A remarkable step forward was the boundary element method, where the discretization process is not extended to the whole space but only to the surfaces and the dielectric boundaries. In the meantime powerful and fast computer programs on this basis have been developed, which allow not only the field analysis of a given arrangement but also the multiple calculation of insulation systems in order to improve and to optimize them.

In the last decades this development in computer software was accompanied by the progress in computer hardware. This progress was accompanied by advances in computer architecture. Parallel computing can be successfully used for the calculation and optimization of three dimensional fields. In addition benefits can be drawn from the excellent research work in numerical mathematics, for instance in solution procedures for large equation systems. Another support comes from the remarkable activities in the discretization of complex geometries and their parametric description as an important requirement for the input into optimization algorithms.

Essential for the design work is the progress in the development in optimization algorithms itself. Very efficient tools are now available, as for instance: multi-directional field search, particle swarm optimization and evolution startegies.

In all this research work branches many scientists are engaged in industry and universities. To some extent they speak very different languages, not only in the linguistic sense of language. But for the progress it is essential that they understand each other. With respect to this the idea of EU supported CASOPT is, to create a common platform, where the scientists of the different areas can communicate in a better way, as an important step forward. Accompanied by Asea Brown Boveri with its scientific and practical design experience in high voltage systems three universities are invited in CASOPT to cooperate and to contribute with their scientific experience to the optimization of high voltage apparatus and systems. Optimization means in this cooperation the reduction of size, improvement of operation safety and finally reduction of costs. Improvements developed in the CASOPT project may also be useful for other branches of design work in electric and mechanical engineering.

One core area of this optimization work is the optimum design of gas insulated substations and gas insulated switch gear. A reduction of space means in this case a minumum of material and in particular a minimum volume of the expensive insulation gas SF_6. In this way the optimization work may also contribute to the solution of future problems in the area of high voltage power transmission, in particular for the application of gas insulated stations for off-shore electric wind power systems.

Another important aspect of such a cooperation is to inspire young people, students or young scientists, for these interesting and challenging tasks. The exchange between universities and industry is helpful not only for the technical project but also for their professional future. In this way the participation in the technical task of optimization of devices and systems may contribute to the optimization of their individual career as well.

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