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EFACEC case study

Carlos Carvalho, Director of Technology at EFACEC, discusses the benefits of software modelling in the design and test of transformers

The EFACEC Group is leading the supply of integrated solutions and equipment in the market of power generation, transmission and distribution. The Group forms a complete value chain, from building turnkey projects to equipment manufacture, where integrated solutions are developed and designed in accordance with clients' needs. The Group offers a comprehensive range of activities such as: Power Generation, Transmission and Distribution, Automation and Telecontrol Systems, Electric Mobility Power Supply Systems as well as Maintenance and Technical Assistance Services.

The director of Technology, Carlos Carvalho, leads a 120 - strong Engineering team in the EFACEC Power Transformers business unit: "Our division has the capability to design and manufacture Core and Shell type power transformers up to 1500 MVA, 525 kV, mobile substations up to 90 MVA, immersed and dry type distribution transformers. As such, a core element of EFACEC's business is the design and manufacture of power transformers. In the current market, transformers need to be ever more effective and competitively priced. To do this, we at EFACEC employ simulation software to build virtual prototypes of the system prior to manufacture, to avoid wasting time on costly mistakes."

He continues, "For the past 26 years EFACEC has been using simulation software from INTEGRATED Engineering Software to help iron out any design issues in the early stages, before they prolong the design lifecycle. The software we use at EFACEC are the ELECTRO, COULOMB, FARADAY and INDUCTO

products. ELECTRO is a 2D/RS electric field solver designed specifically for applications such as transformers. ELECTRO can calculate electric field strength, transmission line parameters and capacitance. Our designers can automatically vary and experiment with geometry, materials and sources, therefore reducing the tedious, repetitive task of fine–tuning multiple design parameters. COULOMB is, by contrast, a 3D electric field solver used for calculations such as electric field strength, transmission line parameters and capacitance. Finally, FARADAY is a 3D eddy current field solver which can calculate force, torque, displacement current, flux linkage, induced voltage, power and impedance."

Despite using software simulation, a yet unsolved problem in the design of transformers came to light. The weak link theory was adapted to the design of the insulating structures inside oil immersed power transformers. The stratified insulation media is composed by pressboard barriers and oil channels. The dielectric permittivity of the pressboard is twice that of the oil and so the electric field accumulates in the oil channels. The oil dielectric strength is also much lower than that of the pressboard, so, in theory, if you can guarantee the dielectric strength of the weak oil, then the whole insulating structure will withstand the electric stress.

This empirical knowledge was developed initially by some power transformer manufacturers, and later, became public knowledge through technical papers published by Weidmann, a major supplier of pressboard to the power transformer industry. Weidmann carried out several research experiments to settle the oil-curves, a group of decaying exponential E-field strength versus length curves that are accepted as almost the standard in the transformer industry.

Carlos continues, "We at EFACEC came across this theory and requested that INTEGRATED develop it into a software solution for inclusion in its programmes. INTEGRATED wrote a programme which was capable of this feature, effectively

turning theory into reality." In less than a month, EFACEC had a custom-made solution to its problem, known as the partial discharge (PD) inception dialog feature.

"The Partial Inception dialog feature helps us in our modelling and design phase by enabling us to simulate the dielectric tests and to evaluate the dielectric strength of the insulating structures between the windings, the leads, the bushing tails and the tank turrets etc. In the power transformer industry we can say that each transformer produced is unique, therefore during the design phase, each transformer is like a prototype and so there are constantly new challenges to analyse", says Jacomo.

There are many other applications for which the PD inception analysis may be useful, as it does not impose the base and the exponent of exponential oil curves. Therefore, users can replace these oil curves with their own air curves, silicon curves, tangential to porcelain curves or similar. Carlos concludes, "We at EFACEC strongly advocate the use of modeling software to test designs as it cuts costs and supplies real flexibility, particularly where a product range comprises of major elements, large transformers in this case, which are always slightly different from the last one manufactured. Even with our very specialised applications we have been able to achieve all the capabilities we require from software simulation."

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