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A2-PS3: Question 3.8:

Considering the technical difficulties to apply short-circuit testing, but also manufacturing tolerances, and unknown parameters of the transformer design and materials, is it possible to rely only on numerical simulation to assess the short-circuit withstand ability?"

Christian SCHMIED, Switzerland

Motivation

There are several reasons why we can not to rely only on numerical simulation, which are:

- Simulations are needed, they are very useful, and the costs are on low level. However, simulations only, will always have inferior validity when compared with real short-circuit testing: there are always things to learn when evaluating the results from the real test.
- To simulate the reality, the deviations from nominal must be known, which are available after manufacturing and processing only.
- The design parameters, e.g., material characteristics, getting described better and better but still need further research work and verification.

Discussion

Particularly, the static clamping forces are not known precisely when the transformer leaves the factory: typically, the final clamping is mostly done when the active part is exposed to the factory environment in a transient temperature cooling-down condition, after the vapor-phase drying.

To model the tolerances, a broad parameter sweep of geometry, material parameter and boundaries will be necessary which complicates the evaluation due to amount of obtained data. More sophisticated material models will be used in numerical simulation tools, but: to which extent reflect the models and simulation tools the reality of the built unit regarding materials used, manufacturing tolerances, applied and remaining clamping forces etc.? Also, even though not related to the topic above: The change of material during service (i.e., aging, short circuit impacts) may not be considered in simulations but should be and improved knowledge about the material characteristic is essential for proper simulation results (see esp. CIGRE WG D1.65, the results will be published later this year).

Experiments

The currently running joint project "DynaLoad" investigates the clamping pressure variation of a 40 MVA transformer in the field, which is equipped with novel sensors suitable to record clamping pressures on-line.

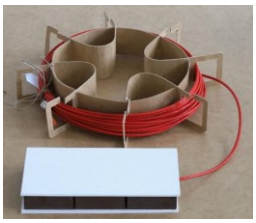

Figure 1: Fibre-optic-clamping-pressure sensor the newest Generation

Figure 2:Built-in fibre-optic-clamping-pressure sensors at the winding top of a transformer

The sensors are made completely of dielectric materials and can therefore build in the clamping structure of a transformer. The measured clamping force is transmitted via a fibre-optic cable to an evaluation unit. The unit can display the actual values and can be used for alarms if a certain value is under- or overshoot.

Conclusion

Built-in pressure sensors give proof of actual levels of clamping pressures as the transformer leaves the factory and indicate any pressure changes during service. The sensors allow continuous online monitoring/recording of the clamping force in service. First results will be published later this year.

Short-circuit testing of transformers may be less frequently advisable if actual clamping forces are close to design values / requirements. Online sensors will give the possibility to determine the actual clamping force in service.