THERMAL ANALYSIS OF A THREE PHASE TRANSFORMER BY COUPLED SIMULATION

Pascal Bayrasy, Ali Salari, Klaus Wolf

Fraunhofer Institute SCAI, GERMANY

ABSTRACT

Thermal performance of an oil-immersed power transformer is governed by the oil flow, which acts as an electrical insulator as well as a medium for the transfer of heat generated in the windings and core toward the tank and the surrounding air. This paper investigates the thermal performance of a three phase transformer by coupling JMAG and Fluent software through MpCCI. Accurate local representation of oil flow and heat dissipations has been achieved by this approach.

In our approach JMAG calculates the magnetic flux and Joule losses but is not able to analyze the behaviour of fluid flow, temperature distribution or the local interaction of losses with coolant. For these effects use a dedicated CFD code like Fluent. With Fluent we could simulate the fluid flow and temperature distribution in different parts of the transformer. Heat generation is handled in a thermal analysis by a steady state analysis of a transformer with oil coolant. Losses distribution has been used as heat source terms for each part (core and coils).

Losses in a transformer include copper loss in the windings and iron loss (hysteresis and eddy current losses) in the core which are calculated in JMAG and passed to Fluent as the heat source. Then, the Fluent passes the temperature back to JMAG. This is a bidirectional coupling, but in this case we could also use a unidirectional coupling from JMAG to Fluent in which Fluent doesn’t return the temperature back to JMAG.

For our benchmarks we used a step down three phase transformer with a turn ratio of 10-to-1 and the primary voltage of 141.42 V operating at 60 Hz. The connection pattern in the transformer and load sides are Delta-Delta and Y connection respectively. The fluid flow and temperature distribution analysis in different parts of the transformer is handled in a thermal steady state analysis of a transformer with oil coolant. We used heptane-n as the coolant and a steel tank surrounding the transformer.

The temperature distribution in coils is very important because standards require heat resistant design for safety. Thermal limits imposed by the IEEE Standard C57.91-1995(R2002) put a limit on the maximum allowable winding temperature and coil temperature to 120°C and 110°C respectively.

SUGGESTED THEMES

CFD, electromagnetic simulation, three phase transformer, co-simulation