20474 | Influence of windings design on the thermal performance of core-type power transformers using mineral oil and natural ester as cooling fluid

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Abstract

Power transformers (PT) are devices used worldwide in the transmission and distribution of electrical energy, being essential for the transformation of high transmission voltages into lower voltages for both domestic and industrial usage. Studies focusing on the internal cooling of PTs are conducted to improve their performance and to avoid the degradation of its insulation materials due to excessive heat, which jeopardizes the transformer lifetime and ultimately leads to its failure. This work aimed to study the influence that the design of the windings of a core-type PT plays in its internal cooling, when performed by mineral oil and natural ester, and to develop a machine learning tool capable of predicting the thermal behaviour of the winding.

Steady-state CFD simulations were performed, considering a 2D axisymmetric model (validated with a 3D axisymmetric model and experimental data) of a core-type PT winding. The axial channel width, radial channel height, and Reynolds number at the winding entrance were the parameters studied. The geometric parameters effect on the winding thermal performance was inferred through the evaluation of the top-oil, average-oil, average-winding and hot-spot temperatures; hot-spot factor and Nusselt number. A machine learning tool was trained to predict the correlations between the PT design parameters and the results obtained in the simulations.

As main results, it was observed that: 1) the trend of pressure drop along the winding is not affected by the heat transfer phenomena; 2) the Reynolds number is the parameter that most affects the temperature distribution inside the winding; 3) the geometric parameter that most influences the results is the width of the axial channels, and 4) the natural ester showed better cooling performance, but higher pressure drop.

The machine learning tool showed to be highly promising in predicting the thermal performance of a core-type PT, however it needs to be fed with more data to ensure a wider and more accurate use.

Keywords: core-type power transformers; CFD; machine learning; windings; internal cooling; mineral oil; natural ester; heat transfer; flow; numerical simulation.

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