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Analysis of Electrical Field in a 6 kv Form-Wound Coil with Flat Shape Voids

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1. Introduction

The term electrical power quality brings together a series of technical concepts founded on an elementary basis: a continuous and uninterruptible power supply.
Ensuring the correct status of the insulating systems in electrical equipment is one of the primary goals to keep power supply without interruptions.
The presence of inclusions consisting of impurities, dirtiness, lack of compactness, etc, in the insulating system of medium and high voltage pieces of equipment may induce the formation of partial discharges that accelerate insulation ageing and thus may produce its final breakdown.
These inclusions have their origin in the manufacturing process or the normal degradation of the insulation system during its operation. Taking into account the relationship between the presence of voids in the insulation system and partial discharge activity it is clear that the analysis of the electrical field in a non perfect and heterogeneous dielectric may lead to a better knowledge about the conditions that may produce discharge activity. For this reason, **a detailed study of the electrical field in the crossection of a medium voltage form-wound coil belonging to the stator winding of an asynchronous 6 kV motor has been carried ou**t. Different finite element models that include voids with different geometry and position inside the dielectric material have been developed. These models have been used to study the behaviour of the electrical field when the void position and orientation into the insulating system of the coil are modified.

2. Models of a form-wound coil with insulation defects

Two dimension (XY plane) models of the crossection of a medium voltage stator winding coil were developed.

All the components of the coil were accurately represented in the models. Figure 1 shows a photograph of the modeled coil. A simplified representation of the bi-dimensional models is shown in figure 2.

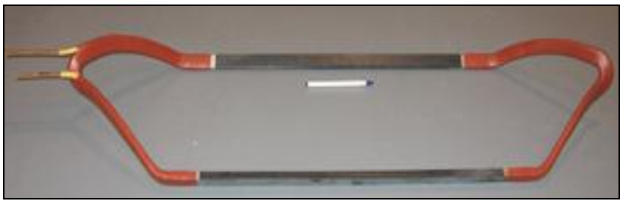

Fig. 1. 6kV form-wound modelled coil

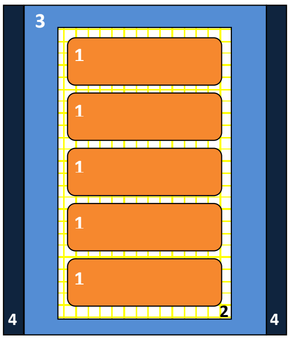

Fig. 2. Geometrical model of the crossection of the coil. (1: copper conductor, 2 conductor insulation, 3: groundwall insulation, 4: iron core)

A study was carried out to analyze the effects caused on electrical field distribution by the presence of a flat void in different locations inside the insulating system of the coil. Figure 3 shows the sites where the voids where defined as well as its size and orientation. As shown in the figure, voids 1-3 correspond to defects on the conductor insulating system, while voids 4-6 are located inside the groundwall insulation.

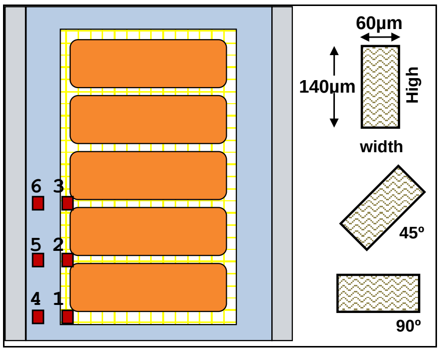

Fig. 3. Dimensions, location and orientation of the voids into the insulation systems (tree different orientations per void were studied).

The models are intended to identify the type of defect that produces the maximum concentration of electric field and, therefore, the higher partial discharge activity. Void dimensions were selected according to the magnitude of actual defects detected by manufacturers in industrial coils.

Conclusions

The electrical field distribution in an industrial form-wound medium voltage coil including some physical defects that may lead to a complete breakdown has been studied by means of finite element models.

Models were designed including in the crossection of the coil a flat shape void placed in different positions and angular orientations. By means of these models electrical field across the void was calculated in all the cases.

The results obtained allowed us to confirm that maximum values of electric field are obtained when the void orientation presents the larger length of the void perpendicular to the electric field lines.

When electric field values are close to the air dielectric breakdown limit, void orientation determines whether the breakdown and thus the partial discharge occur or not.

Regarding voids position it was observed that maximum electrical field values were obtained for the void located in the corner of the coil close to the top and bottom conductors (position 1 in the study).

Location and orientation of the void will influence the pattern of evolution of electric charge distribution during coil operation. The analysis and comprehension of this pattern is essential for a correct evaluation of the insulating system, especially when manufacturing defects are trying to be detected.

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