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"A REVIEW ON ELECTRIC LOSSES IN TRANSFORMER"

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ABSTRACT

Power transformers perform a pivotal role in a power system network in ensuring reliable power supply to electricity consumers. This paper contributes the concept about different types of transformer protection so that will be more helpful for investigating the protection system of the transformer. In this Paper, an effort is made to put together developments in the protection of the transformer. Efforts have been made to cover all the techniques and philosophies used to that end. The article includes the most recent techniques and traditional techniques of the transforme. This article classified the transformer loss problem into three main groups: (a) tank losses due to high-current bushings, (b) losses in transformer core joints, and (c) stray losses in the transformer tank. It is based on over 50 published works, which are all systematically classified. The methods, the size of transformers, and other relevant aspects in the different works are discussed and presented.

Key Words: *Overheating, tank losses, transformer, core joints, stray losses, high current*

I. INTRODUCTION

The function of protective relaying is to initiate the prompt removal of the faulty element from service in order to minimize the damage to the system. Rockefeller first presented the role of digital computers in 1969. Later on, with the development of the microprocessor in early seventies, its role in digital protective relays has become a very attractive option. Among the various elements of the power system, the power transformer is one of the important elements. Due to its importance, its protection needs to be fast and reliable. Hence, significant work has been done in this area. The transformer is part of the power system so proper protection system is important for the transformer. Generally, back up protection should be required for protected transformer because if the relay or circuit breaker failed to operate then, there is the chance of the whole transformer can be damaged so this is not economical. Transformer operation can be classified as follows: Normal operation, magnetizing inrush, over-excitation, and fault condition. For the first three operating conditions, the relay should not operate, but for any fault, the relay must operate. Cost and weight of the transformer are high and we cannot transport the transformer to the maintenance department to clear fault clearing purpose so protection system performs a great role here to avoid this condition classifies failures statistics for six categories of faults which is given by IEEE guide in Protective relay system for Power Transformer. Mostly, due to winding and tap changer near about 70% faults occurred in the transformer and other fault occurring possibilities are quite low as possible so winding and tap changer is the main reason to cause the fault in the transformer. So transformer protection under abnormal condition is great challenging part to engineer. Loose connections are involved as the initiating event as well as insulation failures. The different category includes CT failure, external faults, overloads, and damage in shipment. These failures can be identified by sophisticated online monitoring devices (e.g. gas-in-oil analyzer) before a serious incident occurs. Due to these failure rate observation, proper transformer protection gear is important to maintain continuity of the power supply. So this paper represents various types of the transformer protection system.

II. CLASSIFICATION OF TRANSFORMER PROTECTION RELAY

In general, the faults occurred in the transformer due to weakening or failure of insulation. This insulation failure causes increases in temperature of the transformer oil and this lead to making the poor performance of the transformer. So for that purpose temperature monitoring system is provided for transformer oil. Sometimes due to a transient situation over voltage and over current occurred so for that purpose over current relay and differential protecting system used . There are many faults occurred, but some abnormal fault is not making a big issue in the transformer like magnetic inrush current, over fluxing, low oil level. Although these abnormal conditions are not faults in the transformer. So for these faults, no protective gear is employed. But one important thing is that if the abnormal fault is prolonged for a long time then it makes a big problem in the transformer. The most important protection system chart is given below. Always this protective gear should be working properly otherwise it will make a big problem in the transformer after the occurrence of the fault.

Tank Losses Due to High-current Bushings

There are few studies related to a single current-carrying conductor in the presence of conducting permeable surfaces. The means of preventing local overheating in the windings and other elements of transformers have been studied, but the means to prevent overheating on the structure surrounding the distribution transformer bushings are very scarce.

III. RESEARCH SURVEY

In 1954, Poritsky and Jerrard [1] discussed the eddy-current losses in a semiinfinite solid slab subject to an alternating current by solving Maxwell’s equations both in air space and in the conducting solid. In the case of transformer tanks, the steel plate thickness is greater than the depth of penetration at low frequencies such that it will act essentially like a semi-infinite solid slab. Saturation was neglected by assuming the permeability as constant. Maxwell’s equations are solved by Fourier integral superposition.

Deuring [2] wrote a paper in 1957 about the problem of current-carrying conductors near conducting surfaces. At that time, the high-current connections could carry more than 6000 A RMS. The author presented empirical equations to calculate losses, finding that the induced tank losses in large power transformers vary with current to a power smaller than two when considering unshielded magnetic steel-plate materials. Deuring determined curves of watts per foot for unshielded, and also for shielded, plates. The results of this work are compared with Poritsky’s calculations. No study about conductors at high-voltage levels was presented.

In 1981, Saito et al. [3] presented an experimental analysis of eddy currents in the structure that surrounds the large current bushings of transformers. They used a model with a conducting current of about 20 kA. The model consisted of three buses, a bushing pocket, a bushing base plate (made of stainless steel), a bus cover flange, bus covers, and isolated-phase bus enclosures. The magnetic density on the tank cover and bus cover flange was less than 0.001 T. Therefore, there was no possibility that leakage flux causes local overheating.

In 1990, Renyuan et al. [4] presented an integral equation method to determine eddy-current losses produced by a heavy current in transformer leads. This method can be used to obtain the solution of the open region and boundary conditions that are taken into account inherently by this approach. The method is applied to calculate the sinusoidal eddy-current fields in three dimensions, assuming (a) constant conductivity, (b) isotropic magnetic materials, and (c) sinusoidal excitation current. Also presented was a parametric study of several factors, which include (a) tank materials, (b) distributions of low-voltage leads, (c) different current values, and (d) simulations with and without shields.

Renyuan et al. [5] applied the boundary element method in terms of the magnetic vector potential and the electric scalar potential finding the most serious overheating occurred among the low-voltage bushings. The maximum magnetic flux density considered was 22 mT. In this article, it is assumed that the exciting current varies sinusoidally with time.

In 1994, Junyou et al. [6] applied the boundary element method to the problem of overheating due to heavy current-carrying conductors in a 360-MVA, 500-kV transformer. The authors calculated the eddy-current loss density on the surface of the transformer cover. The total loss was 2.62 kW, and the maximum surface loss was 6.1 kW/m2 . It can be seen from these results that non-magnetic materials with an aluminum screen are favorable to prevent the overheating of the cover.

In 1997, Turowski and Pelikant [7] carried out a computer analysis based on Maxwell's equations and closed formulas of heavy current bushings passing through steel cover plates. The method of calculating eddy-current losses in steel walls was based on Poynting's theorem. The authors obtained a formula for the maximum permissible bushing current in the flat cover. Four cases were simulated: (a) a flat cover with a three-phase bushing without gaps between holes, (b) same as (a) but with non-magnetic metal inserts, (c) same as (a) but with metal turrets, and (d) same as (b) but with metal turrets.

In 1982, Nakata et al. [8] analyzed the magnetic characteristics of cores with steplap joints by using the finite element method. The authors obtained useful results and suggested that increasing the number of laminations per one group increases core losses. They also found that if the number of laminations per one group is small, the effect of gap length on magnetic characteristics is significant.

In 1992, Valkovic and Rezic [9] compared losses with conventional joints and with step-lap joints. It was found that a reduction of the total core losses by 2 to 4.4% was obtained with a step-lap joint. All core models were assembled with 120 laminations per stack and the core material was grain-oriented electrical steel.

In 1994, Löffler et al. [10] found that losses were increased due to air gaps; losses were not a simple function of the mean length but also of the local distribution of gaps. Much higher loss increases can be expected from regionally concentrated gaps.

In 1994, Pfützner et al. [11] found that the permeability Z of the steel sheet is a key parameter for the inhomogeneity of magnetic density. Local inhomogeneities tend to affect the entire magnetic circuit. Air gaps in overlap regions may cause local magnetic densities in z of an order of 0.2 T.

In 1996, Pietruszka and Napieralska [12] presented a method that takes into account the overlapping areas in stacked transformer cores during magnetic field calculations. The method uses an equivalent homogenized reluctivity of the whole structure and the flux density in its layers. In the calculations of magnetic fields in the transformer core, the lamination is neglected, and the overlaps are neglected as well. In this work, the magnetic field distribution is obtained by solving a system of non-linear equations in finite element terms.

In 1998, Elleuch and Poloujadoff [13] presented a three-phase lumped circuit transformer model that takes into account the air gaps, saturation, core losses, and lamination anisotropy. The flux lines remain almost parallel to the rolling direction except in a small area around the joints. In order to take into account this anisotropy effect, transformer yokes and limbs are divided into longitudinal elements according to the rolling direction.

In 1998, Girgis et al. [14] presented experimental results about the effects of core quality, joint stacking, and clamping pressure on transformer core losses and excitation current. The effects were studied for different core material grades and for single- and three-phase cores. The authors showed that the number of steps per group and the number of laminations per step significantly affect the building factor. They showed that large core joint gaps dimensions increase the core losses and excitation current in non-step-lap three-phase cores.

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In 2000, Nyenhuis et al. [15] presented core loss calculations and flux distributions for single- and five-limb three-phase core type units using a 2D finite difference method. The authors determined the flux density in various core types, the harmonic distortion for various core types, and the spatial flux distribution across core laminations. Finally, the authors compared measurements and computed results

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