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Use of Deformation Coefficient for Condition Assessment of Transformer Winding

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***Abstract*— Winding deformation in power transformer affects the mechanical design of winding. Hence deformation diagnosis is a step towards preventing its permanent failure. This paper discusses, the use of terminal capacitance measurement to detect deformation in transformer winding .from the measurement of terminal capacitance the deformation coefficient (DC) is derived. The deformation coefficient is to determine the extent and location of deformation. In this paper we develop a simulation model, two case studies are presented. Simulation results are given to demonstrate the applicability of this method.**

***Index Terms*— Deformation coefficient, power transformer, lumped parameter model, series capacitance, ground capacitance, axial and radial displacement**

I. INTRODUCTION

The transformer plays a central role within electrical transmission and distribution network. The malfunctioning in the service causes far reaching consequences. During its lifetime, it is subjected to various short circuit faults, due to this fault, large electromagnetic forces acting on winding causes deformation in transformer winding. This deformation leads to permanent failure of transformer, if not diagnose in early stages [1]. Hence the condition of the transformer winding should be assessed regularly.

Most widely used techniques are Reactance comparison method, frequency response analysis, swept frequency response analysis. In the transformer diagnostic, FRA is one of the most active research areas. But it is not easy to correlate the changes in transfer function obtained after swept frequency measurement, to deformation location and characteristics. For getting single transfer function several measurements at various frequencies are required.

In this work, the new proposed method is used to assess the condition of coil or winding. In this method, the two measurements are required and deformation coefficient term is derived from it, which helps to determine location and extent of deformation.

II. DIAGNOSTIC METHOD

The transformer lumped parameter model is considered as shown in fig. 1.

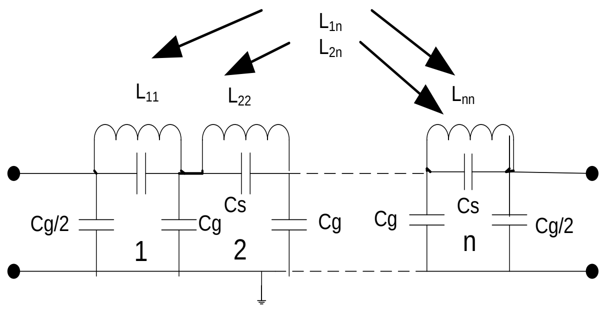

Fig.1 Lumped parameter model of transformer

The series section capacitance C_s, sectional ground capacitance C_g, L_{ii} is self-inductance, L_{ij} is mutual inductance. It is well known that the driving point characteristic of transformer is capacitive in nature at a high frequency. The high frequency modeling of transformer is shown in Fig. 2, is a capacitive ladder network[2]. The winding is divided into number of sections. Each section is represented by 'Π' model.

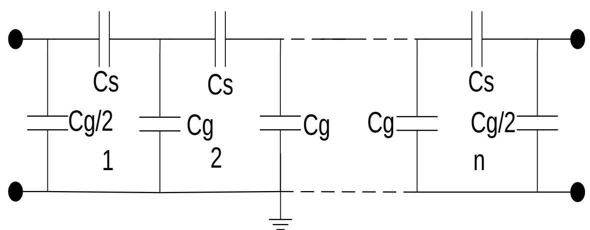

Fig.2 High Frequency capacitive ladder model

In this method, the impedance (capacitive reactance) is measured at both end of winding at selected high frequency. The measurement is done between the terminal 1- 1'and terminal 2-2'. While doing measurement at one terminal, other terminal is kept open circuited and the terminal of other winding, if any is grounded.

Any deformation may be radian or axial displacement leads to change in capacitance of winding. The change in capacitance from the fingerprint value is obtained. The ratio of deviation from fingerprint value at both the end is obtained; the non-limiting function of this ratio is called 'Deformation Coefficient'.

$$DC = log\frac{(C1H - C1H')}{(C2H - C2H')}$$

Where, C1H and C2H are fingerprint values of capacitance at selected high frequency i.e. for healthy winding measured in manufacturer's premises before shipping. C1H'and C2H' are the values of capacitances at selected high frequency after deformation.

Using this coefficient, the deformed section is located. We can calculate the sectional series and ground capacitances by using the standard formula given in book.

III. MATLAB SIMULATION

A. Simulation Model

The simulation model, an equivalent eight section high frequency model is obtained. Each section is represented by equivalent 'Π' model consisting of sectional series capacitance C_s and the two legs are provided with half of sectional ground capacitances each $C_g/2$. The value of sectional series capacitance, C_s=170.1pF and that of sectional ground capacitance C_g=52.75pF is considered in 'Π' model. Thus capacitance ladder network is formed with C_s and C_g. For the simulation studies the±40% of change is considered. The simulation studies for this system are performed and the results are discussed in detail in the next section.

B. Simulation Results

1. DC as a function of change in C_s- by changing the Cs of each section by ±40%, the values of DC are calculated for each section and lookup table is prepared for DC. From the Table1 it is clear that the values of DC for section eight to five are negative of values for section one to four. This is due to symmetric behaviour of the winding.

Table 1. DC Values

Section No	p.u. change	DC for change in C_s	DC for change in C_g
Sect 1	+0.4	3.880893	3.145495
	-0.4	4.085071	2.640058
Sect 2	+0.4	2.593915	2.408035
	-0.4	2.568819	2.048774
Sect 3	+0.4	1.488418	1.517448
	-0.4	1.480391	1.293958
Sect 4	+0.4	0.489052	0.496220
	-0.4	0.525389	0.443824
Sect 5	+0.4	-0.489052	-0.496220
	-0.4	-0.525389	-0.443824
Sect 6	+0.4	-1.488418	-1.517448
	-0.4	-1.480391	-1.293958
Sect 7	+0.4	-2.593915	-2.408035
	-0.4	-2.568819	-2.048774
Sect 8	+0.4	-3.880893	-3.145495
	-0.4	-4.085071	-2.640058

2. DC as a function of change in Cg-by changing the sectional ground capacitance of each leg of a 'Π' mode, the values of DC for different section are calculated and lookup table is prepared. From the Table 1 it is clear that the values of DC for section eight to five are negative of values for section one to four. This is due to symmetric behaviour of the winding.

The fig. 3 shows the variation of DC as function of change in Cs for per unit change from -0.4 to +0.4.

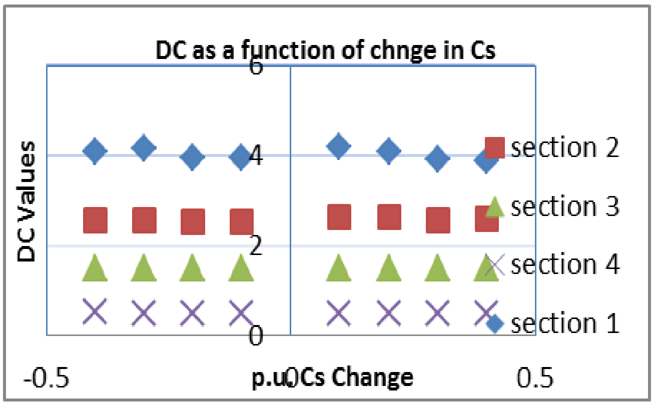

Fig.3 Variation of DC as a function of change in C_s

The fig. 4 shows the variation of DC as a function of change in Cg for per unit change in Cs from -0.4 to +0.4.

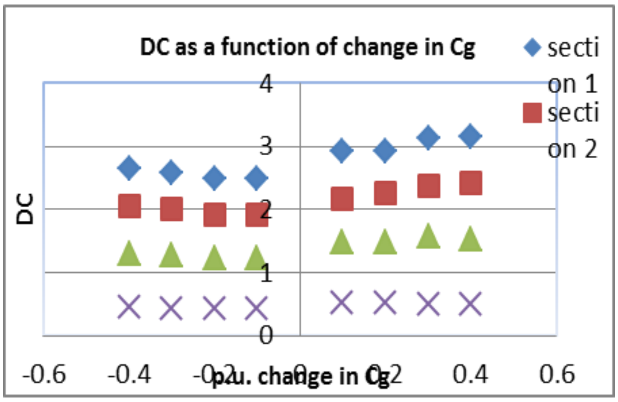

Fig.4 Variation of DC as a function of change in C_g

From the fig. 3 and fig. 4 it is clear that the value of deformation coefficient lies in a narrow band.

IV.CONCLUSION

The deformation in winding of transformer may occur during transport or during its lifetime due to short circuit forces acting because of the interaction of short circuit current and mutual flux of transformer. The frequency response method requires special skills and requirement. But the method discussed in this paper is a simple, easy to apply, generalized method and is desirable for deformation diagnostic. This method requires three terminal measurements.

Deformation coefficient calculated from terminal capacitance measurement is found effective tool for locating deformed section and to find extent of deformation.

REFERENCES

[1] S. V. Kulkarni and S. A. Khaparde, Transformer Engineering: Design and Practice, Marcel Dekker, Taylor and Francis Group, New York, May 2004.

[2] P. M. Joshi and S. V. Kulkarni, "A novel method for detection of winding deformation using terminal measurements," Advanced Research Workshop on transformers, ARWtr2007,Baiona, Spain,October, 28-31, 2007, pp. 343-348

[3] R. Raghavan and L. Satish, "An efficient method to computetransfer function of a transformer from its equivalent circuit,"IEEE Trans. Power Delivery, vol. 20, no. 2, April 2005, pp 780-788.