Comparative Analysis to Demonstrate the Effect of Core Deformation on Various Parameters of 1 KVA, 3 Phase Transformer

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***Abstract*- As we know that one of the most important equipment in power system, transformer plays a major role for stable operation of the power system. The transformer working under high and medium voltage network influences various stresses under working condition. As the ageing processes or minor faults on the transformer can cause the core deformation which leads to change the mechanical and electrical properties of the transformer.**

Sweep frequency response analysis (SFRA) is used as a tool for detection of core deformation or mechanical deterioration in transformer which is due to large electromechanical forces occurring from the fault currents or due to transportation and relocation of transformer. In this method, the frequency responses of a transformer is taken both at manufacturing industry and concern site. Then both the response is compared to predict the fault taken place in active part. But in old aged transformer, this response is not possible. So Cross Correlation Co-Efficient (CCF) measurement technique can be a suitable process for fault detection in these transformers. These two methods are mostly used to identify the winding displacement

This paper briefs about the mechanical core deformation in 1KVA, 3-phase laboratory manufactured transformer (both of same rating) which includes different tests results of healthy as well as core deformed transformer. The test results of healthy transformer is compared with core deformed transformer for analyzing the effects of core deformation.

Index Terms- Transformer, core deformation, winding, testing, sweep frequency.

I. INTRODUCTION

Transformer is the most important device used in the grid for transmission, distribution- step up, step down transformer is required. At initial condition of the transformer, its winding suffer from axial as well as radial forces due to the flow of current through the winding due to which it causes a core deformation. Hence special prevention should be taken during monitoring of transformer condition. At the time of short circuit occurring on the power system, active parts of transformer like core and winding experiences a mechanical movement due to electromagnetic forces. The core of power transformers is mostly made up of CRGO (cold rolled grain oriented) steel lamination which have the best performances in the Rolling Direction (RD). Several studies proves that this clamping modifies the GO(grain oriented) sheet properties such as the permeability or the magnetostrictive behaviour.

Thus determining the effect of transformer core deformation to avoid major failure in the transformer must be considered.

II.METHOD TO IDENTIFY CORE DEFORMATION

There are various causes of core deformation and various method used to detect the core deformation of transformer which are as follows.

A. Exciting Current

It detects the core problems in the transformer which includes shorted laminations and several other problems that affects the reluctance of flux in the core, such as a slightly shifted or open core joint, sensitive to core magnetization.

B. DC insulation resistance

It Checks unintentional core grounds problems involved in the core ground insulation. Low insulation resistance values between the core and ground is obtained by shifting the core laminations or by conductive contamination or foreign objects that bridge core-to ground insulation

C. Capacitance/power factor/dissipation factor method

The capacitance of the low voltage winding is measured during a power factor/dissipation factor test which influences the deterioration or complete loss of core ground connection

D. Cross Correlation Method.

Distribution transformers undergoes the thermal and electrical stresses. This stresses generally affects the main mechanical active parts in transformer such as core and winding. In field, due to lightning or faults in cable ,it may cause problem in the transformer core and winding. SFRA detection is a proven method which is based on the comparison between two SFRA responses and any significant difference in low, middle or high frequency region would potentially indicate mechanical/ electrical problem .Instead of comparing graphically, using statistical techniques such as Cross-correlation Coefficient Function (CCF), Standard Deviation (SD), absolute Sum of Logarithmic Error (ASLE) are used to interpret the SFRA results in a proper manner.. For the analysis of a measured response, the response is compared with one of the following:

- The same phase tested with the same tap changer position.
- If earlier result is not available then another phase of the same transformer, tested at the same instance.
- The same phase and same tap changer position but on a unit believed to be of the same design group and made at the same factory. It is found that Cross Correlation coefficient (CCF) is the most reliable statistical indicator to take data from comparison method.

E. Sweep Frequency Response Analysis

(SFRA) is a solid method to find the mechanical integrity of core, windings and clamping structures of power transformers by measuring their electrical transfer functions over a wide range of frequency. SFRA is a method used for frequency measurements. The SFRA is a relative method i.e., evaluation of the transformer condition is done by comparing an actual set of SFRA results to the reference results. Three methods which are commonly used to assess the measured traces:

- Time-based – current SFRA results compared with previous results of same unit.
- Type-based – SFRA of one transformer compared with an equal type of transformer.

A. Discussion on Natures of SFRA Plots Of Various Types Of Connection:

The end to end SFRA connection is the most frequently used connection in the SFRA test. i.e. end-to-end open circuit (secondary winding open-circuited) and end-to-end short circuit (secondary winding short-circuited). The purpose of the end-to-end open circuit connection is particularly to check core condition in addition to the condition of windings. The low-frequency area (up to 10 kHz) which has one dominant valley which is due to resonance between the core-dominant inductance and the winding capacitance. The initial downward drift is governed by the inductance while the upward drift in the curve is influenced by the winding capacitance.

III.METHODOLOGY

We took two transformers of same rating i.e 1KVA where one is healthy and other one with purposely deformed core. It actually occurs due to harmonic, assembly structure, vibration or any other activity of transformer. With these two transformers we undergo for different test independently, like inductance test, resistance test, voltage ratio test, open circuit test and short circuit test. With all the test results we have identified the differences in the parameters of both the machine

IV. SPECIFICATION OF TEST TRANSFOMER CHOSEN

- kVA rating: 1 kVA

- Input voltage- 415 V, 50Hz
- Output voltage- 415V, 50Hz
- LV turns- 600
- HV turns- 600
- LV gauge-33
- HV gauge-33

V. TEST CONDUCTED ON 3-PHASE, 1 KVA TRANSFORMER

- Resistance Measurement
- Inductance Measurements
- Voltage and turn ratio
- Open circuit test
- Short circuit test

These are the few tests which have been carried out for identifying the different parameters of test (healthy) transformer. This data is used for the comparative study with core deformed transformer

A. Resistance Measurement

Resistance measurement is done with the help of multimeter.

ON HEALTHY TRANSFORMER:

TABLE 1:PRIMARY SIDE

Sr. no	Phase	Resistance in ohms
1	R-N	5.7
2	Y-N	5.6
3	B-N	5.7

TABLE 2:SECONDARY SIDE

Sr. no	Phase	Resistance in ohms
1	R-N	4.8
2	Y-N	4.7
3	B-N	4.7

ON DEFORMED TRANSFORMER:

TABLE 3:PRIMARY SIDE

Sr. no	Phase	Resistance in ohms
1	R-N	5.6
2	Y-N	5.7
3	B-N	5.6

TABLE 4:SECONDARY SIDE

Sr. no	Phase	Resistance in ohms
1	R-N	4.8
2	Y-N	4.8
3	B-N	4.7

A. Inductance Measurement

The measurement of inductance is done with the help of LCR meter and these values are depicted in tabular form shown below.

ON HEALTHY TRANSFORMER:

TABLE 5: PRIMARY SIDE

Sr. no	Phase	Inductance in Henry(H)
1	R-N	0.76
2	Y-N	1
3	B-N	0.73

TABLE 6:SECONDARY SIDE

Sr. no	Phase	Inductance in Henry(H)
1	R-N	0.75
2	Y-N	1.01
3	B-N	0.73

ON DEFORMED TRANSFORMER:

Sr. no	Phase	Inductance in Henry(H)
1	R-N	0.73
2	Y-N	1.03
3	B-N	0.73

TABLE 8:SECONDARY SIDE

Sr. no	Phase	Inductance in Henry(H)
1	R-N	0.76
2	Y-N	0.76
3	B-N	0.73

A. Voltage Ratio Test at 415 Volts ON HEALTHY TRANSFORMER: TABLE 9: PRIMARY SIDE

Sr. no	phase	Voltage in volts
1	R-phase-Neutral	244
2	Y-phase-Neutral	244.8
3	B-phase-Neutral	244.5
4	R-phase- Y-phase	423.4
5	Y-phase- B-phase	425.4
6	B-phase- R-phase	421.8

TABLE 10: SECONDARY SIDE

Sr. no	phase	Voltage in volts
1	R-phase-Star point	243.8
2	Y-phase-Star point	244.5
3	B-phase-Star point	243.5

4	R-phase-Y-phase	419.2
5	Y-phase-B-phase	417.6
6	B-phase-R-phase	421.5

ON DEFORMED TRANSFORMER:

TABLE 11:PRIMARY SIDE

Sr. no	phase	Voltage in volts
1	R-phase-Neutral	241.2
2	Y-phase-Neutral	240.9
3	B-phase-Neutral	241.2
4	R-phase- Y-phase	420.2
5	Y-phase- B-phase	419.5
6	B-phase- R-phase	419.4

TABLE 12: SECONDARY SIDE

Sr. no	phase	Voltage in volts
1	R-phase-Star point	240.2
2	Y-phase-Star point	240.9
3	B-phase-Star point	240.7
4	R-phase-Y-phase	415.9
5	Y-phase-B-phase	424.4
6	B-phase-R-phase	418.6

D. Open circuit test and short circuit test

To conduct open circuit test & short circuit test two wattmeter method is used for measurement of power

TABLE 13: Open circuit parameters of healthy transformer

Sr.no.	Open circuit parameter	Reading
1	V0	415 V
2	I0	0.67 A
3	W1	40 W
4	W2	80 W

TABLE 14 : Open circuit parameters of deformed transformer

Sr.no.	Open circuit parameter	Reading
1	V0	415 V
2	I0	0.28 A
3	W1	38.5 W
4	W2	75.6 W

TABLE 15: Short circuit parameters of healthy transformer

Sr. no	Open circuit parameter	Reading
1	Vsc	240 V
2	Isc	2.369 A
3	W21	130 W
4	W22	130 W

TABLE 16: Short circuit parameters of deformed transformer

Sr. no	Open circuit parameter	Reading
1	Vsc	142V
2	Isc	1.5A
3	W1	230W
4	W2	200W

Comparative characteristics of test transformer

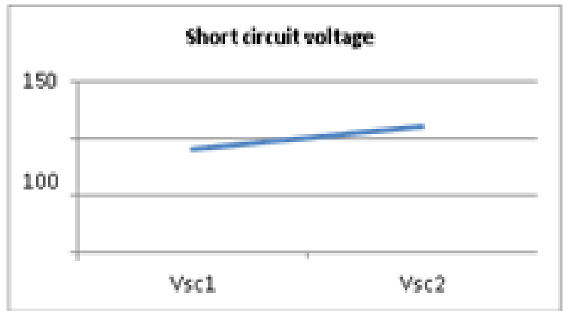


Fig 1: Short circuit voltage of healthy (Vsc1) & core deformed transformer (Vsc2)

The vertical axis in fig. 1 indicates the voltage range & horizontal axis indicates the comparative rise in the short circuit voltage of the test transformer when subjected to core deformation whereas fig. 2 indicates the decrease in short circuit current when transformer is subjected to core deformation.

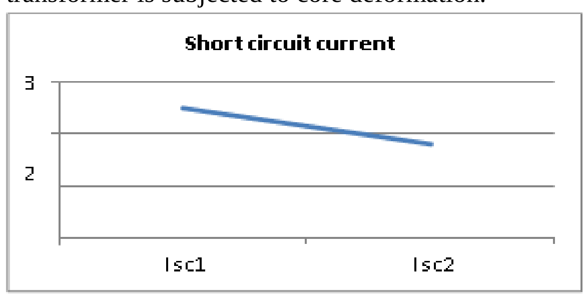
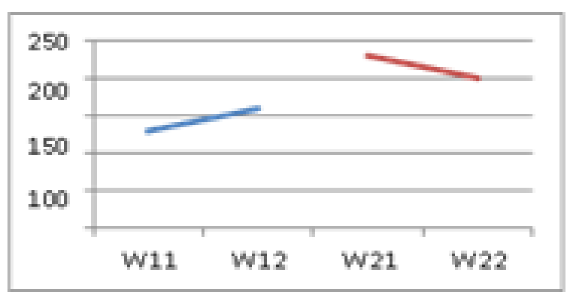


Fig 2: Short circuit current of healthy (Isc1) & core deformed transformer (Isc2)



VI .CONCLUSION

For analysis of effect of core deformation on 1kva ,3-phase, 1:1transformer a laboratory fabricated transformer is choosenr and few tests have been conducted on healthy and unhealthy transformer. The test results obtained are compared, tabulated and represented graphically.

As per the above results, leakage reactance of core deformed transformer increases. Also the short circuit voltage and current of deformed transformer rises as compared to healthy transformer. The wattmeter gives the rise in losses in deformed transformer.

Hence a priority should be taken for continues testing of transformer at supplier end and consumer end.

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