EFFECT OF RESIDUAL MAGNETISM ON THE MAGNETIC CORE OF A TRANSFORMER

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Abstract:- *Transformer is the most important unit in an electrical distribution network. All transformers are subjected to various tests at the manufacturer's test laboratory before dispatch to the destination of erection. Tests are part of a manufacturer's internal quality assurance program .A manufacture's own criteria have to be fulfilled in addition to requirements specified by customers and applicable standards. Differing requirements are generally combined and published in national and international standards[1]. The primary standards organizations are IEC (International electro technical commission) and ANSI(American Standards). Every transformer has to undergo the pre commissioning tests. In this paper we have concentrated on the magnetic balance test. The transformer which was found to have a perfectly balanced magnetic core during the testing in the factory, and the same transformer which failed to pass the magnetic balance test at site is explored with measured results. The application of a D.C voltage has caused these changes in the core balance of the system and in the magnetizing currents. It is very important to do a no-load test on the transformer subjected to such a D.C magnetization.*

Keywords: Transformer, Magnetic Balance, IEC, ANSI, Magnetization

1. MAGNETIC BALANCE TEST ON TRANSFORMERS

The Magnetic Balance test is conducted on Transformers to identify inter turn faults and magnetic imbalance. The magnetic balance test is usually done on the star side of a transformer. This indicates that the transformer is magnetically balanced. If there is any inter-turn short circuit that may result in the sum of the two voltages not being equal to the applied voltage. The Magnetic balance test is only an indicative test for the transformer. Its results are not absolute. It needs to be used in conjunction with other tests. One of the important precommissioning tests normally conducted on a transformer is the core-balance test, also known as the magnetic balance test.[2]

1.1 Test Procedure

Magnetic Balance test is carried out by applying a low single phase voltage at 50 or 60 Hz to each H.V winding in succession and measuring all the other voltages both on high voltage and low voltage side . Under ideal conditions, the results on each limb conform to a particular pattern, depending upon the magnetic lengths to be traversed by the flux the reluctance of the various portions and the division of the flux in the return paths provided by the remaining two limbs.

Figure I. Test Specimen

1.2. Test for magnetic balance in Factory

Experimental investigation was carried on 5000KVA, 33KV/11KV, Dyn11 transformer as specified above in the factory.

The results were

RN Phase	YN Phase	BN Phase
250 V	225 V	25 V
126 V	250 V	124 V
25 V	225 V	250 V

Table I.

This test is done to find out the condition of stacking of core laminations, tightness of core bolts and perfection of magnetic circuit. Assuming about 250 volts being applied between 'RN' phase leg of the H.V(High Voltage) winding, we find that 'YN' leg of the H.V winding indicates a voltage of '225V', which is '0.9' times of the input voltage of 'RN' .The voltage on 'BN' leg of the H.V winding indicates a voltage of (1 – 0.9) times 250 volts. More or less the same pattern is followed if we energize the "WN' leg. When 'VN' leg is energized the input 250V is divided almost equally by the outer legs[3].

1.3. Test for magnetic balance at Site

RN Phase	YN Phase	BN Phase
250 V	180 V	70 V
50 V	250 V	180 V
75 V	175 V	250 V

Table II

The same procedure was followed to check the magnetic balance. It was found to have mismatch.

2. REASONS FOR THIS CHANGE IN MAGNETIC BALANCE AT SITE

2.1. Manufacturing defects:

The proper stacking of laminations, avoiding of air gaps during core-building and due care during reyoking process can easily be achieved during the manufacturing process itself. This can rarely be a very serious contributory factor for the magnetic unbalance.

2.2. Transport defect:

The only contributory factor for the failure of magnetic balance test can be due to the movement of the unit itself during transit and during shunting processes.

2.3. Inter-turn defect:

Any inter-turn fault in one limb may cause the so called magnetic balance to be upset. But the chances of such an inter-turn fault occurring during transit (as the transformers are tested for their inter-turn strength at the factory) are nil, unless a serious accident causes the windings to be damaged.

2.4. Core bolts defect:

Another contributory factor can be the failure of the core bolts, both in the yoke and in the limbs. While there is no possibility of testing the limb-bolts for failure of the limb-bolt insulation once the coils are lowered, such a fault should show up durng factory tests. The recent trend towards binding the cores with resin-bonded fibre-glass tapes at once gives two advantages that the failure of a magnetic circuit due to limb bolts is fully eliminated and the resilient fibre-glass tapes give much needed flexibility, when the core becomes hot during service conditions. The chances of such a core bolt failure (mechanical failure of the core bolt insulation or clamp to bolt insulation) occurring during transit are almost nil unless the entire unit is subjected to violent jerks during transit.[3]

3. MEASUREMENT OF MAGNETIZING CURRENT

Another important precommissioning test carried out on a transformer at site, is the measurement of magnetizing current of each phase energized on the H.V or L.V winding by means of low single phase A.C voltage at 50or 60 Hz. In case of very high voltage transformer, it may be necessary to apply the low A.C voltage to the L.V winding or even a third winding of still lower voltage to bring the magnetizing current to fairly readable values. The magnetizing current drawn by the outer two legs when energized on such low voltages are approximately equal and slightly higher than the one drawn by the centre limb. Normally this test is carried out at the works and the figures obtained at site are compared with these figures before commissioning the transformer.

Just as in the case of the magnetic balance test at site, we may end up with very marked changes in the values of the magnetizing currents, either in one of the legs, or two of the legs or all of the legs even, depending upon the certain condition. Since an inter-turn failure of failure of clamping bolt insulation after testing at works is highly unlikely, the changes in magnetizing currents and the changes in the magnetic balance may not necessarily mean that something is wrong with the transformer. The reasons for such changes need to be looked into, as otherwise the mere figures may lead us to the conclusion that something is wrong with the transformer under question.[5]

4. MAGNETIC BALANCE UPSET:

A direct current of 3 amps was passed by applying a D.C voltage across the line and neutral of the L.V winding of ‘V’ phase for few seconds and the same measurements were repeated.

	‘U’ phase	‘V’ phase	‘W’ phase
Measured ratio	4.544	4.545	4.542
H.V magnetizing current in milliamps,@ 250V A.C	4.89	3.30	3.70
Magnetic balance test	50 volts	250 volts	180 volts

Table III

4.1 Observations:

The ‘V’ leg was subjected to a D.C magnetization and then applied with AC voltage. The results shows an increase in A.C magnetizing current and other two legs also show a slight increase in their A.C magnetizing current

The magnetic balance in the core is upset.

5. RESIDUAL MAGNETISM IN THE CORE

Under the effect of residual magnetism, the core-balance may easily be upset and for such a test to be decisive there should absolutely be no remanence at all. If the results of the magnetic balance test do not conform to a pattern, it may not necessarily mean that something is wrong with the transformer. Unless the core is brought to the ideal unmagnetized condition, the test may have no meaning and if the test is carried out after an application of D.C voltage (as in the case of winding resistance measurement and verification of turret C.T polarities) the results are not valid at all.[4]

Under the effect of remanance, the A.C magnetizing current (in one, two or all legs) goes up significantly. A higher magnetizing current may thus indicate a fault in the transformer, but also may indicate a remanent flux condition in the core.

Under the influence of the remenent flux, there is an apparent increase in the ratio of the transformer accompanied by a slight shift in the vector positions of the voltages, responsibilities for the ratio.

6. MAGNETIC BALANCE TEST AFTER OPEN CIRCUIT TEST

Certain tests was carried out on the same 5000 kVA 33KV/11KV , Dyn11 transformer, clearly confirmed the fact that magnetic unbalance and marked changes in magnetizing currents may be caused not only by faults in the magnetic circuit/electric circuit of the transformer, but also by another very important fact- the residual magnetism in the core.

The following test was carried out, after the open circuit test was done on the transformer. The magnetizing currents and the wattmeter readings record a steep increase initially once the saturation level is reached, we see that both ammeter and wattmeter readings start coming down gradually and we have to allow quite a few seconds for the readings to stabilize.

	‘U’ phase	‘V’ phase	‘W’ phase
Measured ratio	4.542	4.542	4.542
H.V magnetsing current in milliamps, at 250V A.C	2.95	2.33	3.10
Magnetic balance test	126 volts	250 volts	124 volts

Table IV

6.1. Observations:

We find the magnetic balance of the core is perfect

7. CONCLUSIONS

For the magnetic balance test to be a decisive pre-commissioning test, it apparently follows the magnetic circuit should be devoid of excessive air-gaps, the windings should be healthy and there should be no mechanical failure of the insulation of the clamping bolts. All these are ensured at the factory itself before transformer is dispatched[7].

Since under D.C magnetizing conditions, the MMF involved is very high, the demagnetization of such a core may require that the core be taken to near-saturation regions for the residual flux density to vanish when we apply an A.C excitation. Hence it is very much essential that due precaution must be taken to conduct the core balance test as well as the test for measurement of magnetizing currents, immediately after the no-load loss test when we get the right figures. At site, precaution should be taken to carry out these tests immediately after transformer is ready, before any other precommissioning test is carried out, barring megger[8].

It is very much necessary that the current drawn by the instrument used for voltage measurements during core-balance test should be extremely low compared to the magnetizing current of the transformer. Otherwise when being used on the two unenergized limbs, the voltmeter will act as a load, drawing a current, which will cause an apparent unbalance in the results. Hence it is very much essential to use voltmeter with a very high input impedance

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Acknowledgement

The authors wish to thank Dr. M.T Nicholas, Chairman, LITES, Dr. Satheesh, COE, LITES and Eng. Jeba Peace.P, Nokia Siemens, India for their support and encouragement

References

[1] .IEC 60076 -1 , “Power Transformers” –Part 1: General, 2000 A.Jenni, M. Pasquier ,R.Thommen:

[2]. “Testing of High Voltage Power Cables with series Resonant Systems and water terminations” , Documentation Emil Hafely & Cie

[3] IEC 60060-1 , “High Voltage Test Techiques” – Part 1: General, 1989

[4] IEEE/ANSI Standards C57.12.00 “IEEE Standard General Requirements for Liquid Immersed Distribution , Power, Regulating Transformers“, 2000

[5] IEC 60354-1 ,“Loading guide for oil immersed power transformers”, 1991

[6] IEEE/ANSI Standards C57.123“ IEEE Guide for Transformer Loss Measurement“,

[7] 2002 ABB , “Testing of Power Transformers“,Zurich,2003

[8] IJOAT , “A review about Testing of Distribution Transformers” ,Vol 2, No 1. Geno Peter. P ,2011