DEVLOPEMENT OF THE DYNAMIC RESISTANCE MEASUREMENT (DRM) METHOD FOR CONDITION ASSESSMENT OF OLTC

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Abstract

Many failure of power transformer are due to the failure of On Load Tap Changer. If we apply some diagnosis test during the function of OLTC, some of degradation effects can be assess. This paper concentrates on OLTC diagnostic method based on the measurement of dynamic resistance. Some experiments were applied to the OLTC using DRM. With the result of these experiments, it becomes possible to assess the condition of OLTC contacts and transient resistance.

Keywords: *Condition Assessment, On Load Tap Changer, Transformer Testing, Dynamic Resistance Measurement.*

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1. INTRODUCTION

A power transformer basically has two functions: Link the different voltage levels in the high voltage power grid And Keep the voltage at the acceptable level when the load changes.

The second function to regulate the voltage is accomplished by adjusting the transformation ratio of the power transformer. For performing this function the transformer winding is equipped with tapped windings that can be selected by an on load tap changer. As the transformer oltc also has long life and high level of reliability, but the average age of the total oltc (transformer) population is also high. So the Transformers which are in services currently are degraded and failure occurs regularly. In most of the cases failures of transformer is due to the failure of oltc. Hence the oltc becomes the very important part of the transformer. Its failure can result in unavailability of the power transformer or total loss of the power transformer. The sudden failures of power transformer not only include the replacement cost but, safety, environmental issues and, in case a spare transformer is not directly available additional cost for not delivered power and penalty cost should also be considered. So it is become necessary to get the information about the condition of the oltc. Conventionally maintenance of any equipment is predefined with fixed time interval by its manufacturer or supplier. Now a Modern tendency is to perform condition based rather than time based maintenance. It can be reduce the maintenance cost, extend the service life of equipment and prevent possible catastrophic failure. In condition based maintenance one need to know the condition of the tap changer to determine when and what maintenance is necessary. Also diagnostic measurement on OLTC's can be used for the pre-failure detection of defects not seen during maintenance and to assess the condition of parts that are not easily accessible. There are different methods developed for condition assessment of OLTC such as DGA, Acoustic fingerprint, Motor power measurement, Temperature measurement and static resistance measurement. Dynamic resistance measurement is suitable for detecting irregularities in the OLTC contact resistance, as are static resistance measurements. The main difference between dynamic measurements and static measurements is that the tap changer is operated during the measurement. Important information about the importance and location of the long-term effect on the change-over selector contacts can be extracted from the measurement. The contacts do not remain at each position long enough to allow the measurement current to stabilize (stabilization is attained after a relatively long time constant caused by a high inductance of transformer windings).). Despite the fact that DRM can be considered less accurate than static resistance measurements, it may provide more information about the type and location of defects inside the OLTC. DRM was originally used for circuit breaker analysis, in which a high current, typically 100 A or higher, is applied to the closed circuit breaker and the voltage across the circuit breaker is measured[1]. The circuit breaker is then opened. Valuable information about the arcing contacts inside the circuit breaker can be extracted from the contact resistance of the moving contacts and a high resolution can be obtained by the high measurement current.

2. OLTC DEGRADATION

The understanding of tap changer degradation is become important due to high rate of failure of OLTC. The degradation mechanism of OLTC can be electrical, mechanical, thermal and chemical. The properties of different part of OLTC with possible degradation are mention below[2].

2.1 Arcing Switch

Table -1: Properties and degradation symptoms of arcing switch

Properties of arcing switch	Degradation Symptoms
Regular Uses	Contact pitting
Accessible for inspection	Contaminated oil
Switches load current	Oil leakage
Fast operation	Oil contamination
Has Transistor resistor	Friction
Have Arcing contacts	
Electrical Treeing	

2.2 Coarse Tap Selector, Reversing Switch and Tap Selector

Table -2: Properties and degradation symptoms of coarse tap selector, reversing switch and tap selector

Properties	Degradation Symptoms
Infrequent use	Long term effect (Oil and Coking)
Not accessible for inspection	Discharges
Clean oil	Friction
Switches zero current	Oil contamination
Slow operation	Friction
Have no arcing contacts	
Have no transition resistor	

2.3 Drive Mechanism

It consist motor, mechanics and spring which have degradation like wear, friction and weak spring.

2.4 Contact Degradation

An OLTC has sets of contacts that switch different currents at different recovery voltages. For example, the main contacts of the arcing switch are designed to transfer the load current to the transition contacts. The arcing contacts of the arcing switch are designed to break the load current and the circulating current. In contrast, the contacts of the tap selector and the change-over selector are not designed to switch current. Therefore these sets of contacts wear differently. Change-over selector contacts (including tap selector contacts) do not wear as fast as arcing switch contacts that wear due to the switching of load currents. These contacts will not switch significant currents, but can show pitting of the contacts and the development of pyrolytic carbon. This contact degradation is not due to the arcs caused by switching the current but by a long term overheating process.

Usually, the contacts of the change-over selector are infrequently used and can be motionless for long periods. This activates the second degradation mechanism of change-over selector contacts: a long-term aging effect on contacts under oil henceforth referred to as the 'long-term effect'. The long-term effect is the most common degradation mechanism on the change-over selector.

Three basic stages of the long-term effect can be distinguished and are shown in Figure (Fig -1)

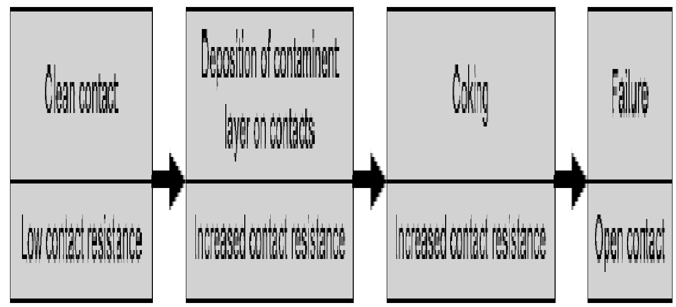

Fig -1

3. CONDITION ASSESSMENT OF OLTC

There are many methods for assessing the condition of the OLTC, such as Dissolved gas analysis, Vibration/Acoustic fingerprint, Temperature measurement, Motor power measurement and Static resistance measurement (SRM). All the method other than static resistance measurements are not sufficiently suitable for condition assessment of the arcing switch and change over selector of OLTC. Static resistance measurement method is very suitable for assessing the condition of change over selector but it does not provide the complete information about arcing switch. The condition of the transition resistor (which is the part of the arcing switch) is not assessed by SRM, as it is in the role when the OLTC moves from the one tap to another. During this operation the high amount of current is flows from the transition resistance. Hence the assessing the condition of the OLTC based on SRM is not fully reliable. The Dynamic resistance measurement (DRM) method is very successful in assessing the condition of the circuit breaker contacts. So it motivates the manufacturers of OLTC to develop dynamic resistance measurement method for condition assessment of the OLTC. As it can gives the information for whole cycle of OLTC operation.

4. DYNAMIC RESISTANCE MEASUREMENT

Dynamic resistance measurement is used as a method to diagnose the contact condition of on-load tap changers offline. This method is able to detect many types of defects or deterioration of change-over selector contacts and arcing switch contacts without accessing these contacts. A DC current is injected into the transformer and flows through the tap changer. The measurement reads the flow of current through the tap changer during its operation. Since DRM measures the OLTC while it is moving through its entire taps, the measurement is done without static impedance. Therefore this resistance measurement is dynamic. Test setup of Dynamic Resistance Measurement with OLTC in delta connected winding. Three measurements need to be performed for phase U-V, V-W and U-W. A short circuit connection of secondary winding provides a path for the test current [3].

5. APPLIED TO OLTC

5.1 Test Setting

Use the TR Tap Check test card to measure the winding resistance of the individual taps of a power transformer's tap changer, and to check whether the on-load tap changer (OLTC) switches without interruption. The CPC 100 injects a constant current from the 6A DC output into the power transformer and the current is led via the IAC/DC input for measurement.

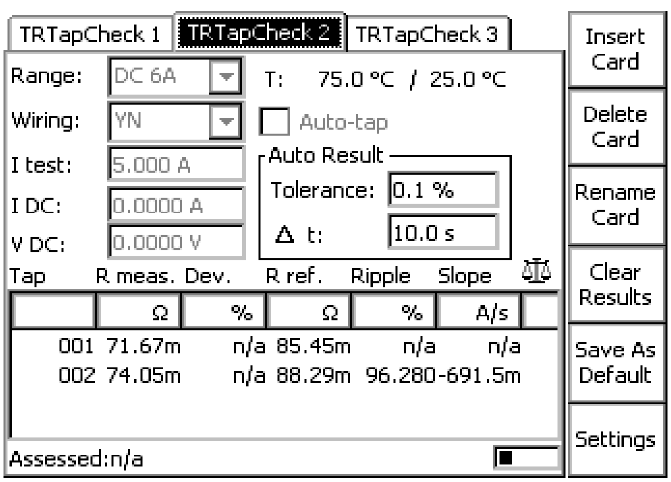

Fig -2: TR Tap check test card with test results

Alternatively, the current injected from the 400A DC output is measured internally (Itest is limited to 100 A). From this current value and the voltage measured by the V DC input (see Fig -3) the winding resistance is calculated.

The moment the tap is changed, the IAC/DC measuring input detects the sudden, very short drop of the current flow. A properly working tap change differs from a malfunctioning one, for example, an interruption during the change, by the magnitude of the ripple and slope values. An interruption will result in much higher ripple and slope values than a properly functioning tap change.

The ripple and slope values are indicated at the TR Tap Check test card's measurement table (refer to Figure (Fig -2)).[4]

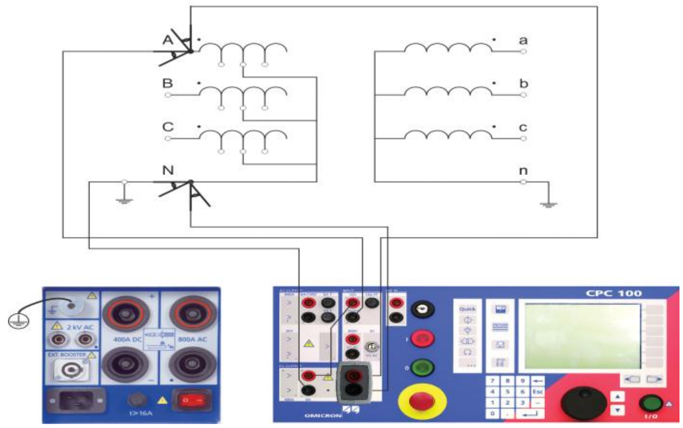

Fig -3: Setup for a tap changer test - winding resistance and interruption

5.2 Parameter Selection

Table -3: Setting of the parameter for TR Tap

Range:	Output range
Note:	The 400A DC output range provides maximum current 100 A.
I test:	Nominal test current
Wiring:	• D, Y, YN: for measurements on the high-voltage side • d, y, yn, z, zn: for measurements on the low-voltage side The measurement is performed where the tap changer is mounted.
Tolerance:	Tolerance of the deviation in percent. This setting refers to the Auto Keep Result function
Δt	Settling time. This setting refers to the Auto Keep Result function.

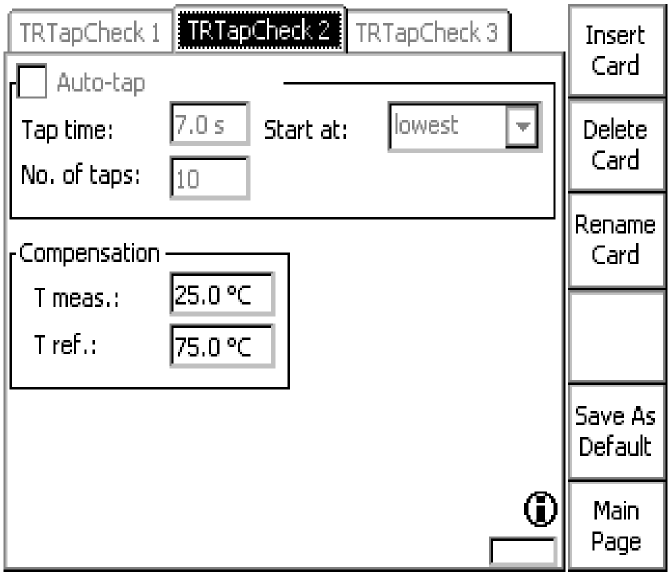

Fig-4: Second page of TR Tap check test card

Pressing the Settings menu key or activating the Auto-tap operation mode will open the second page of the TR Tap Check test card.[4]

Table -4: Setting of the parameter for TR Tap

Tmeas	Actual specimen temperature
Tref	This is the reference temperature at which the manufacturer measured the taps' winding resistance values.
Tap time, Start at, No. of taps	These settings are only available with the CP SB1 connected. For further information refer to the CP SB1 User Manual.

5.3 Measurements

The TR Tap Check test card displays the measurement results in two display fields and a table:

Table -5: Output data as results of the test

IDC	Actual test current from the 6A DC output measured at the IAC/DC input or from the 400A DC output measured internally.
VDC	Voltage measured at the 10V DC input
Tap (in table)	Displays the transformer tap identifier and tap number for the measurements in the respective line of the table
Rmeas	Actual resistance, calculated from VDC / IDC
Dev. in %	Deviation in % between the maximum and the minimum measured values evaluated within the settling time (t).
Rref	Temperature-corrected resistance value, that is, the resistance value at an actual specimen temperature of Tref
Ripple	Samples and holds the biggest measured current ripple that occurred in the measuring cycle. It is indicated in % with reference to IDC.
Slope	Samples and holds the biggest measured steepness of the falling edge of the actual test current that occurred in the measuring cycle.

6. EXPERIMENTS WITH OLTC CONTACTS

Here the result of one experiment is present. With the graph of ripple and slope the condition of the OLTC contacts can be assessed.

6.1 Ripple per Tap Changer Position

From the graph of ripple and slope it is seen that the contact of tap number 7 of B phase is degraded. The condition of the transition resistance can also be found. The mechanical fault can also be assessed. With such experiments and more research this method can become very useful to manage the lifecycle of the transformer.

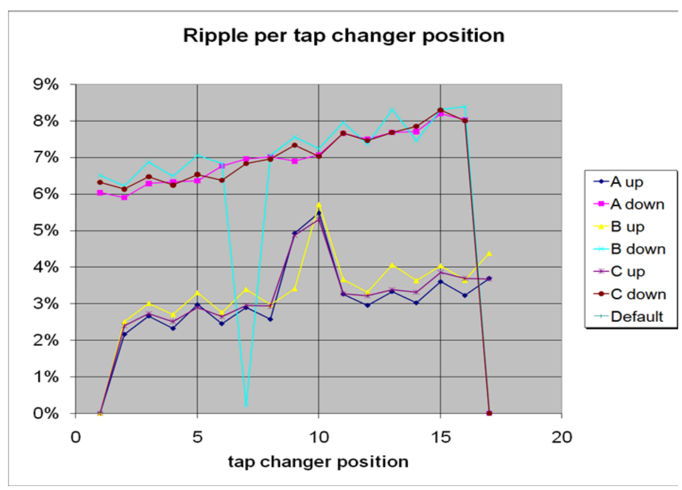

Fig -5: Ripple per tap changer position

6.2 Slope per Tap Changer Position

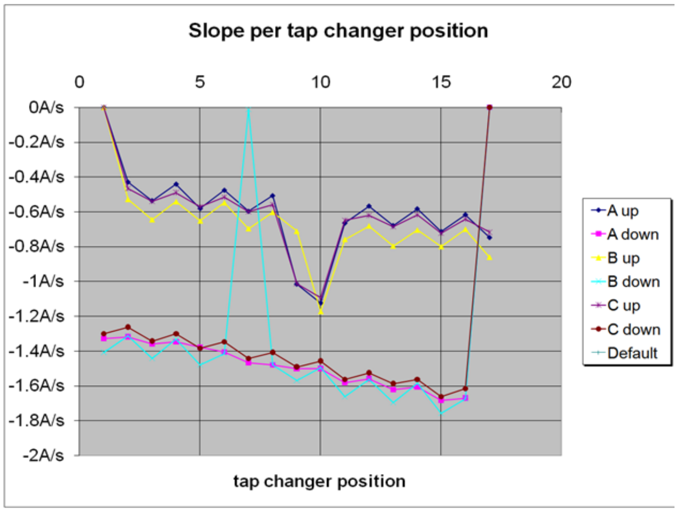

Fig -6: Slope per Tap Changer Position

7. CONCLUSIONS

This paper concludes that OLTC is very important part of the transformer. Its parts like arcing contacts, course tap changer contacts and reversing switch contacts are degraded due to operation of OLTC. As the contact degradation is increased the resistance of the contact is increase. With the application of the DRM (Dynamic Resistance Measurement) these contacts with higher resistance can be assess. More research on this topic can make some rule to interpret the graph.

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