On-load Tap Changer Fault Diagnosis and Maintenance of 100 MVA Power Transformer

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Abstract— **This paper presents fault diagnosis and trouble shooting method of an on load tap changer (OLTC) of 100 MVA transformer, at 220/110 kV Receiving Station, Vajjarmatti, Karnataka. An on load tap changer (OLTC) is the most maintenance intensive subassembly on a power transformer. Maintenance of a transformer is essential to operate OLTC in proper condition. OLTC consists of operating of voltage to a desired level as per the load demand. In this paper the OLTC fault has been identified and mentioned troubleshooting method and maintenance of 100 MVA transformer is given.**

Keywords— **On Load Tap Changer, Fault detection, troubleshooting and Transformer Maintenance Schedule**

NOMENCLATURE

V_s : Induced voltage in the secondary winding.
V_p : Induced voltage in the primary winding.
N_s : Number of turns in the secondary winding.
N_p : Number of turns in the primary winding.
I_s : Current flowing through the secondary winding.
I_p : Current flowing through the primary winding.
E_s : Induced e.m.f in the secondary winding.
E_p : Induced e.m.f in the primary winding.

I. INTRODUCTION

On-Load Tap Changers (OLTCs) are parts of the voltage regulating system in an electrical transmission network. They are connected to the transformer and are responsible for maintaining the voltage level under variable loading conditions. By changing a tapping on the winding, the OLTC enables the turn's ratio of the transformer to vary and thus the level of output voltage. Fig.1 shows schematic of OLTC, it OLTC has two main components; a selector switch and a diverter switch. A selection of tapping on the transformer winding is done via the selector switch. Load current is afterwards switched over a set of electric contacts by means of the diverter switch. The OLTCs have high failure rates compared to other electrical transmission equipments because their mechanical parts operate very frequently. Their failures can cause damage to the complete transformer unit. It is, therefore, important for the utilities to be able to assure the reliability of the OLTCs. Consequently, an extensive maintenance is required. However, a routine maintenance of the OLTCs is a major expenditure, both in time and material. [1]

During the operation of tap changer, series of mechanical and electrical events produce distinctive vibration and noise patterns. Since all electric contacts are enclosed in oil filled steel tank, an on-line monitoring of the OLTCs with a non-invasive acoustic technique was proposed [1] as a mean to investigate the vibration signals from a tap-change process. In modern high-speed resistor tap changers, the current transfer over the electric contacts via the transition resistors in the diverter switch takes place in about 40-70 ms, depending on the type of mechanism used. This transition time interval is expected to be constant as long as no fault appears. Therefore, it is possible to check the reliability of the OLTCs by monitoring the tap-change transition time.

The main purpose of an on load tap changer (OLTC) is to modify the transformer voltage ratio in response to voltage variations in the electrical system, while maintaining the transformer's output voltage. The OLTC changes the tapping connection of the transformer winding while the transformer is energized.

II. OLTC FAULT DIAGNOSIS

The 220kV/110kV, 100MVA Transformer at Vajjarmatti, has been commissioned during 2005. The substation is operating with 84 MVA total transformation capacity [Two transformers: with 2x100MVA, 220kV/110kV (BHEL)]. Transformer no.2 rating of 100 MVA (BHEL make) failed on 23-08-2011 at 11:40 Hrs at Vajjarmatti substation.

A BDM (Breakdown and Maintenance) Committee has been constituted to assess the cause of failure and rate of failure of various substation equipment of rating 220 kV and above voltage class and to suggest remedial measures so as to minimize / avert such failures in future. As part of such activity, Asst. Executive Engineer and Asst. Engineer of KPTCL visited the site and the meeting was held with BDM officials and fault has been detected by operation and maintenance staff.

The assessment / analysis of failure of a transformer is discussed in Table-I

TABLE I
ANALYSIS OF A 100MVA TRANSFORMER

Transformer Particulars	Details
Name of Substation	220KV/110KV R/S Vajjarmatti.
Make	BHEL
Rating	100 MVA
Sr. No	2019245
Type	Auto transformer (oil-cooled)
Year of commissioning	2008
Date of Failure	23-06-2011
Failed device	OLTC connecting rod
Insulation level	LI950/AC395(HV), LI170/AC70(Neutral), LI550/AC230(IV), LI170/AC70(LV)
% Impedance	HVLV 26% ±15 Tolerance

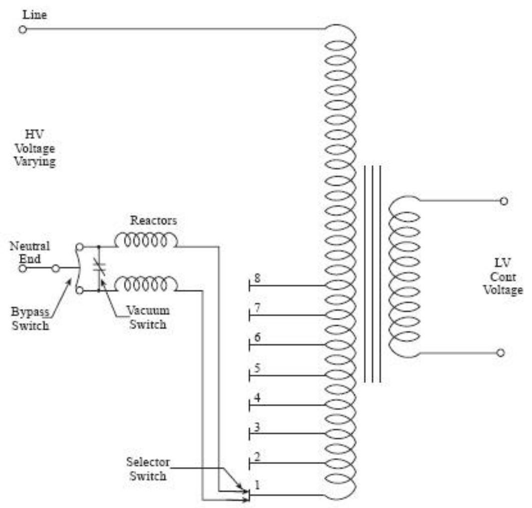

Fig.1: Schematic wiring diagram of OLTC.

III. TROUBLESHOOTING OF OLTC OF 100MVA TRANSFORMER

Symptom: Fluctuation in the voltage.

Fault: On load tap changer connecting rod has been broken due to displacement of bolt and wear and tear of nuts.

Remedy:

On load tap changer connecting rod has been taken out and replaced by new bolts and nuts, and same is fixed on the transformer and for proper operation of OLTC the following steps have been conducted,

1. BDM committee person tested the tap changer both automatically and manually.

2. By automatic method or remote control the gear rotates 33 revolutions for each tap change.

3. The same has been tested by the manually, the tap changer has been rotated manually for 33 revolutions and at the same time the tap must be changed otherwise the tap must set same for all three rods.

4. After attending the tests the tap will be set to the proper position at the desire voltage level.

The operation of an OLTC during the troubleshooting is shown in fig.3

IV. MAINTENANCE SCHEDULE OF TRANSFORMER

Transformers will run practically trouble-free if proper maintenance is done. An on load tap changer (OLTC) is the most maintenance intensive subassembly on a power transformer, for this purpose a maintenance schedule can be drawn. Though this schedule shall be only indicative in nature and tests may be conducted at more frequent intervals depending upon the severity of service [2]. Such a maintenance schedule is given in Table II.

Fig.2: Troubleshooting of OLTC broken rod of 100MVA transformer by the BDM committee workers (left), and manually operating the tap changer (right), at 220/110kV R/S Vajjarmatti, Mudhol Tq. Bagalkot.

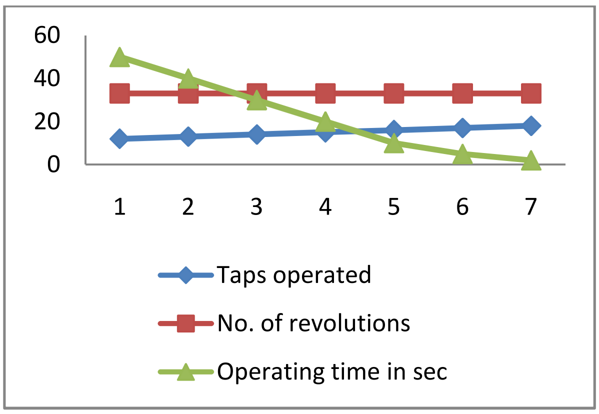

Fig.3: Operation of an OLTC during troubleshooting of transformer

TABLE II
MAINTENANCE SCHEDULE FOR 100 MVA TRANSFORMER [3]

Inspecting Frequency	Items to be inspected	Remarks
Hourly	Ambient temperature, winding temperature, oil temperature, load and voltage.	Adjust load if temperature is high.
Daily	Oil level. Relief diaphragm. Dehydrating breathers (check for free air passages. Check colour of silica-gel	If low top up with dry oil Look for any sign of leakage Replace if broken Change if colour is pink
Quarterly	Lubricate bearings etc. of cooler fans, circulating pumps etc., if any.	- - -
Half yearly	Check oil for dielectric strength and presence of moisture Check bushes, insulators etc. Check cable boxes etc.	Filter or replace if necessary
Yearly	Check oil for acidity, sludge and flash point, if possibly. Check relays, alarms, contacts etc. Check earth resistance Check lighting arrestors	Filter or change oil as necessary. Methods of lowering resistance may be followed if required.
Five yearly	Over-all inspection including lifting of core and coils.	Wash by hosing down with clean dry oil.

Fig.4 shows schematic of an ideal transformer with load, in an ideal transformer, the induced voltage in the secondary winding (V_s) is in proportion to the primary voltage (V_p) and is given by the ratio of the number of turns in the secondary (N_s) to the number of turns in the primary (N_p) as fallows,

$$\frac{V_S}{V_p} = \frac{N_S}{N_p} \qquad (1)$$

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient. All the incoming energy is transformed from the primary circuit to the magnetic field and into the secondary circuit. If this condition is met, the input electric power must equal the output power:

$$P_{incoming} = I_p V_p = P_{outgoing} = I_S V_S \qquad (2)$$

Giving the ideal transformer equation,

$$\frac{V_S}{V_p} = \frac{N_S}{N_p} = \frac{I_p}{I_S} \qquad (3)$$

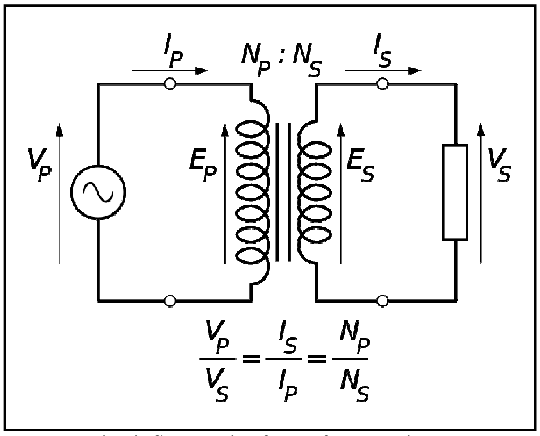

Fig. 4: Schematic of transformer with load.

V. CONCLUSION

On-load tap changing transformers play important roles in any modern power system, since they allow voltages to be maintained at desired levels despite load changes. Traditionally, on-load tap-changer is a complex mechanical device, which has some deficiencies.

The outage data analysis carried out on 100 MVA transformer in receiving station presents, the major cause of outage in the 100MVA transformer, the fault detected was due to on-load tap-changer failure operated parallel to change the tap position of transformer. Troubleshooting of OLTC given was very effective, it reduces the operating time and an OLTC as a part of a transformer the maintenance of transformer was essential, therefore maintenance schedule for 100 MVA transformer been presented in this paper.

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