

Monitoring and Analysis of Pole Mounted Distribution Substation

Pratik Mahale¹, Dipali Mahale², Chaitali Kshirsagar³

¹Department of EE, Mumbai University, Mumbai

Email: pratikmahale@viva-technology.org

²Project Engineer, Teckon Engineering Solutions, Mumbai

Email: dipalikhate013@gmail.com

³Lead Maintenance Engineer, Teckon Engineering Solutions, Mumbai

Email: chaitaliksagar@gmail.com

Abstract— The Transformer is a key element in the electrical power system. The main purpose of this paper is to gather information about the distribution transformer. Monitoring of the Transformer based on deviation in voltage and current and their effects on the rise in temperature of Transformer oil and cables of the distribution transformer. This paper also includes analysis of different faults, which are responsible for the failure of Transformer, failures of Transformers such as insulation failure, winding failure, bushing failure, and core failure. Monitoring and analysis of distribution transformer are necessary and advantageous as it plays a very important role in the distribution system.

Keywords— *Bushing, Core, Distribution transformer, Insulation, Winding.*

I. INTRODUCTION

A distribution transformer is a static device that transfers power from one circuit to another circuit without changing its frequency and keeping power constant on both sides. Monitoring is important because it provides the only consolidated source of information displaying project progress. Monitoring on the regular basis observation and recording of all data activities taking place in this work. It is a process of routinely collecting the information on all aspects of the project. To monitor is to check on how work-related activities are in progress. A distribution transformer of 100 KVA is monitor during a different time, events and observes its increasing voltage, current, temperature. Due to an increase in temperature, overheating takes place and insulation of transformer is deteriorates due to which hotspots are created in insulation. Most of the fault in the transformer is due to internal winding faults this is increasing day by day since loading transformer closes to their rated capacity. These internal faults result in degradation of the transformer winding insulation, which tends to cause a breakdown in dielectric strength. There are also different types of faults that occur in the transformer such as short circuit, open circuit, earth fault. These faults cause failure in transformers such as winding failure, core failure, bushing failure, tank failure, and insulation failure.

II. MONITORING OF DISTRIBUTION TRANSFORMER

We have conducted a small experiment to calculate and monitor the overall load distribution of three-phase transformer at our college. We have monitored different values of voltages, currents and frequency at a secondary side of the transformer on the panel and at the primary side of the transformer using a clamp on meter at different intervals (i.e. in the morning, afternoon and evening) and on a different occasion. From that data, we have calculated power and plotted a graph of voltage and current with time.

From the graph, it seen that the voltage on the B phase and current on the R phase was more. An unbalance was observed between phases and as a result, the current was flowing through neutral. We also checked the temperature of the incoming and outgoing cable by using a temperature sensor and observed that the temperature of the incoming Y phase was more.

It observed that voltage on B phase and current on R phase was more because of the unequal distribution of single-phase loads. An excessive level of voltage unbalance can have serious impacts on power quality and unbalance in the line currents can lead to excessive line losses and malfunctioning of a relay. Hence by proper load distribution problem can be solve and temperature of Y phase was more so care should be taken before any further problem arises.

TABLE 1
DAILY LOG TABLE

| Date | Time | Vry | Vyb | Vrb | Iry | Iyb | Irb | Power(KW) |
|------------|------------|-----|-----|-----|-----|-----|-----|-----------|
| 31/07/2018 | 08:45 A.M. | 387 | 400 | 396 | 88 | 64 | 44 | 40385.5 |
| 31/07/2018 | 12:10 P.M. | 376 | 383 | 381 | 107 | 89 | 62 | 47332.8 |
| 31/07/2018 | 03:45 P.M. | 374 | 381 | 381 | 106 | 85 | 73 | 51792.0 |
| 01/08/2018 | 09:30 A.M. | 365 | 368 | 374 | 143 | 133 | 128 | 76987.4 |
| 01/08/2018 | 11:31 A.M. | 358 | 369 | 368 | 119 | 96 | 65 | 52852.4 |
| 01/08/2018 | 03:45 P.M. | 381 | 387 | 389 | 81 | 68 | 55 | 40162.8 |
| 02/08/2018 | 08:50 A.M. | 387 | 399 | 400 | 100 | 67 | 53 | 46009.3 |
| 02/08/2018 | 12:00 P.M. | 363 | 375 | 372 | 137 | 110 | 88 | 59497.4 |
| 02/08/2018 | 03:41 P.M. | 378 | 381 | 388 | 70 | 78 | 51 | 37470.8 |
| 03/08/2018 | 09:11 A.M. | 390 | 401 | 404 | 112 | 86 | 66 | 54121.3 |
| 03/08/2018 | 12:35 P.M. | 408 | 419 | 420 | 127 | 110 | 82 | 67200.1 |
| 04/08/2018 | 09:32 A.M. | 387 | 394 | 396 | 76 | 62 | 46 | 36620.6 |

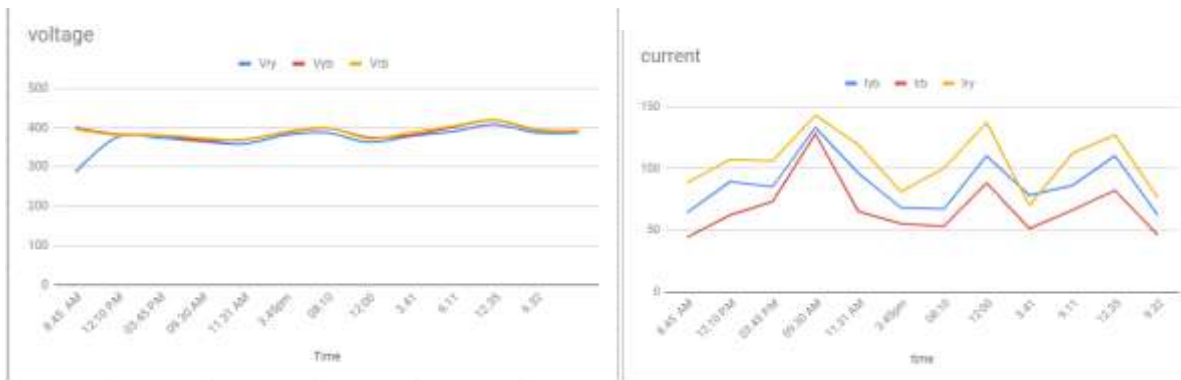


FIGURE 1: Voltage time & current time graph.

III. ANALYSIS OF DISTRIBUTION TRANSFORMER

3.1. CAUSES OF FAILURE

3.1.1. Winding failure

Winding is an essential part of the transformer. Its purpose transfer power from one winding to another through electromagnetic induction. Main reasons for failure are due to stress which causes braking in transformer winding and leads to the breakdown of dielectric strength. Insulation breakdown results in flashover of winding turn and short circuit.

3.1.2. Bushing failure

A bushing is the insulation and protective device. Its provide an easiest path to current through the tank wall. Loosing of this conductor causes vibration, which results in overheating. Bushing failure usually occurs because of ageing.

3.1.3. Core failure

The working of the core is to maximize the magnetic flux in working plane. The core is laminated for reducing the eddy current. The breakdown of lamination results in thermal heat due to eddy current. The heat produces by faults and overloading of the transformer damages the oil in the transformer resulting in the release of gas.

3.1.4. Tank failure

The tank is a container, which contains oil. Oil is used for the insulating and cooling purpose. It also acts as a supporting system for other equipment. Faults in a tank occur due to environmental conditions like corrosion, high humidity and sunray's results in leakage or cracks in the tank wall. Due to this, cracks oil spills from the tank causing a reduction in oil.

3.1.5. Insulation failure

Insulation of transformer winding slowly breaks down and becomes brittle over time. The rate of thermal breakdown approximately doubles for every 10-degree thermal aging has cause insulation brittle, which leads to the current that passes through transformer will mechanically shake the winding, a crack will form in insulation, and the internal fault will result. This is the reason hotspot is created in the winding.

The main dielectric medium in the transformer is oil-impregnated paper, which degrades with time. Replacement of oil after deterioration is easily possible, but on the contrary, the replacement of oil-impregnated paper is difficult after serious degradation. Cellulose paper is the solid insulating material. There are different calculation methods to obtain the resistivity value of the paper.

3.1.5.1. The Aging condition and resistivity of paper

The physical and chemical property of paper will change under its aging process. The graph (figure1) below show different resistivity and DP value of paper impregnated with different kind of oil under aging temperature.

IV. TEST CARRIED ON TRANSFORMER

4.1 Oil breakdown value of oil

For measuring BDV of transformer oil, a portable BDV measuring kit is used. A port in which oil is kept has a pair of electrodes with a gap of 2.5mm between them. Slowly voltage is increased between the electrodes at 2kv/s rate. Mostly 10 reading is taken an the average of them is considered.

BDV for new oil- 40 to 70 KV

BDV for old oil- 30 to 40 KV

4.2 Flashpoint test of oil

Flashpoint is important because it speeds the chance of fire hazard in the transformer, so it is desirable to have a very high flash point of the transformer. In general, it is more than 140°.

4.3 Viscosity test of oil

Viscosity test is about the resistance of flow, under normal condition. Good oil should have low viscosity, so it offers less resistance to the conventional flow of oil thereby not affecting the cooling of the transformer.

4.4 Megger test

The main purpose of this test is to find the overall insulation of the transformer. It checks the insulation level between HV and LV side of the transformer with respect to earth.

PE= 72GΩ

SE= 7GΩ

PS= 59GΩ

V. CONCLUSION

A pole mounted distribution substation has different kind of parts, which correlated with each other. All these parts have different faults, which cause different failures. Some are more severe than others are, some occur more frequently while some are hard to detect. One thing that is clear is that a single fault not only has an effect on that specific component but on many others in the transformer, therefore, a bigger failure occurs in the transformer from a little fault. Even the smallest fault must not be ignored. The forced outage of the transformer has a serious impact on the blackout, revenues. The prediction of remaining life of transformer helps to take a decision on replacement or relocation of an asset.

REFERENCES

- [1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," *Phil. Trans. Roy. Soc. London*, vol. A247, pp. 529–551, April 1955. (*references*)
- [2] Shroff, D.H.; Stannett, A.W. A Review of Paper Aging in Power Transformers. *IEE Proc. C* 1985, 132, 312–319.
- [3] Saha, T.K. Review of Time-domain Polarization Measurements for Assessing Insulation Condition in Aged Transformers. *IEEE Trans. Power Deliv.* 2003, 18, 1293–1301.
- [5] Lin, Y.; Yang, L.; Liao, R.; Sun, W.; Zhang, Y. Effect of Oil Replacement on Furfural Analysis and Aging Assessment of Power Transformers. *IEEE Trans. Dielectr. Electr. Insul.* 2015, 22, 2611–2619.
- [7] Krause, C. Power Transformer Insulation—History, Technology and Design. *IEEE Trans. Dielectr. Electr. Insul.* 2012, 19, 1941–1947.
- [8] D.P. Gupta, "Loading and life of transformers" in *TRANSFORMERS* Bharat Heavy Electricals Limited Bhopal (M P), Tata McGraw-Hill Publishing Company Limited.
- [9] O. Aljohani ; A. Abu-siada ; S. Islam. "Impact of insulating oil degradation on the power transformer frequency response analysis." 2015 IEEE 11th International Conference on the Properties and Applications of Dielectric Materials (ICPADM).
- [10] J. Cheng ; P. Werelius ; M. Ohlen. "FEM analysis of the transformer insulation XY model." PES T&D 2012.
- [11] J.M. Sketchley." The role of transformer oil analysis in the detection of fault conditions." IEE Colloquium on Assessment of Degradation Within Transformer Insulation Systems.
- [12] Hongkui Li ; Yan Li ; Xi Sun ; Dongxu Li ; Youteng Jing." Analysis of three-phase power transformer windings forces caused by magnetic inrush and short-circuit currents." 2009 International Conference. on Applied Superconductivity and Electromagnetic Devices