International Journal on Emerging Technologies **8**(1): 109-112(2017)

ISSN No. (Print) : 0975-8364
ISSN No. (Online) : 2249-3255

A Study on Power Transformer condition Monitoring Technology

M.A. Khan and R.K. Taksande
Lecturer, Kalaniketan Polytechnic College, Jabalpur (Madhya Pradesh), India.

(Corresponding author: M.A. Khan)
(Received 09 April, 2017 accepted 25 June, 2017)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The electricity market deregulation seeks to achieve competitive prices without compromising system relevance, reliability and safety, so transformers need to age with acceptable performance. The purpose of this work was to determine if a particular condition monitoring technique could be applied to complex natures, new materials, and extreme environments within the energy industry. If successful, it improves safe working conditions and complements traditional applications. Power transformers contain a variety of complex materials and shapes. Some transformers are exposed to extreme environmental conditions and others rotate at high speeds. Of the various condition monitoring methods, dissolve gas analysis and partial discharge were considered to be the most promising. The main results of this survey are: Various condition monitoring studies were compared for early failure detection and real-time condition monitoring. Matching the status of age and wealth will be an important tool. Monitoring to avoid unplanned outages, economic loss of revenue, environment all damage.

Keywords: Condition Monitoring, Power Transformer, Partial Discharge Analysis.

I. INTRODUCTION

The actual operating condition of the transformer in the electricity market is an important aspect of the interms of the stability of the power supply. Economic pressure has forced utilities to adopt an efficient maintenance strategy of that performs only the most important tasks. An additional controller is required to keep the transformer "normal". The monitoring system provides the ability to measure the operating status of the transformer over a long period of time. Deterioration of transformer insulation can be detected early by condition monitoring technology. Transformer condition monitoring considers the following characteristics: Improvements to traditional maintenance, Reliability-centric maintenance, Transformer maintenance at service, Reliable supply, Priority on-site repair and line processing, Minimize corrective actions and develop the most effective, corrective actions, Comprehensive life assessment and update. However there are some failures in the implementation of condition monitoring technology. These obstacles or problems are: Increased system cost with additional monitoring sensors and additional circuits and control systems, Protection and overall Surveillance system complexity is increasing, The need for a new high speed processing system for data processing and decision making, You also need the appropriate storage for database knowledge.

The condition monitoring system must be sufficient to better understand the exact occurrence of a failure under a particular load, operate under the all condition and perform all its tasks. Still, its cost should be lower than the cost of maintenance and downtime. Implementing shouldn't be easy either. In general, the cost of the condition monitoring is much lower than the maintenance cost, and loses utility costs. The condition monitoring is a technique that provides information for preventive maintenance of transformers. Traditionally, regular maintenance of has been the main maintenance. But that's a plan for a long time. Regular maintenance can prevent many failures, but causes many unwanted shutdowns and can cause unexpected accidents between two maintenance operations. Preventive maintenance saves labour costs, time, and costs. Preventive maintenance provides the operator with more insight into the condition of the equipment, clearly showing when and which maintenance is needed, saving personnel, costs and reducing unnecessary shutdowns. Preventive Maintenance is the best maintenance service that uses the condition monitoring system to provide accurate and useful information about the status of the transformer. Transformers with electrical interference, predicting the need for maintenance before serious degradation or failure, identifying the type of maintenance required to identify defects, and even transformers life [1-5]. There are several reserve state monitoring techniques for transformer failure, including vibration analysis, thermal analysis, transfer function analysis, partial discharge, and dissolved gas analysis.

II. THERMAL ANALYSIS

Transformer thermal monitoring is a simple temperature measurement technique. It can provide useful information about the condition of the transformer. This method can find the initial failure of a transformer. Deterioration of used oil/paper insulation depends primarily on the hotspot temperature of the solid insulation system.

Therefore, this is the dominant factor that limits the life of a transformer. The life of a transformer can be severely affected when the continuous maximum hotspot temperature reaches 98°C with paper insulation. We also assume that the aging rate doubles for every increase in 6°C. Transformer oils are also susceptible to thermal degradation, and elevated oil temperatures can accelerate other aging processes. Determining the temperature of the insulation hotspots on the windings is a very complex task. Oil conditions affect the ability of a transformer to withstand an emergency overload. However, the condition of the oil can is subject to renewal or change. Temperature monitoring falls into two categories. First, development of a thermal model for predicting the thermal behaviour of a transformer. Second, artificial neural network for predicting the temperature of a transformer Technology Development of a thermal model for evaluating the thermal behaviour of a transformer is Transformer. The Transformer thermal model is discussed in many publications with different precisions and different construction techniques. An analogy between the transformer thermodynamics and the electrical circuit is presented in [6], which creates a thermal model of the transformer to predict the upper and lower temperature limits of oil. A relationship was found between the thermal circuit on which the thermal model was built and the electrical circuit. Using the genetic algorithm, we found a thermal model input and parameters to overcome the measurement compactness. This thermal model can be used to monitor transformer status in the field and provide engineer with real-time data monitoring [6]. The artificial neural network is a very good way to predict about the temperature of transformer hotspots and top oil.

The temperature of all three windings of the transformer is measured. This measured temperature is used in the artificial neural network to predict the hot spot and top oil temperature. More inputs to the artificial neural network can be used to improve the accuracy of predictions of top oil and hotspot temperatures. The temperature of predicted from the previous sample. A new attempt was made to provide a thermal model with parameters that could be primarily determined from the simple measurements. Nevertheless, the most accepted model is the model specified in the IEC standard. You can calculate the maximum load current that can operate the transformer at a given ambient temperature and the maximum permissible hot spot temperature with no time limit papers have been published proposing improvements to the thermal model of the current IEC standard. Hotspot. The standard approach to temperature calculation is via which uses the temperature of the characteristic points. Vulnerable models are published in [7-12].

Transformer condition monitoring is performed using artificial neural network technology, thermal model development, or both. We know that more research is needed to develop a more accurate model that can handle a variety of operating conditions, including; prediction of transformer thermal behaviour.

III. VIBRATION ANALYSIS

Vibration Analysis is a recently developed method. This method uses a vibration signal to evaluate the state of the transformer. The state of the core, windings, and on-road tap changer can be accessed from the vibration characteristics of the transformer tank. Various tank vibrations are used for cores, windings, and under load tap changers. These vibrations generated by propagate through the transformer oil as they reach the walls of the transformer. The vibration sensor (accelerometer) is used on the tank wall of the transformer
to detect these vibration signal patterns. The vibration signal is collected by the accelerometer. The collected signal can be detected at as a series of decay bursts. Each burst is the result of a finite number of combinations of decaying sinusoidal waveforms. The Fourier transform was used to analyse these collected signals. The Fourier transform indicates that the transient ringing signal is in the range of 10 to 2000 Hz. However, the state assessment of the transformer online load tap changer was successfully performed on the using the vibration pattern. Online load tap changer has its own vibration pattern, which depends on the number of rising edges of the vibration failure and the duration betweens for every two consecutive rising edges. These vibration patterns can be analysed by various signal processing techniques to predict failures. Wavelet transform is an important and useful technique. This technique analyses the vibration peak generated by the operation of the online load tap changer. This is due to its reliable ability to extract useful features from the unsteady, fast transient signal [13-14]. Finally, more work is needed to assess the condition of all transformer components. The work done in this area is focused on using vibration analysis only for OLTC sanity assessment.

IV. TRANSFER FUNCTION ANALYSIS

Transfer function analysis uses as wept generator to apply sinusoidal voltages at various frequencies across the terminals of the transformer windings. The frequency spectrum of the measured transfer function (range: 20 Hz to 2 MHz) shows the deformation or displacement of the winding due to excessive mechanical acceleration during transportation ordynamic forces caused by external short circuit current [15-16]. Displacements in the windings, as occurs especially with older brittle paper insulation, do not necessarily lead to immediate failure of the transformer, but increase the risk of insulation breakdown at the next over voltage or may increase the short circuit. The main advantage of the transfer function procedure is obviously the avoidance of the costly inspection of open transformers. Early transfer function studies relied onto time domain measurements in which the signal was analysed with a digital Fourier transform. Despite the relatively cheap equipment, the frequency-domain method is more widely used due to its superior signal-to-noise ratio in the field, resulting in better sensitivity to small changes.

However, the problem with the transfer function is that that application requires special precautions and you simply can't run the online.

V. PARTIAL DISCHARGE ANALYSIS

Partial discharge can be caused by dielectric insulation deterioration or aging insulation deterioration inside the transformer. Hydrogen is the dominant as in partial discharge because it is formed under a low energy electrical load of and is less sensitive to temperature. During the partial discharge fault, the rate of hydrogen as evolution increases. Partial discharge provides information on aging of transformer insulation. Therefore, the partial discharge is less likely to cause the transformer to overheat. Therefore, if no corrective action is taken in this early stage of, the fault may develop into serious electrical fault and cause further damage to the transformer. Therefore, partial discharge of may correlate with degradation of cellulose. The alternating power source for the excitation of the onsite power transformer must ensure the following characteristics: portability, test voltage and frequency variability, and test voltage without noise and partial discharge. The controllable test voltage makes it possible to determine the partial discharge threshold voltage and the erasure voltage. Using a test frequency that is different from the power frequency, the noise generated by the power frequency can be identified against the phase-correlated partial discharge signal. In addition, the increase infrequency prevents saturation of the core at test voltages higher than the rating. The partial discharge was used for condition monitoring of the transformer insulation system. But; in fact, many insulation issues start with the partial discharge activity. In fact, the partial discharge of is considered the raw data used to perform the conversion condition monitoring. The partial discharge data should be used to assess her condition of the transformer, diagnose her failure, and find the location of the failure. In most cases, partial discharge data is large enough for human interpretation, so integrating partial discharge data with artificial neural network is widely used to build a complete condition monitoring system and solves the problem. And recognize and identify the input [17-20]. The location of partial discharge activity can also be determined using artificial neural network.

VI. DISSOLVE GAS ANALYSIS

Dissolve gas-in-oil analysis is based on the concentration of gas dissolved in the transformer oil and is one of the most widely used methods for diagnosing early transformer failure. There are problems with this established method. Some laboratories compress the gas in the presence of oil when extracting gas from the oil sample. This causes the extracted gas to be reabsorbed by the oil. Therefore, the requires a correction factor for the result of the extracted gas when calculated back to standard pressure and temperature. Next, there are various methods used in gas chromatography. Some labs use a single chromatography column and others use two detectors. Therefore, the standard was introduced to address these issues. The

standard test method for the analysis of gas dissolved in electrical insulating oil by gas chromatography and the standard practice for sampling gas from transformers under positive pressure are standard methods established by approved institutions. The interpretation of the Shokiera isas outlined in IEEE StdC 37.104-1991 [21]. The decomposition of mineral oil into gases with different molecular weights is closely related to the thermal stress and electrical stress. A temperature of below 500°C or a low to medium discharge produces a relatively large amount of low molecular weight gas. These gases are composed of hydrogen (H_2) and methane (CH_4), and trace amounts of high molecular weight gas (such as ethane (C_2H_6) and ethylene (C_2H_4)). When the temperature exceeds 500°C and or high intensity discharge occurs, the concentration of high molecular weight gas exceeds the concentration of low molecular weight gas. If the magnitude of the discharge approaches the magnitude of the arc, or if a continuous discharge produces temperatures from 700ºC to 1800ºC, such as specified in the standard. The amount of acetylene (C_2H_2) is pronounced. The standard also establishes a operational priority that provides the engineer with a set of standard procedures that the follows. Detection is a top priority because anomalous behaviour can be detected as soon as possible to minimize damage and avoid failures. Next, use a set of guidelines or recommendations to assess the impact of the anomaly on the operability of the transformer. Finally, taker recommended actions starting with to enhance monitoring and perform confirmation or supplemental analysis. This allows determining load sensitivity, reducing load dependency on a failed transformer, or shutting down the unit in actual. Transformer failure analysis and interpretation of from user view. Fault Interpretation Using a Set of Actual Transformer dissolve gas analysis data there are three different methods. The first method used was the Dornenberg method. This method uses the gas ratio and range of the standard to classify transformer failures. The Roger ratio method was also used in the demonstration. This method is very similar to the Dornenberg method, with the only difference being that the ethylene / ethane gas ratio was used instead of the ethane / acetylene ratio. The third method was the key gas method. This technique interprets transformer failures based on the presence and amount of a particular gas. Finally, keep in mind that a broader set of transformer gas generation data is needed to improve the diagnostic accuracy of transformer failures. However, there are some restrictions on these monitoring methods. The state in the transformer is not uniform and the system will never be in true equilibrium. Temperature and pressure gradients and different types of flow characteristics contribute to the overall complexity of the transformer system.

The ratio method does not provide the meaning off or the magnitude of the number used to calculate the ratio, and produces ode digits. If the number itself is small, fluctuations in the value can cause very large changes in the ratio, thus producing digits. Therefore, the diagnosis of transformer failure is not a science, but a form of art; because those who use these methods need to be aware of the condition and the parameter must be a transformer. There is no method that can proactively provide good diagnostic results [21-23].

VII. CONCLUSION

This paper sought to verify some of the latest condition monitoring methods for proper transformer analysis. It was found based on in the literature search. Dissolve gas analysis is the most widely used method for investigating the initial failure. However, this requires special precautions to limit online monitoring by the dissolve gas analysis. Many-condition monitoring techniques are available to analyse the transformer. The IEEE and IEC standards also mention some condition monitoring schemes. It is very difficult to consider a single method as the best method for converting condition monitoring. These transformer condition monitoring technologies require more work to improve the operation. These integrate them with data mining and artificial intelligence agents to build a complete online commercial.

REFFRENCES

[1]. M. Arshad, S. M. Islam and Abdul Khaliq, "Power Transformer Asset Management," *in proc. International Conference on Power System Technology PowerCon 2004*, Vol. **2**, pp 1395, 1398, Nov. 2004.

[2]. S. D. J. McArthur, S. M. Strachan, and G. Jahn, "The Design of a Multi-Agent Transformer Condition Monitoring System," *IEEE Trans. Power Del.*, vol. **19**, no. 4, Nov. 2004.

[3]. J. K. Pylvänäinen, K. Nousiainen, and P.Verho, "Studies to Utilize Loading Guides and ANN for Oil-Immersed Distribution Transformer Condition Monitoring," *IEEE Trans. Power Del.*, vol. **22,** no. 1, pp 201-207, Jan. 2007.

[4]. A. K. Shrama, Rakesh saxena, M. Ahfaz khan, "Expert System For Condition monitoring and fault Diagnosis of Power transformer*", in IEEE International Conference, PEDES 2006*. India

[5]. Y. Han and Y. H. Song, "Condition Monitoring Techniques for Electrical Equipment -A Literature Survey," *IEEE Trans. Power Del.*, vol. **18,** no. 1, pp 4-13, Jan. 2003.

[6]. Enzo CARDILLO, Prof. Dr.-Ing. Dr. h. c. Kurt FESER "Monitoring System of Large Power Transformers Based on up to date Information Technology" *Institute of Power Transmission and High Voltage Technology University of Stuttgart*

[7]. W.H. Tang, Q.H. Wu and Z.J. Richardson, "Equivalent heat circuit based power transformer thermal model," *IEE Proc. Electr. Power Appl.,* vol. **149,** no. 2, March 2002.

[8]. SCHAEFER M., FESER K., *Thermal Monitoring of Large Power Transformers,* IEEE Power Tech, udapest, Hungary, 1999.

[9]. IEEE *Std, C57.91 – 1995, IEEE Guide for loading Mineral Oil-Immersed Transformers*, (1996).

[10]. J. Aubin, Y. Langhame, *Effect of oil viscosity on transformer loading capability at low ambient temperatures,* IEEE Transaction on Power Delivery, Vol. *7*, No. 2, pp. 516-524, April 1992.

[11]. J. Osztermayer, E. Cardillo, S. Markalous, M. Lenz, S. Hoek, R. Wimmer, K. Feser, *Asset Management Based on Improved Online Monitoring Systems Applied to a 110/380 kV Substation,* IEEE Power Tech, Bologna, Italy, 2003.

[12]. L.W. Pierce, *An investigation of the thermal performance of an oil filled transformer winding,* IEEE Transaction on Power Delivery, Vol. 7, No. 3, pp. 1347-1358, July 1992.

[13]. P. Kang and D. Birtwhistle, "Condition Assessment of Power Transformer On-Load Tap-Changers Using Wavelet Analysis," *IEEE Trans. Power Del.*, vol. 16, no. 3, pp 394-400, July 2001.

[14]. P. Kang and D. Birtwhistle, "Condition Assessment of Power Transformer Onload Tap Changers Using Wavelet Analysis and SelfOrganizing Map: Field Evaluation," *IEEE Trans. Power Del.*, vol. **18**, no. 1, pp 78-84, Jan. 2001.

[15]. A. Zargari and T. R. Blackbum, "Acoustic detection of partial discharges using non- intrusive

[16]. M. Hässig, R. Bräunlich, R. Gysi, J.-J. Alff, V. Der Houhanessian, W. S. Zaengl "On-Site Applications of Advanced Diagnosis Methods for Quality Assessment of Insulation of Power Transformers

[17]. V. M. Catterson and S. D. J. McArthur, "The Practical Implications of Bringing a Multi-Agent Transformer Condition Monitoring System On-Line," *in proc. IEEE PES*

[18]. M. D. Judd, S. D. J. McArthur, J.R. McDonald and O. Farish, "Intelligent condition monitoring and asset management: Partial discharge monitoring for power transformers," *IEE Power Eng. Jor.*vol. **16**, no. 6, pp. 297-304, Dec. 2002.

[19]. X. D. Ma, C. Zhou and I. J. Kemp, "DSP Based Partial Discharge Characterization by Wavelet Analysis," *in proc. IEEE 19Ih Int. Symp.on Discharges and Electrical Insulation in Vacuum*, 2000.

[20]. Q. Su and K. Sack, " New techniques for online partial discharge measurements," *in proc. IEEE International Multi Topic Conference Technology for the 21st Century*, 2001.

[23]. IEEE *Std,* C37.104-1991*, IEEE Guide for loading Mineral Oil-Immersed Transformers*, (1991).

[22]. D. V. S. S. Siva Sarma G. N. S. Kalyani*,* "ANN approach for condition monitoring of power transformers using DGA," *in proc. IEEE Region 10 Conference TENCON*, 21-24 Nov. 2004.

[23]. Y. C. Huang and C. M. Huang, "Evolving Wavelet Networks for Power Transformer Condition Monitoring," *IEEE Trans. Power Del.*, vol. **17**, no. 2, Apr. 2002.