Review Paper on Diagnostics Study of Dry Transformer

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Abstract

Where fire safety and reliability are the major concern due to Non-flammable characteristics, dry type transformer suited for schools, high rise buildings, hospitals, chemical factories, steel plants, small scale industries etc. These transformers are available indifferent ratings ranging from 25KVA-12500KVA. It suffers issues related with temperature rise of low voltage and high voltage windings, winding insulation failure, more losses due to overloading and in case of insulation burnout whole windings and core limb have to be changed. In long run these issues will impact the transformer functioning life, or may cause the transformer failure.Various strategies and methods were utilized by numerous analysts to limit these impacts and promising outcomes. In this paper literature review, techniques, merits and demerits are discussed.

Keywords

Dry Transformer, Insulation design, Insulation safety, Temperature rising, Hot-spot temperature.

1. Introduction

Due to rapidly increase in maximum demand, the need of improvement in grid infrastructure and its components for the smooth operation and management with high reliability is required. The transformer plays a significant role for the distribution of electricity from the generation to the distribution end consumers.

Dry type transformers are the best choice, where the safety of the people and reliability are the major concerns. Physical dimensions of these transformers are smaller in comparison with the oil protection transformers. Likewise, they enjoy benefits like a higher mechanical strength, the chance of establishment near the load point is more, doesn't need transformer infusion wells for oil assortment, oil oversight adornments, firefighting frameworks, fireguard dividers and the most minimal degree of partial discharges internally (because of its vacuum encapsulation) [3, 12]. Therefore, they are normally utilized in populated regions, for instance, in enterprises, skyscraper private structures and medical sectors. However, these transformers are more costly and have power and voltage limits. Because of this malfunctioning of these equipment's greatly impact on the financially loss of the company and social loss to the people [19]. So, their design must be specifically analyzed before manufacturing as per the specific usage needs, meeting the limit sets by international standards [11]. Designing of transformer is very crucial in order to reduce the losses and increased its life span [16].

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While designing of dry transformers, main aim is to decrease the power losses occurs internally [2]. Iron core and windings are the main source of internal losses and varies with the resistance of windings, interior surface temperature, current flowing through windings, voltage across the load, connected load and type of aluminum (quality) used [23]. Ultimately, these losses influence the entire machine's temperature system, which straightforwardly diminishes the effectiveness and the transformer's lifespan. Due to this the thermal stress is a significant reason for its failure, as it causes the weakening of the protecting material [18]. However, predicting the interior temperature (or an increase in temperature) is a big challenge while designing the transformer design.

In this paper a brief survey is done on the dry type transformer parameters such as temperature rise, construction design, losses due to overloading, insulation breakdown due to excessive heat.

2. Literature Review on Different Techniques Used on Dry Transformer

A brief summary is done below which describes the monitoring techniques, monitoring parameters and their advantages and disadvantages.

Table 1

Transformer health assessment methodologies comparison.

Monitoring Techniques	Year	Monitoring Parameters	Merits	Demerits
Soft Computing Techniques using ANFIS by Ebenezer et. al [1]	2010	-Harmonics problems due to Non- Linear Loads -Winding Temperature	-For any load variation temperature prediction can be done. -More accurate results compare to other techniques. -Harmonics reduction can be done by using filters.	-Large data required for Training for optimum results.
Transformer Temperature Controller Using HCI system by Long et. al [2]	2008	-Temperature -Transformer Health life	-Real time monitoring and controlling -Low cost -High reliability -User friendly HCI system	-To improve precision further research needs to be done.
Automatic Partial Discharges diagnosis using multi sensor system by Werle et. al [3]	2002	-Voltage -Apparent charge	-Automatic -Damping or distortion has no effect on results. -Small physical dimension -High accuracy	-For improving accuracy and quality of PD tests, a calibration impulse has to be injected

				in parallel to the specimen as well as to the winding ends. -Sensors needed.
Analysis of Temperature field based on Fluid-solid Coupling by Ding et. al [4]	2012	-Temperature Field distribution	-Hottest spot-on LV windings lie at 1/3 of the top. -Makes online monitoring easier by defining the location of the sensors. -Reduce maintenance cost -Extend life span	-Need to add the hottest spot on HV windings. -Effect of temperature on the insulation was not discussed.
Condition monitoring using LabVIEW with Fuzzy Logic Controller Simulation Panel by Muhamad et. al [5]	2008	-Voltage -Current -Fuzzy Logic Controller -DGA -Interpretation of Fault behavior	-Monitor all size and rating of oil and dry type transformer. -User friendly interface for monitoring through LabVIEW. -Identifies fault types -Predict the transformer health condition.	-To enhance the accuracy broader testing needs to be done.
Comprehensive study with Swarm-based metaheuristic optimization methods by Aksu et. al [6]	2018	-Invasive Weed Optimization (IWO) -Firefly Algorithm -Particle Swarm Optimization (PSO) -Current density -Iron section compatibility factor	-In short time, give near optimal results. -Time saving -Reduce weight of Dry transformer -Increase efficiency	-Not guarantee for the best results. -Works specifically to a particular problem structure.
Digital measurement system for temperature rise by Srinivasan et. al [7]	2011	-Cold Resistance of LV and HV -Hot Resistance of LV and HV -Temperature	-Low-cost digital measurement system -Accurate measurement -Low errors -Data Acquisition System not	-Not applicable to all measurement

		rise	required.	systems i.e proper algorithm required in the programming environment. -High speed DSP required
Design of temperature controller based on IoT by Leng et. al [8]	2020	-Temperature -Real time monitoring	-Simple structure of few devices -Make remote centralized monitoring -Reduce costs, labour -Improves efficiency management -Data can record and view easily through cloud -Integrate multiple temperature controllers. -Monitor multiple Dry type transformers. -Low power consumption	-Fast communication medium required. -Interference or data lost during long remote location monitoring -Data is not secure on cloud
Monitoring using Fiber optictechnology by Gockenbach et. al [9]	2001	-Temperature rise of windings -Failure of secondary windings -Life Expectancy	-Prevent secondary failures and cost -Offline analysis gives the indication of short circuits -Repair costs, maintenance reduced.	-Every time PD detection system is not economical.
3-dimensional Finite Element analysis on Fluid Thermal Field by Ning et. al [10]	2012	-Temperature rise -Age -Temperature field	-Reliable -Very low error -Simulation analysis helps in minimizing temperature rise.	-Does not work on the low voltage winding temperature rise.
Online condition monitoring and diagnosis	2016	-Leakage flux	-Fault localization	-

techniques by Subramaniam et. al [11]		during inter-turn fault.	-Helped in detection of potential monitoring parameter.	Insulation constraints -Fault detection by terminal current analysis is limited to fault identification and cannot use for fault localization.
Different temperature Sensing and control technology by Feng et. al [12]	2011	-Infrared, Thermal resistance, Fiber optic temperature sensing technique - Transformer windings -Current -Voltage -Power factor	-Reliable - Provides a more efficient solution to difficult problems - It's simple to increase or change the system's performance. -Back Propagation Neural Network (BP) increase response speed.	-The accuracy depends majorly on selected parameters. -Need to train with large number of samples for accurate results. -Expensive sensors used which increased the overall system cost
Mathematically analysis of temperature distribution using Finite Difference Method by	2007	-Temperature distribution in windings -Eddy current	-Reduce heating by variation of air duct width with temperature rise. -Eddy current reduces by	-Lab environmental condition

Rahimpour et. al [13]	losses. -Radiation from the outer surface -Heat transfer from top and bottom surface	modification of cross-section of conductors. - The external cooling medium lowers the amount of radiation emitted from the outside surface.	s such as air displacement creates inaccuracy. -Error in temperature reading due to magnetic field impact on infrared periscope. -Errors due to computational operations while rounding and estimation

3. Miscellaneous Techniques

3.1 Study of the Internal Winding Temperature Distribution using Simulation Models.

Basic heat transfer theory is used to analyze the internal structure of dry type transformer and simulate via Analysis of Systems (ANSYS) simulation software [14]. The highest temperature location separately for iron core, low voltage winding and high voltage winding was determined. For analyzing the temperature field distribution of the dry type transformer, a 2-D model of dry type transformer is used to locate the positions of the hottest temperature of the iron core, HV winding and LV winding. Results of ANSYS simulation used as a reference and compared with the experimental results.

The prognosis system is based on changing the ambient temperature changed the thermal modelling of a cast-resin dry transformer. The developed system was utilized to keep the transformer aging rate within a specific value during the transformer operation [15]. The short-circuit withstand test was performed on the dry type transformer unit of 72.5kV. Schering Bridge with a reproducibility of 0.1% was used to measure the short circuit inductance of transformer [16]. A 3D finite volume based Computational Fluid Dynamics (CFD) model produced in the ANSYS CFX software and a Finite

Element Modeling (FEM) based model that employs an experimental analytical method for vertical air-cooled ducts. [17].

For this 800 kVA transformer, the CFX result are accurate, but the proposed FEM model was accurate enough for practical design applications [17]. Form these two models, the losses increased, due to the temperature decreases as their air ducts width decreases, and increases as the width of the air duct increased to a certain limit.

3.2 Advance Methods used in Dry Transformers Diagnostics

Dry type transformers are designed in a certain way which involves the huge number of factors in estimations and the relationships between these factors. The concept of multi-insulation design and the solid insulation system bolstered by precision design and defect-free manufacturing is discussed in [18]. The safety and the dependability of the dry-type transformer are considerably improved, the logical inconsistency of the insulation protection safety and energy-saving design are handled, and the dry-type transformer's performance is enhanced further. The manufacturing process is straightforward and dependable, the prior process includes complex pouring cycle which was totally kept away, and the manufacturing effectiveness and item quality are ensured. The finite element analysis is an efficient tool for determining the temperatures of a dry-type transformer under load.

In [19] another strategy of a thermal simulation utilizing finite element theory hypothesis is being proposed. The heat diffusion equation was utilized, with the accompanying limit conditions: convection and radiation conditions, qualities of the materials utilized, the estimation information and the elements of the transformer. The position of the hotspot temperature, cycle of thermogenesis and thermolysis of transformer was investigated to anticipate the insulation life loss of dry-type transformer [20]. Artificial Neural Network (ANN) assists with seeing the subtleties that are practically difficult to be seen utilizing traditional tools, inferable from the intricacy in mathematical simulations. The use of artificial neural networks in modelling influences various design factors on the internal temperature of dry type transformers. The ANN results are contrasted with 300 transformers were put through their paces in a real-world test. [21]. The outcomes of ANNs were shown to be capable of modelling, with incredible exactness, the connection between different design parameters, losses and internal temperature increase in dry-type transformers. Temperature rising forecast of transformers (dry-type) by coupled temperature-dependent power loss and thermal fluid filed methodis one of the critical thoughts that utilized mathematical tests [22].

In Electrical Partial Discharge (PD) localization method of a dry type power transformer an adjustment signal was infused through a plate sensor set along the windings on the outside surface of the transformer coil in various positions [23]. After that PD signals are recorded from both coil terminal sites utilizing digitizer. Measured PD signal during test assessed and contrasted with calculated transfer function. The depicted strategy empowers not just localization of the PD source additionally assurance of the apparent charge. This assessment can be more exact than ordinary PD measurements by utilization of quadruple and coupling capacitor adjustment and can be utilized during manufacturing process as well as diagnostic in field. In thermal model for foil winding, the temperature distributions were dictated by the finite element method (FEM). FEM limits the non-consistency of the heat fluxes transitions in the foil windings because of induced currents, diverse convection coefficients and shifting air temperature along the vertical height of the foil winding [24].

4. Hotspot Temperature Prediction of Dry-Type Transformers using IoT

The internet of things (IoT) is an active scientific study field in identifying research issues connected with its application in a number of industries, including consumer convenience, smart energy, and energy conservation, as well as IoT organizations, as an emerging technology. Sensors are important IoT components that send data in the form of a data stream for further processing. It can be used to store information or communicate with each other across the globe of dry transformer. In [25] systematic review of integration of semantics into sensor data for the IoT was discussed and found the interoperability of diverse connected digital resources a major issue. The proposed techniques employed the use of sensor data which is always changing and real-time semantic annotation is required to store the data in data store as static data and subsequently merged with semantics. A Particle Filter Support Vector Regression (SVR) technique was used in hotspot temperature prediction of dry transformer in [26]. The particle filter may dynamically track fresh data and provide the system with the best SVR parameters. IoT can improve real-time approaches for integrating and interpreting semantic annotations in dry transformer future work.

5. Conclusion

From the literature survey, it is observed that various methods were proposed by different researchers in order to eliminate the different types of failures in Dry Transformer. However, most of the researchers worked on simulation-based models and not much work is done with the real-world datasets. Various techniques proposed by researchers, to minimize the temperature rise and hot spot temperature prediction we find that there is scope of improvements in these methods to detect the fault at early stage using advanced real-time methods for integrating and interpreting semantic annotations including Artificial Intelligence (AI) with IoT real time monitoring.

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7. References

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