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배전설비의 온라인 모니터링과 진단 기술 동향

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A Technical Trend on On-Line Condition Monitoring and Diagnostics of Power Equipments

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Abstract - Continuous temperature monitoring and event recording provides information on the energized equipment's response to normal and emergency conditions. On-line temperature monitoring helps to coordinate equipment specifications and ratings, determine the real limits of the monitored equipment and optimize facility operations. Using wireless technique eliminates any need for special cables and wires with lower installation costs if compared to other types of online condition monitoring equipment. In addition, wireless temperature monitoring works well under difficult conditions in strategically important locations. Wireless technology for on-line condition monitoring of energized equipment is applicable both as standalone system and with an interface with power quality monitoring system. The paper presents the results of wireless temperature monitoring of switchgear at a power plant over a two-year period.

1. Introduction

Continuous temperature monitoring of energized equipment provides true information about the condition of the equipment while in service compared to testing the different parameters during preventive maintenance (PM) cycles. Generally speaking, physical conditions of electrical contact may display different values and trends depending upon measurement conditions. For example, the most common technique of determining the quality of contact condition today is measuring the contact resistance while applying 100ADC to the primary path.

Needless to say, in real life when the same contact is exposed to thousands of amperes of alternating current, it may behave very differently. For example, some of the laboratory tests demonstrated that high contact resistance during the test does not lead to overheating when in service, due to the presence of films on the contact surface with non-linear resistance values [1]. On the other hand, a loose, "hand-tight" connection could easily pass the Contact Resistance Test. Therefore, having the ability to directly measure the temperature of the contacts while in service will provide more information to determine the true condition of the equipment. Corrective actions could be performed only when a degraded condition requires maintenance, thus reducing the time and cost of PM testing.

Continuous temperature monitoring will identify potential problem areas that can lead to substantial equipment damage. Correlation between the temperature measurement, and load and ambient conditions would allow abnormal conditions to be identified and early alarms to notify operation and maintenance personnel of a potential problem. Further deterioration of the condition could lead to a recommendation to take the equipment out of service for repair and maintenance. The real value of the on-line monitoring is not in setting off multiple alarms but in triggering the maintenance events leading to a true conditionbased maintenance, and providing the key answers to implementing the plant assets management.

In this paper, the authors introduce the ability to continuously monitor the condition of energized equipment (on-line monitoring) enables operation and maintenance personnel with a means to determine the operational status of equipment, to evaluate present condition of equipment, timely detection of abnormal conditions, and initiate actions preventing upcoming possible forced outages [2]. The consequences of such faults are serious enough to justify the efforts to build a temperature monitoring system to protect electric facilities from disaster.

2. Experimental

Various combinations of fiber optic technology come in many forms and offer solutions for a variety of applications. Fiber optic wire may be used as a temperature data carrier or as an active sensing element. In the latter, temperature dependent modification of the optical transmission properties is used (distributed fiber optic temperature sensing) [3]. As a temperature data carrier, one fiberoptic cable delivers light to the sensing element and another cable carries back the signal modified by the changing temperature in the sensing head. Sensitive elements at the fiber tip provide rapid and accurate temperature measurement. Mounting the sensing element at the end of a small optical fiber allows placement of the sensor in difficult-to-access locations. The materials in the fiber that communicate with the sensitive element exhibit low thermal conductivity as well as a narrow cross-sectional area. This minimizes heat flow to and from the active sensing element from outside the volume whose temperature is to be sampled. Fiber-optic temperature transducers are compact, immune to EMI/RFI, resistant to corrosive environments, and provide high accuracy and reliability of temperature measurements [4-5]. The probe requires no wires or other metal parts. It is electrically nonconducting, unlike thermocouples and Resistive Temperature Detectors (RTD). Therefore, it can be deployed in high-voltage (HV) environments. Fiberoptic technologies are used for temperature monitoring of cables and HV transformers. Applying fiberoptic modifications to an existing power distribution system would require substantial modifications to the equipment with subsequent design verifications and testing.

3. Results and Discussion

The temperature of the top and bottom FCs on Phase A and C are very close. The difference in temperature between Phase B and Phases A and C is usually in the range 5-10 oC. The first warning signal was an observation of a very high temperature of the ambient air within the main cells. It was reaching 60 oC even though the current was well below the maximum rated current for the breakers. As a result, the temperature on the finger clusters occasionally reached 100 oC, which is very close to standard maximum for current-carrying parts of MV circuit breakers (105 oC) (Fig. 1, A). It was determined that the elevated temperature within the cells was caused by a poor ability to evacuate heat build-up. The existing switchgear did not provide louvers on the doors and no forced ventilation within the cells. It was strongly recommended to improve ventilation within the cells, which was done with minimum expense. An opening was made in the door of the cell with two small vents installed to increase airflow inside the cell. The result was very promising: temperature of the air within the cells dropped an average 10 oC for the same current accompanied with the corresponding drop of the temperature on all six finger clusters (Fig. 1, B). This drop in temperature provided a large and safe temperature margin for the load on the main circuit breakers. The temperature has suddenly risen 10-15 oC on Phase A's finger clusters and they become as hot (or hotter) as the FCs on Phase B. The temperature rise usually happened when the load rose (Fig. 2).

Events have been observed on one main breaker during one year of temperature monitoring. Duration of the rise varied from 40 to 400 hours. Since temperature rises have been within standard limit (< 65 oC) during these events, the Temperature Monitoring System issued no alarms.

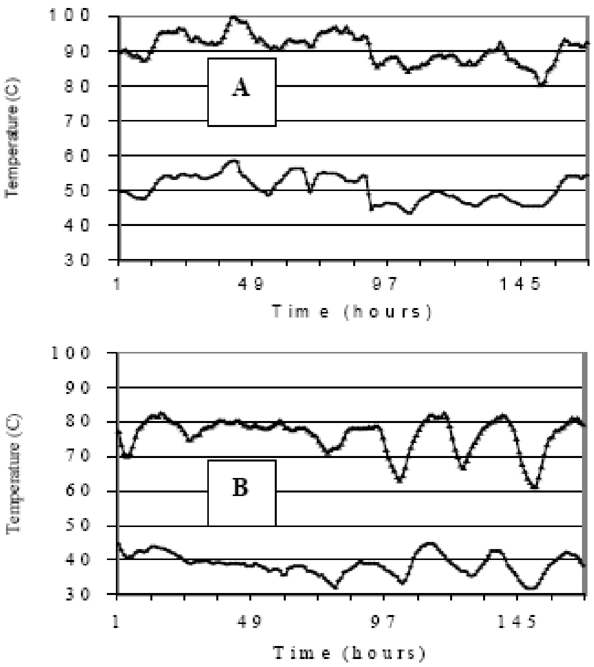

Fig. 1. Ambient temperature (bottom curve) and on B Phase Top FC (top curve) in the same cell without ventilation (A) and with forced ventilation (B).

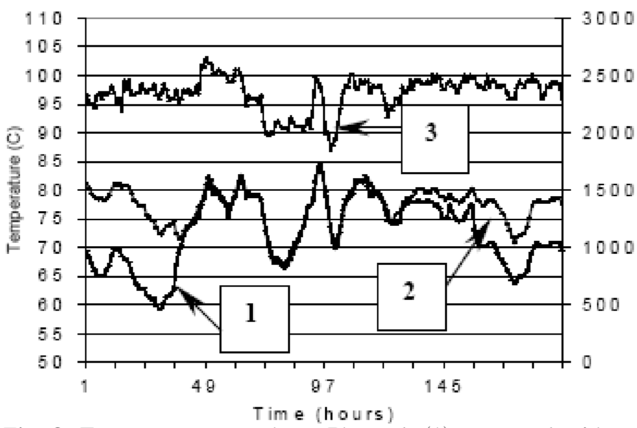

Fig. 2. Temperature growth on Phase A (1) compared with that on Phase B (2) and current (3).

4. Conclusion

Continuous temperature monitoring of energized equipment provides true information about the condition of the equipment while in service. The benefits of wireless online temperature monitoring are:

1. Ease of System Application. Wireless Temperature Monitoring System can be easily applied to existing power equipment. The wireless technology allows installation of the Temperature Monitoring System on existing equipment with short interruption in service. The monitoring system provides accurate measurements and consumes as little power as possible to ensure long operating life.
2. System universality. The Wireless Sensors can be used throughout a facility without any limitation to the type of equipment to be monitored. This finally would provide a universal tool to manage and control various assets. The sensors may be installed on motors, transformers, panelboards, and switchgear as well as on boilers, pipes, PC boards, air compressors, etc. In other words, such monitoring system would become a key component in asset management.

Acknowledgement

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[References]

[1] Denis Koch, Ruben Garson. "Square D Type FB4 SF6 Circuit Breaker Contact Resistance", *Minutes of the Sixty-First Annual International Conference of Doble Clients*, 1994, p. 5-6.1-5-6.19

[2] Jeffrey H. Nelson. "Electric Utility Consideration for Circuit Breaker Monitoring", *Proceedings of the 2001 IEEE/PES Transmission and Distribution Conference and Exposition*, Oct 28-Nov 2, 2002, Atlanta, Georgia, p. 1094-1097.

[3] E. Gockenbach, P. Werle, V. Wassenberg, H. Borsi. "Monitoring and Diagnosis Systems for Dry Type Distribution Transformers", *7th International Conference on Solid Dielectrics (ICSD)*, Eindhoven, Netherlands, June 2001, p.2.10.1-2.10.8.

[4] Izabelle Alexander. "Fiber-optic Temperature Measurement", *Sensors*, May 2001.

[5] Jeff Stokes and Gail Palmer. "A Fiber-Optic Temperature Sensor", *Sensors*, August 2002.