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배전반 설비의 온라인 모니터링 및 진단

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On-Line Condition Monitoring and Diagnostics of Distribution Equipment

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Abstract : Continuous on-line temperature monitoring provides the means to evaluate current condition of equipment and detect abnormality. It allows corrective measures to be taken to prevent upcoming failure. 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.

Key Words : On-line Condition Monitoring, Wireless Sensors, Contact Degradation, Thermal Failure

1. Introduction

Equipment reliability may be significantly improved through the effective prediction of equipment degradation. Condition monitoring technologies allow achieving this goal by minimizing downtime through the integrated planning and scheduling of repairs indicated by condition monitoring techniques. Conduction problems caused by loose connections or deterioration of contact surfaces result in local temperature rise, which contributes to the reduction of contact quality. Thermal runaways induced by conduction problems deteriorate insulating material and cause disruptive dielectric discharges resulting in arcing faults. 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[1]. The consequences of such faults are serious enough to justify the efforts to build a temperature monitoring system to protect electric facilities from disaster.

Temperature monitoring would provide the historic databases for new equipment design and modification. Online temperature monitoring would serve as the "missing link" between the product designers and end users with the real applications. In order to optimize and improve the design of new equipment, the design engineer has to have the feedback on how it behaves under various conditions (ambient, load).

This information is presently based on test results and simulations at testing laboratories. The on-line temperature monitoring and database of events would allow the design engineer to better analyze the equipment's response to normal and emergency conditions. Equipment specifications and ratings could be more closely coordinated to the real market needs with the main focus on reliability and cost reduction of the new designs.

2. Experimentals

The Wireless Temperature Monitoring System has been installed at one of the power plants at a large utility. which suffered multiple violent thermal failures on main breakers. The goal was to use the temperature sensors to continuously monitor temperature while the breakers are under load. The stand-alone system is able to provide warning alarms as soon as the temperature of the points where sensors are installed reaches a pre-determined level. Wireless temperature sensors have the following parameters:

· uniquely identified sensing units are built from miniature and dielectric components and operate in direct contact with the surface;

- sensors are calibrated in wide temperature range: from −0℃ to 150℃ (for outdoor applications sensors are calibrated from −40℃ to 85℃);
- transmittance intervals are based on the rate of a temperature change: signal is sent every minute at temperature rising for 3oC per minute and once in 3 minutes at stable temperature (battery life saving mode);
- Sensing units use a small coin battery as a power source; minimum battery life 5 years, typical 7−10 years, easily changeable.

Two other breakers are used as reserve. Every cell is also equipped with a sensor on the internal wall to measure temperature of the ambient air within the cell. One reading device installed in the control room receives RF signals with information about the location and temperature of each point where the sensors are installed (there are a total of 28transmitters). This information is continuously transferred from the Reader to the local PC located in the operator room and connected with a reading device via communication cable. The temperature data is continuously collected in the database and analyzed together with load data to determine any abnormalities in temperature behavior.

3. Results and Discussion

Through two years of temperature monitoring and data analysis, the normal heat distribution within the cell and temperature of finger clusters (depending on the location within the cell) was determined. The change of finger cluster temperature (Fig. 1, A) follows every increase and decrease of the current (Fig. 1, B) with very short delay (minutes). The shape of the temperature curve is very similar to that of the load, copying even minor changes of the current.

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 ℃. After one month of monitoring, the first warning signal was an observation of a very high temperature of the ambient air within the main cells. It was reaching 60 ℃ 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 ℃, which is very close to standard maximum for current-carrying parts of MV circuit breakers (105 ℃). 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.

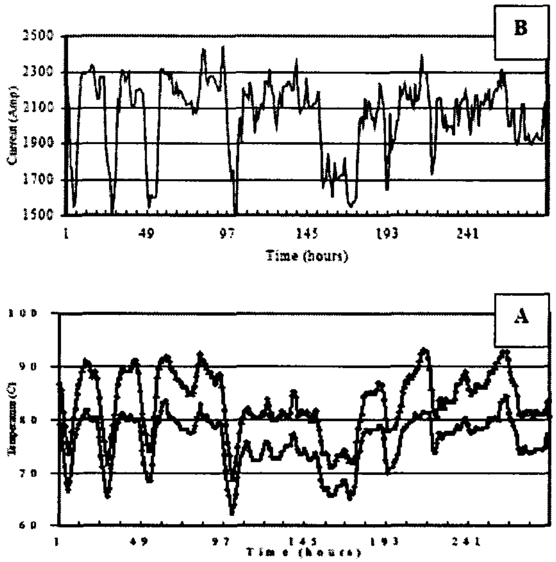

Fig. 1. Temperature (A) on Top FC of Phase A (bottom curve) and B (top curve) and Load (B).

4. Conclusion

Wireless Temperature Monitoring System provides information on the condition of power equipment, which facilitates planned maintenance and decreases downtime, and increases the reliability and availability of power equipment. Based on information available online and real-time, equipment operators could use it to make system restoration decisions after an interruption, or possibly even prevent an interruption by removing a distressed apparatus in a controlled manner.

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