Shimoichi Water Intake Station: Adoption of Surface Current Sensor to Detect Partial Discharge by Deterioration of Molded Transformer Insulation

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Keywords Partial discharge, Partial discharge detector, Surface current sensor, Insulation deterioration

Abstract

Aging high-voltage substation facilities were replaced with renewed power receiving and distribution facilities at Shimoichi Water Intake Station of Bureau of Waterworks, Nara Prefecture.

To detect partial discharge due to insulation deterioration in two 200 kVA power transformers (molded transformers), surface current sensors were attached to each transformer installed inside the panel. The insulation of molded transformers deteriorates over time even during normal operation. By attaching a surface current sensor to the transformer and diagnosing it with a partial discharge detector, it is, therefore, possible to ascertain the occurrence of partial discharge within the insulating mold. By detecting a partial discharge, it is possible to appropriately judge the progression of insulation deterioration and implement preventive maintenance.

1 Preface

In recent years, there have been risks of system failures in power equipment, such as power transformers, due to aging deterioration. In many cases, facility aging can greatly affect the health conditions of substation facilities.

Currently, it is difficult to detect insulation deterioration at an early stage, so replacement is performed at certain intervals of time. In this paper, we introduce transformer deterioration diagnosis based on partial discharge detection. This method can detect deterioration at an early stage.

2 Partial Discharges

Partial discharge is a phenomenon of partial discharge rather than a flashover between electrodes. If a defect occurs on the surface or inside of the insulation material for electric equipment or cables, a weak discharge may occur. This discharge energy accelerates the deterioration of the insulation, leading to insulation breakdown of the equipment. Fig. 1 shows the voids in transformer windings.

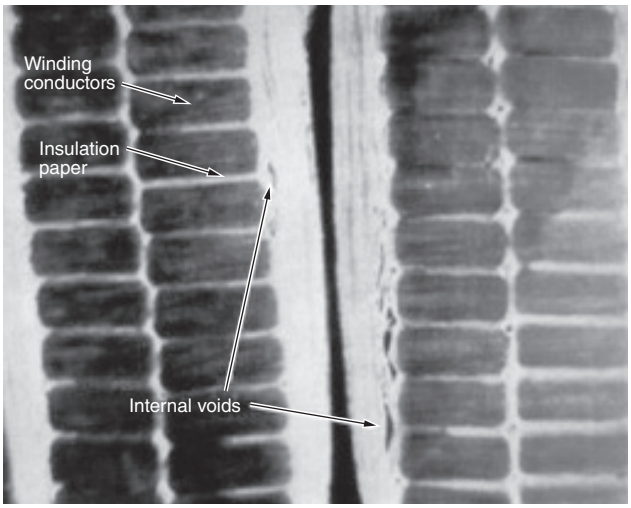

Fig. 1 Voids in Transformer Windings

Voids in transformer windings are shown. Due to presence of these voids within transformer windings, weak partial discharges may be generated. By the effect of generated discharge energy, insulation deterioration is accelerated and finally leads to insulation breakdown.

3 Method of Partial Discharge Detection

We have adopted the following three partial discharge detection methods.

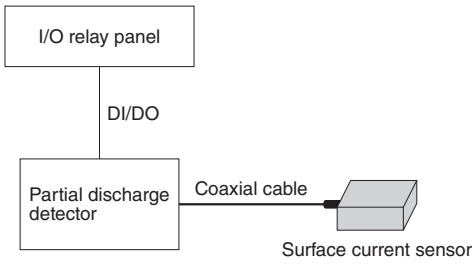

Fig. 2 **Simple Connection Diagram for Partial Discharge Detector and Surface Current Sensor**

A simple connection diagram for the partial discharge detector and the surface current sensor is shown. The partial discharge detector is a device to detect noise in electrical facility caused by partial discharges so that the sensed signal is sent to an external device. Supported by external control, the data gathered for noise detection can be transferred to external equipment. The surface current sensor is used for noise sensing.

(1) The AE sensor method

It converts the weak sound generated by partial discharge into an electrical signal and analyzes it.

(2) The electromagnetic wave method

It converts weak radio waves generated by partial discharge into electrical signals and analyzes them.

(3) The Corona Detection Camera method

It visualizes the ultraviolet rays generated by partial discharge.

The electromagnetic wave method is used to detect insulation deterioration in transformers. The electromagnetic wave method is a method of detecting leaking electromagnetic waves on the surface of a metal, whereby detecting the position of a partial discharge with high accuracy by installing multiple measuring units and measuring TOF (Time of Flight). Electromagnetic waves are reported to have a wide range of frequency components from 10 Hz to over 200 MHz. By measuring these phenomena, it is possible to detect partial discharges, which are precursors to dielectric breakdown, but since they are all weak signals, consideration must be given to local environmental noise. **Fig. 2** shows the simple connection diagram for partial discharge detector and the surface current sensor.

4 Partial Discharge Detector Based on Transient Earth Voltage (TEV) Method

TEVs are capable of high-precision measurement and are particularly suitable for partial discharge detection in power transformers and switchgears. In addition, since the structure is simple, it is inexpensive and easy to install at the site.

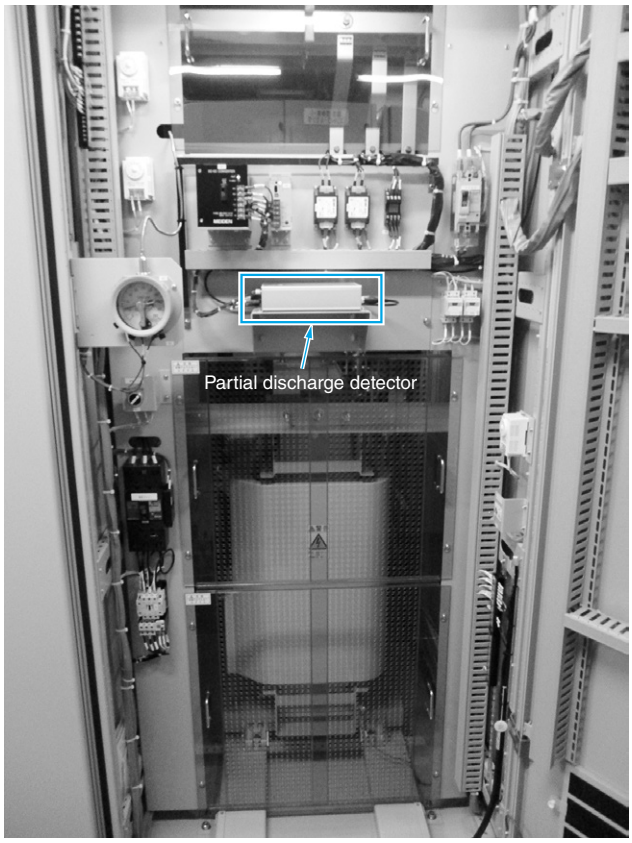

Fig. 3 **Interior View of Power Transformer Panel**

An overall view of the panel interior (front side) of No.2 power transformer panel (LA-4) for Shimoichi Water Intake Station is shown. To detect partial discharges due to insulation deterioration caused in the 200 kVA molded transformer, partial discharge detectors and surface current sensors are installed inside the panel.

5 Example of System Introduction

This section introduces the partial discharge detector delivered to Shimoichi Water Intake Station. In order to detect partial discharge due to insulation deterioration in two 200 kVA power transformers (molded transformers), we installed partial discharge detectors and surface current sensors in each transformer installed inside the panel. By attaching a surface current sensor to the transformer and diagnosing it with a partial discharge detector, it is possible to tell the occurrence of partial discharge within the insulation mold. In the field test, we measured the noise level of the on-site installation environment and set the detection threshold based on the measured noise floor level. When a “partial discharge operation” or “partial discharge equipment failure” is detected, an alarm is issued to the central monitoring system to achieve early deterioration diagnosis. **Fig. 3** shows the interior view of the power transformer panel, **Fig. 4**

Fig. 4 Partial Discharge Detector

The partial discharge detector installed inside the No.2 power transformer panel (LA-4) for Shimoichi Water Intake Station is shown.

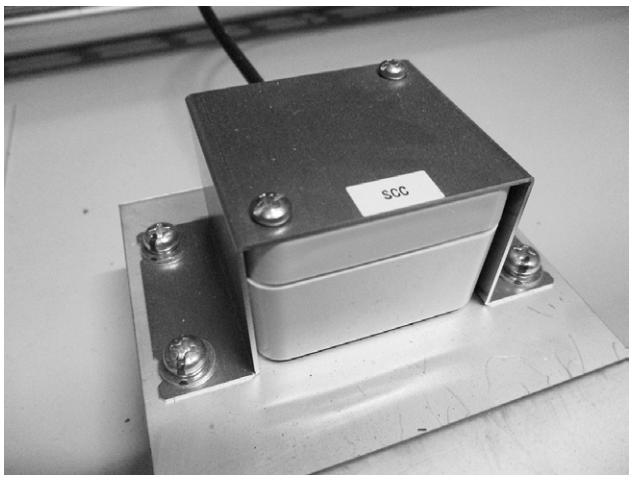

Fig. 5 Surface Current Sensor

The surface current sensor installed inside the No.2 power transformer panel (LA-4) for Shimoichi Water Intake Station is shown.

shows the partial discharge detector, and Fig. 5 shows the surface current sensor.

6 Postscript

A partial discharge detector and surface current sensor were installed in the transformer installed at the substation for Shimoichi Water Intake Station, and insulation deterioration was diagnosed. By detecting partial discharge, the progression of insulation deterioration can be determined appropriately, and preventive maintenance can be performed, whereby maintenance can be expected to improve.

In the future, we will accumulate data from partial discharge detectors and use them as a means of understanding trends in aging deterioration.