Diagnosis and Operation of Aged Transmission and Distribution Facilities

Background and Objective

Due to the recent economy in Japan, power utility companies face cost reduction issues with tremendous aged underground power apparatus as well as degradation of overhead transmission lines due to sea salt and rust over the surface of transmission towers. Therefore, maintenance cost reduction and review of maintenance strategy for aged and degraded apparatus have become more important than before. This project aims to develop diagnostic methods for high voltage XLPE power cables, large power transformers and GISs (Gas Insulated Switchgears) and their effective utilization methods and also aims to develop several decision support tools for maintenance strategies of aged power apparatus based on recent asset management technologies. The project also supports development of a diagnostic method for paint coatings of transmission tower surfaces in order to establish efficient re-coating strategies.

Main results

1. Development of diagnostic methods for power apparatus of underground power transmission and substations

We improved the method for the thermal degradation diagnosis of insulation paper in power transformers [W99033, W00031] in order to expand its applicability up to 500kV transformers. The temperature rise calculation method was improved based on experimental results. Both relationships between temperature rise of a coil and load current and between oil temperature rise and power loss have been measured as shown in Fig. 1. The improved method can estimate the paper degradation in terms of the polymerization degree within the error of ±10%. On other hand, a portable checker of layer short-circuit of a pole transformer has been developed based on FRA (Frequency Response Analysis) [H09008] as shown in Fig. 2.

We have improved the pre-breakdown voltage-cut-off method to find a water-tree as a breakdown triggering point using a new noise reduction system. We succeeded in finding a small water-tree of 0.33 mm in a long 77kV XLPE power cable for the first time in Japan as shown in Fig. 3.

We verified the effectiveness of the developed diagnostic method of a GIS with several conventional gas-absorbents. This method is based on the evolved gas analysis from a gas-absorbent system in a GIS [H09009].

2. Decision support tools for maintenance strategies of aged power apparatus

We have developed several decision support tools for maintenance strategies for power transformers, GCBs (Gas Circuit Breakers), GISs and overhead transmission lines composed of conductors, ground wires, and towers based on maintenance costs [H06014, H07013, H08011, H09010]. We provided several customized decision support tools to electric power companies.

3. Development of diagnostic method for paint coatings of transmission tower surfaces

We proposed a new electrode system composed of an aluminum foil and high viscosity electrolyte instead of a standard platinum foil and normal viscosity electrolyte to measure coating film impedance. We experimentally verified the effectiveness of the new electrode system. It can measure the impedance with almost the same accuracy as the standard electrode system as shown in Fig. 4.

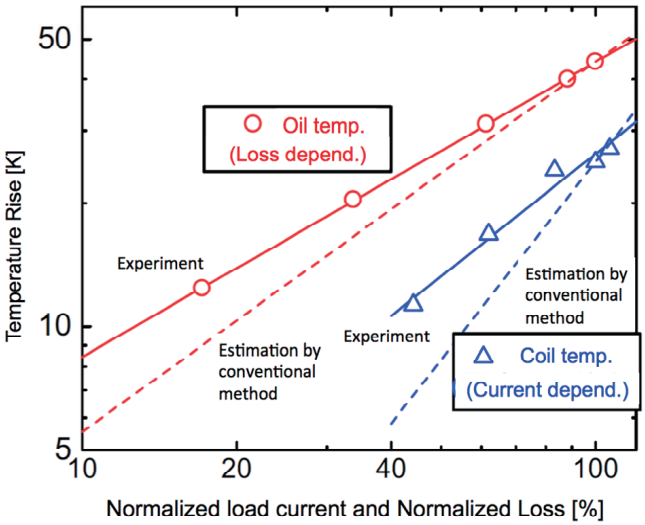

Fig. 1 Measurement results of temperature rise of a coil and insulation oil of a 60kV class transformer

Temperature rise of insulating oil and coil has significant effect on the estimation of paper degradation. It was found that conventional estimation methods give lower temperature rise than the measured ones. This information was taken into account in the new paper degradation estimation method and brings higher accuracy of degradation estimation.

Fig. 2 Portable layer short-circuit checker of a pole transformer

This checker can instantly detect layer short-circuit of a pole transformer with simple operation

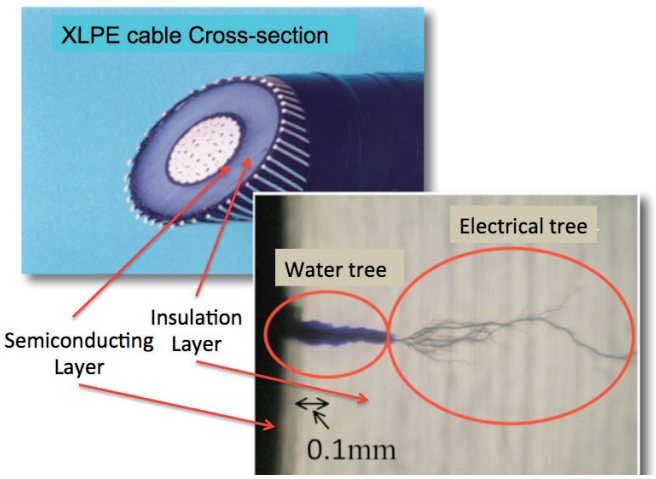

Fig. 3 Example of a small water-tree found in a removed 77kV XLPE power cable

Aged XLPE power cables of 77kV or less voltage are thought to be suffering from water-trees. To understand in detail the progress of water-tree deterioration due to aging through removed cable inspections, it is important to detect tiny water-trees. We succeeded in detecting a tiny water-tree as small as 0.33 mm from which electrical trees grew.

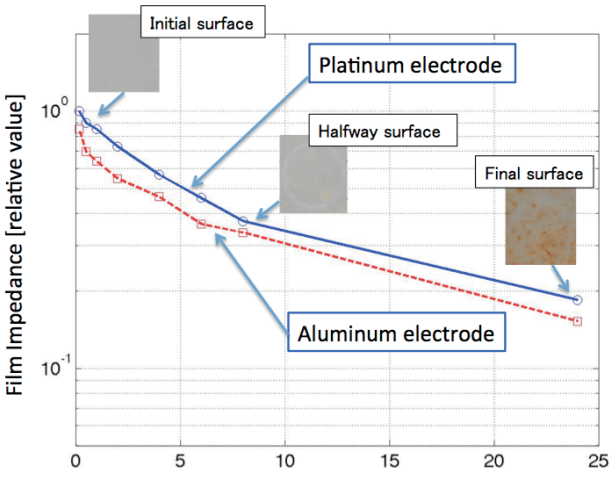

Fig. 4 Coating film impedance changes of a painted steel specimen exposed on an outdoor stand

Impedance change due to exposure time was measured using a new electrode system and a standard electrode system at 1 kHz. The new electrode consisted of an aluminum foil and high viscosity electrolyte and the standard electrode system consisted of a platinum foil and normal viscosity electrolyte. It was found that both changes agreed with each other and the new electrode was found to be usable for the measurement.