Priority Subjects with Limited Terms — **Further Improvement of Facility Operations and Maintenance Technologies**

Development of a Maintenance Scheme for Aged Power Transmission and Distribution Facilities

Background and Objective

It is predicted that a large amount of power equipment introduced in the high economic growth period will require replacement within a few decades. As such, the development of power equipment maintenance technologies for the standardization of maintenance and replacement of aged power equipment, as well as cost-effectiveness, are important.

This project provides equipment replacement planning support tools with equipment operation information and device reliability as evaluation criteria, for the sophistication of equipment diagnosis technology essential for rational maintenance control as well as to support equipment replacement planning.

Main results

1 Establishment of a strategic life estimation method of a power transformer based on the stress-strength life estimation method considering regional characteristics

Insulation paper degradation in a transformer may change due to the load history of the transformer. Moreover the stress applied to the insulation paper (mechanical force) may change due to the lightning-strike frequency and network structures. Based on the stress distributions and degradation of insulation papers in a transformer, we developed a probabilistic method to estimate the degradation of a transformer as shown in Fig. 1. A comparison is made of estimated life distribution considering conventional life estimation and stress distribution based on mechanical force reduction due to insulation paper degradation and the necessary strength found by the electromagnetic force dependent on maximum short-circuited current. As a result of this comparison, it was discovered that the estimated life of the transformer may increase as shown in Fig. 2 (H12013).

2 Clarification of cost reduction benefits of introducing the strategic life estimation method into maintenance planning of power transformers

It was discovered that life estimation of a transformer can be performed based on the power equipment management support tools using the failure history of the transformer and the lighting-strike density of the area where the transformer is located. It is assumed that Japan has been using about fifteen thousand 66kV transformers in substations of towns and cities. Based on the assumptions of 10,000 transformer and this total number remains the same, the total required cost based on the equipment replacement and diagnosis cost has been estimated with developed tools. The total maintenance cost appears to decrease by approximately 40% based on the stochastic estimation of transformer maintenance costs (H12013).

3 Collection of various diagnostic data with electric power utility companies Investigation of aging mechanism of power cables and transformers

Various diagnosis data for the actual power apparatus are essential for effective application of the supporting tools. As for the transformers and power cables, the cooperative work with power utility companies that actually operate the power apparatus is very effective to collect the diagnostic data. Presently, we have been accumulating the diagnostic data for the transformers and the power cables by on-site diagnosis and the investigation of the deterioration as shown in Fig. 3. We are building up the database for the deterioration diagnosis based on the collaborative researches and we have developed the diagnostic techniques applicable to the on-site diagnosis and to the strategic maintenance.

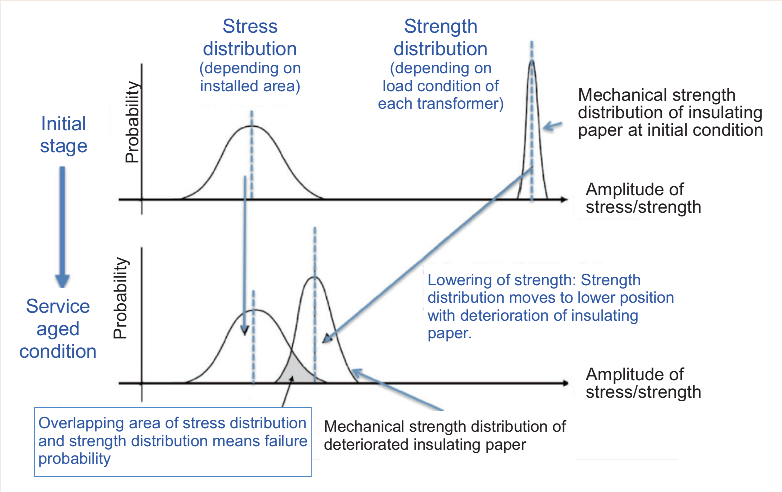
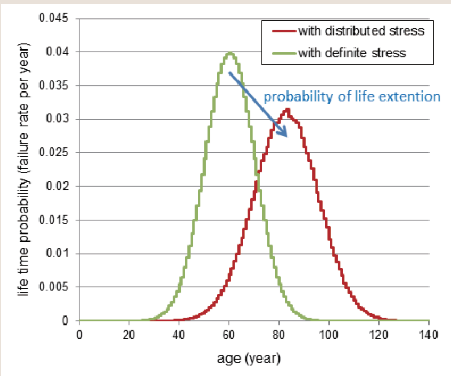
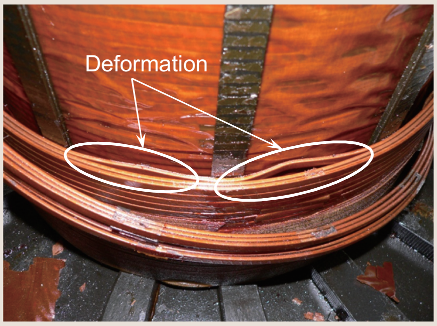


Fig. 1: The concept of stress-strength life estimation method of power transformers based on regional characteristics

The life of a transformer may depend on the overlapping of stress and strength. Normally the strength of a coil will reduce as it ages, increasing the likelihood of breakdowns. The strength of distribution transfers from the right hand side to the left hand side. On the other hand, the overlapping of stress and strength may depend on the location where the transformer is used. Therefore, maintenance personnel must evaluate life with consideration to the degree of overlapping for each transformer.

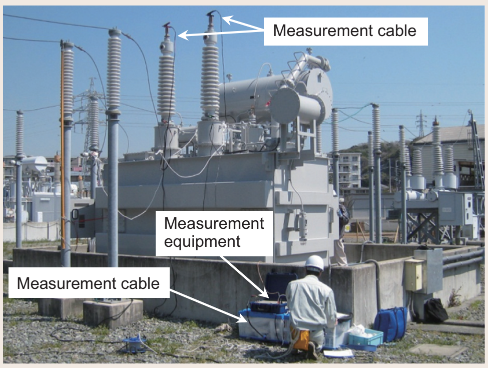




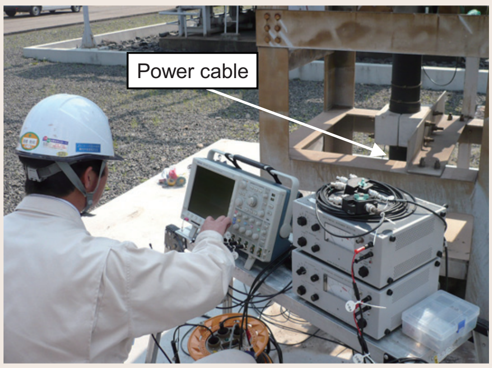
Deformed transformer winding based on the given short-circuited current (mechanical stress)

Fig. 2: Life estimation of power transformers based on the short-circuit electro-motive force (This example indicates the average life of 60 years and the standard deviation of 10 years until the average polymerization decreased to 450.)

If stress distribution is not considered, the life of a transformer will be determined by the maximum short-circuited current. However, if we assume that the maximum current of a transformer depends on the location where it is used, then the life of the transformer may increase as shown in this figure.



(a) Diagnosis of power transformer winding abnormality irradiation materials



(b) Partial discharge measurement of power cables

Fig. 3: On-site measurements at the power equipment

On-site measurements of power equipment such as transformers and cables have been performed to acquire real data.