Degradation Diagnosis for Cable Insulating Layers Using DC Current Integrated Charge Measurement Method

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ABSTRACT

In order to develop a method for diagnosing the degradation of solid insulation materials for cables, an evaluation method was attempted by measuring a partially heated cable sample using the DC current integrated charge method; Q(t) method. Even if age-related degradation occurs in solid insulation materials for cables, it is difficult to ascertain the state of degradation and to identify the location where it occurs. On the other hand, the Q(t) method is relatively easy to measure even for cable-shaped insulating materials and is a promising method for evaluating insulation properties. In this method, the partial heating method, in which only a part of the cable is heated for measurement, is expected to be a method that enables the evaluation of installed cables with relatively low voltage application and makes it possible to identify the degradation points. In this study, the Q(t) method by partial heating was applied to a partially thermally degraded sample to investigate whether the degradation state could be determined by applying a relatively low voltage. As a result, it was shown that the measurement results obtained by partial heating of the thermally degraded part were different from those of the undegraded part and that it is promising for use in the diagnosis of actual cables.

KEYWORDS

Cable insulating layer, DC charge integral charge method (Q(t) method), Partial heating method. Degradated position identification

INTRODUCTION

In general, it is difficult to determine the degradation status of the insulating materials of installed cables. Still, the development of diagnostic techniques is desired, as cables beyond their service life may lead to dielectric breakdown caused by insulation degradation. The DC current-integral charge method (hereafter referred to as the Q(t) method) [1], which we have developed, can be applied to insulation materials in the cable shape. There are actual examples where the insulation properties of insulation materials, such as cables containing water trees [2] and gamma-ray irradiated cables [1], were evaluated. In the insulation estimation using the Q(t) measurement, the results generally show differences in the state of insulating materials when excessive DC voltages are applied to the test samples. However, applying an excessive DC voltage to the equipment should be avoided for safety reasons. Furthermore, the application of high DC voltage for diagnosing AC cable may induce the accumulation of the space charge, which is usually not accumulated in AC usage. It means that the high DC voltage application may cause deterioration of the material's insulation properties and should therefore be avoided. The partial heating method [3] was therefore devised. Usually, the current flowing through the insulating material increases with the applied DC voltage and the temperature at which the voltage is applied. Still, because the temperature dependency of the current is higher than the dependency on the applied voltage, an increase in temperature within the permissible temperature range leads to an increase in sensitivity of the Q(t) method due to the large current flow, and it has already been reported [5]. Even if the part of the cable in which the temperature is increased is short in relation to the total cable length, the large current flow due to the temperature increase should enable the evaluation of the characteristics of the heated part. Furthermore, if the current in the heated section is dominant in the measured values, it can be expected to identify the degraded position by performing measurements at different measuring sections. Therefore, in the present study, cable samples with partially thermally degraded insulation materials were tested using the partial heating Q(t) method. It was confirmed that the measurement sensitivity could be improved and the position could be identified, and this is reported.

SAMPLES AND EXPERIMENTAL PROCEDURE

Samples

In this study, the same kind of cable as the past investigated one was used [3] to compare previous results. The used sample is a commercially available four-core power-supply cable (2PNCT 5.5 mm^2, Mitsuboshi Co., LTD.). The main insulating material for the wire is EPR (ethylene-propylene rubber). The cable is usually used for driving a motor, and the power source is connected to the motor using the cable. From the products catalog for the cable, it can be available at temperatures below 80°C. The maximum working voltage is 600 V_{rms} from the catalog. In the cable, the conductor is insulated using an ethylene-propylene rubber layer, and the thickness of each insulating layer is 1 mm. The length of the test cable for the measurement was 2 m. In the Q(t) measurement, a dc voltage was applied to a core conductor of the cable, one other conductor was connected to a detection capacitance of the Q(t) meter, and the other two cores were electrically floated by disconnection. The floating conductors were insulated using insulating tape to prevent flashover. In the Q(t) measurement, an integrated charge of the conduction current passing through the sample cable is observed by

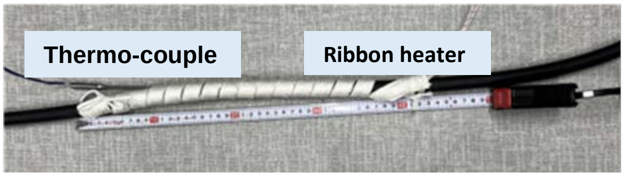

Fig. 1: Cable sample with a ribbon heater and a thermo-couple.