ELECTRICAL AND TEMPERATURE CHARACTERISTICS OF POLYMER SURGE ARRESTER WITH THERMAL MECHANICAL STRESS AND MANUFACTURING CONDITIONS

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Abstract: This paper describes the multi-ageing, temperature characteristics and thermal mechanical test with the structure of surge arresters for distribution system.. The multi-ageing test results showed that there is no evidence arresters were degraded. In temperature characteristics tests, three types of polymer housed arresters exhibited almost the same leakage current value below 100℃, but above 100℃, the polymer housed arrester whose module was injected into polymer housing with the grease exhibited the highest leakage current. In contrary, In contrary, the arrester manufactured by directly injecting silicone rubber onto the arrester module exhibited the lowest leakage current. The rapid rising of leakage current of the polymer housed arrester with the grease at 120℃ was because of the grease between the FRP(fiber reinforced plastics) module and the silicone rubber housing. All polymer hosed arresters exhibited the same surface temperature characteristics but the ceramic housed arrester was slower than the polymer housed arresters in heat emission despite the lowest leakage current. In the moisture ingress test by thermal mechanical test, the reference voltage was little changed and the leakage current showed slight changes.

1. INTRODUCTION

In the power system, the arrester is used to protect lines and electrical devices from surges and overvoltage. As a result of many studies, lightning faults have been reduced with the improvement of the performance and the economic efficiency of the arrester [1].

In the recent accelerated aging tests of polymer arresters for distribution, their internal and external aging characteristics were evaluated through diverse diagnostic techniques, including the international-standard IEC 60099-4 arrestor test, the salt spray test, the multi-aging test, the secular variation test, and the temperature cycle test based on IEC 61109. The arresters that were used in these tests were manufactured in diverse forms, and showed diverse aging tendencies according to their structural differences [2-3].

A normal voltage is applied to the arrester and a low leakage current flows through it. The arrester absorbs the overvoltage caused by lightning strokes or line faults, due to which the temperature of its element rises. When this happens, the leakage current through the arrester continues to flow even after the line is restored to its normal state. With the passage of time, the temperature of the arrester element is restored to its normal level, and the leakage current decreases. The high temperature caused by the abnormal voltage needs to be restored fast, however, to improve the life of the arrester.

2. EXPERIMENTAL SETUP

2.1. Manufacture of polymer arresters

After the ZnO varistor element and corn disk were arranged to reduce the displacement between the upper and lower electrodes of the polymer arrester, an arrester module was manufactured using the filament winding method. This arrester module was classified as shown in Table 1. Types 1 and 2 were classified into the dry type and the wet type according to the existence of grease as a sealant at the interface for the insertion of the arrester module, and type 3 was a single body type wherein silicon rubber was directly extruded into the arrester module. The porcelain arrester was prepared for comparison with the polymer arrester. Fig. 1 shows the polymer and porcelain arresters. The leakage distance and the overall length of the insertion-type specimen were 665mm and 247mm, respectively; and those of the single body type were 718mm and 274mm, respectively. These figures show that the single body type had a slightly longer leakage distance and overall length than the insertion type.

2.2. Multi-ageing test

The chamber for the multi-aging test was 10 ㎥ (2×2×2.5m) big, and its interior was manufactured with stainless steel. Using a transformer, the maximum continuous operating voltage of the 18kV arrester for power distribution, 15.3 kV, was applied to each specimen. Based on the cycle stipulated in IEC 61109 Annex C, which involves the multi-aging environment, the aging parameters, including the precipitation, drying, salt fog, humidity, and voltage application, were determined. The precipitation was extended by three hours from that in Annex C, considering the rainy season in summer, and the temperature in the drying parameter was set at 70°C, up by about 20°C. Salt spraying was performed at a conductivity of 4,000µS/cm, which was lower than the 16,000µS/cm that is recommended in Annex C. Fig. 1 shows the one-day (24-hour) multi-aging test cycle. The multi-aging test was limited to the polymer arrester, and the aging state of the arrester was checked by measuring the AC leakage current and the reference voltage before, after, and during the test.

Table 1: Test setup parameters seen in

Samples	Houshing	Manufacture	Remark
Arrester 1	Polymer	Insertion	Dry
Arrester 2	Polymer	Insertion	Wet
Arrester 3	Polymer	Single body	Injection
Arrester 4	Porcelain	Bushing	-

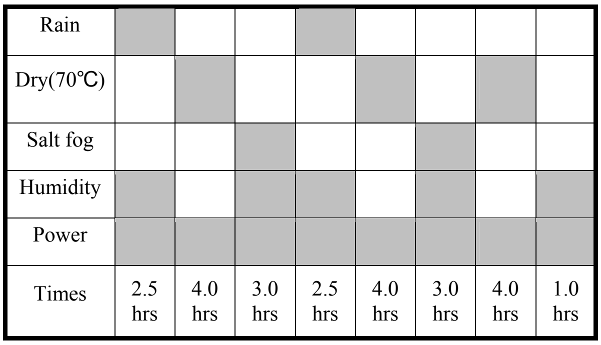

Figure 1: cycle of multi-ageing test.

2.3. Temperature & leakage current tests

To measure the change in the leakage current according to the temperature of the polymer and porcelain arresters, the arrester was positioned at a place where the temperature of the thermostat rose up to 300°C, and the leakage current was measured by varying the temperature from the normal temperature to 120°C at 20°C intervals. The maximum continuous operating voltage (MCOV) was applied with a high AC voltage application device, and the overall leakage current of the arrester was observed using an AC current detector.

To examine the thermal release and temperature characteristics of the arresters, each arrester was placed in the 120°C thermostat for two hours and then in the air, after which the changes in their leakage currents and surface temperatures were checked under MCOV with the passage of time.

2.4. Thermal mechanical test

The moisture ingress test of the arresters was performed according to the thermal mechanical test presented in IEC 60099-4. It was performed within a temperature range of normal to 70°C, in a chamber with the same size as that in the multi-aging test, for four load directions (0°, 180°, 270° and 90°), with two hours as one cycle. A mechanical load of 100kgf was applied to the specimen, which was the cantilever load of the insulation hanger of the polymer arrester for distribution. The internal humidity of 50%, which is 40-80% of the typical humidity in summer, was maintained. Fig. 2 shows the load and temperature cycle of the moisture ingress test.

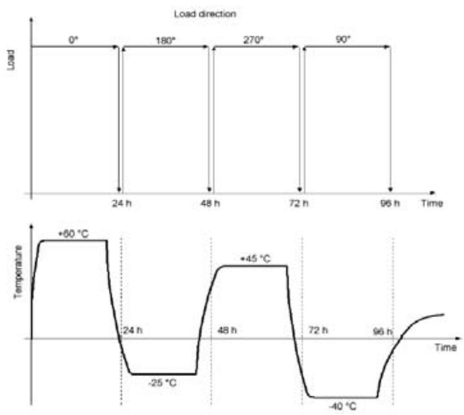

Figure 2: Cantilever load and temperature cycle of thermal mechanical test.

3. RESULTS

Fig. 3 shows the change in the overall AC leakage current during the multi-aging test with the polymer arrester specimens 1-3. The leakage current was measured with an arrester leakage current program that uses Labview. The effective leakage current that flowed through each specimen was 190-230[㎂] at MCOV. There was no change in the leakage current during the multi-aging test according to the arrester structure, and there was no aging in the arrester specimens even after 1,000 hours.

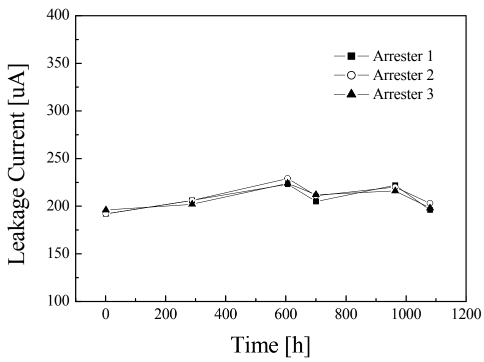

Figure 3: Variation of leakage current during tests.

During the multi-aging test shown in Fig. 4, the reference voltage likewise did not change according to the arrester structure, and no aging was observed before and after the test. To evaluate the results of the multi-aging test and the moisture ingress test, AC and DC leakage current measurement, PD measurement, and third harmonic current measurement are typically used, among which the AC and DC leakage current measurement is known to be the best method. According to this study, the single-body-type arrester has the best characteristics. It has been reported that it has better characteristics when there is less air inside.

IEC 60099-4, which is the international arrester standard that is widely accepted in and out of Korea, does not include the multi-aging test of the polymer arrester. Recent study trends show, however, that the multi-aging characteristic of the arrester is generally examined based on the polymer suspension insulator standard IEC 61109. It is expected that the multi-aging test that was applied to the polymer insulation material will also be applied to the arrester, and that more diverse methods will be used to examine the aging characteristic of the arrester.

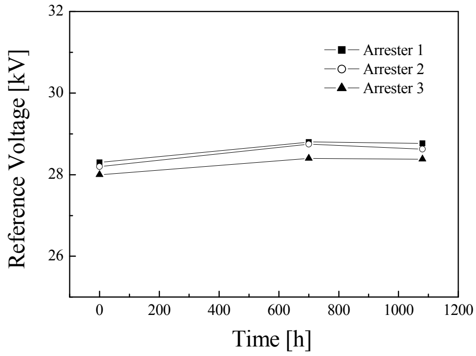

Figure 4: Variation of reference voltage during tests.

The arresters that underwent the multi-aging test were kept in an indoor temperature condition for a long period (more than three months), and the temperature characteristic test was performed with the porcelain arrester to examine the temperature characteristic according to the arrester structure.

Fig. 5 shows the overall leakage current of specimens 1-4 at each temperature with respect to the continuous operating voltage of the arrester. As shown in the figure, the polymer arrester specimens 1-3 showed almost the same leakage current up to 100 □ because they used the ZnO varistor element of the same manufacturer. The porcelain arrester specimen 4 had a lower leakage current than the ZnO varistor element in the polymer arrester. This depended on the electrical characteristic of the ZnO varistor element, regardless of the arrester characteristic. The leakage currents at the MCOV of the arrester were 176, 177, 178 and 161 ㎂, respectively, under a normal temperature condition.

Specimens 1-3 had significantly different leakage currents at a temperature of 120°C. The wet/insertion type had the highest leakage current, followed by the dry type and the single body type. When the ZnO varistor element and all its parts were identical, considering that there was a difference in the interface between the arrester module and the silicon housing, it seemed that the thermal release and absorption varied with the structural characteristic of the interface and with the increase in the temperature. The polymer arresters showed similar leakage current values at around 280 ㎂ at 100°C, and the values for specimens 1-3 were 380, 450, and 351 ㎂, respectively, at 120°C. The significant increase in the leakage current of the wet/insertion-type arrester indicates that this arrester is hardly influenced by the leakage distance and the overall length of the arrester housing. Because many studies on the multi-aging test emphasized the excellence of single-body-type arresters and most manufacturers of arresters that are used for power stations, substations, and transmission lines adopt the single-body structure via the direct extrusion method, it was expected that single-body-type arresters for distribution would also have excellent characteristics, including tightness, moisture absorption, and temperature.

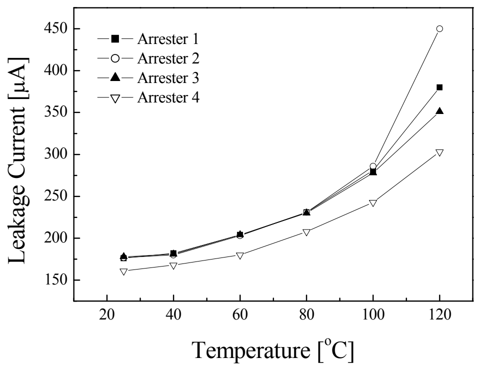

Figure 5: Leakage current with temperature.

4. CONCLUSION

1) The multi-aging test was performed on the polymer arresters. Aging was not found in all the specimens before and after the test, which showed no change in the overall AC leakage current and the reference voltage.
2) The polymer arrester specimens 1-3 showed similar leakage currents regardless of their manufacturing method at a 100°C or lower temperature, but showed a decreased current at a 100-120°C temperature. The highest leakage current decreased in the wet/insertion type, followed by the dry/insertion type and the single body type.
3) It seems that the leakage current of the wet/insertion-type polymer arrester increased at 120°C because it was influenced by the grease between the arrester module and the polymer housing, which was used to improve the tightness and the working convenience during the manufacture of the arrester.
4) In the thermal mechanical test, the displacements of the specimens were 47 mm, 50 mm, and 57 mm by the horizontal load in the directions of 0° and 90°. The residual displacement after the removal of the load was 2-3 mm.

5. REFERENCES

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