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파라미터를 이용한 LDPE 절연열화 과정의 수명예측

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A LIFE PREDICTION OF LDPE DEGRADATION PROCESSING USING PARAMETERS

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Abstract - Our studies diagnose insulation degradation using the method of computer sensing system, which has the advantages of PD(partial discharge) and AE(acoustic emission) sensing system. To use advantages of these two methods can be used effectively to search for treeing location and PD in some materials. In analysis method of degradation, using statically operator such as the center of gravity (G), the gradient of the discharge distribution(C), we have analyzed for the prediction of life which we can be obtained the time, occurred of many pulse of small discharge amplitude.

1. Introduction

PD is an important means of testing the reliability of HV cables, transformers, insulators, etc. Throughout the years, a large amount of work has been done on the degradation of insulating materials caused by PD occurring at various defects in the polymer insulator itself and at the interfaces between electrodes and the insulating materials. Specially, internal voids in insulators give rise to partial discharges, which cause local breakdown and even entire insulation breakdown.

Treeing due to PD is one of the main causes of breakdown of the insulating materials. Recently, the necessity for establishing a method to diagnose the aging of insulation materials and to predict the breakdown of insulation has become important[1]. We studied the deterioration process of insulating materials due to the electrical treeing by using a complex system.

We developed a complex system which has the advantages of PD measurement system and A.E system. The advantages of A.E system are : adaptability to non-transparent materials and complicated electrode arrangements, immunity to electrical and magnetic interferences, and the possibility for real time observation of tree propagation.

The advantages of electrical charge detection method are : absence of the influence of noise and its direct correlation to the goodness of high voltage apparatus insulation. The advantages of these two methods can be used to search for a treeing location in some materials.

We can be examined the middle stage of insulation and small group of discharge used the new parameters G and C, which shows the relation between pulse number graph and amplitude graph by method of least squares, predicted the time to breakdown in the early stage of aging when arise to small group of discharge by the discharge measurement, such as discharge magnitude, pulse number, S, K[2,3]. After look for Parameters, we have analyzed for the prediction of life which we can be obtained the time, occurred of many pulse of small discharge amplitude.
The illustration of parameters is shown in Table 1.

Table 1. The illustration of parameters

parameters	illustration of parameters
S	skewness(asymmetry of a distribution)
K	kutosis(sharpness of a distribution)
G	cener of gravity
C	the gradient of the discharge distribution
PDA	average pulse amplitude of partial discharge
PDN	average pulse number of partial discharge
AEA	average pulse amplitude of acoustic emission
PDA_S	skewness of average pulse amplitude of partial discharge
AEA_S	skewness of average pulse amplitude of acoustic emission
PDN_S	skewness of average pulse numbers of partial discharge
AEN_S	skewness of average pulse numbers of acoustic emission
PDA_K	kurtosis of average pulse amplitude of partial discharge
AEA_K	kurtosis of average pulse amplitude of acoustic emission
PDN_K	kurtosis of average pulse numbers of partial discharge
AEN_K	kurtosis of average pulse numbers of acoustic emission

2. Electrode system and experimental procedure

Low density polyethylene(LDPE) specimens were used in this work to observe the tree growth. The electrode system is shown in Fig. 1.

A stainless steel needle was molded in pellet. The size of the LDPE specimen is $30\times40\times3.5[mm^3]$. A stainless steel needle with diameter of about $0.56[mm\varphi]$ was used for the upper electrode, the tip curvature radius made by etching method was $10[\mu m]$ and the bottom of the specimen was coated with conductive Sliver Paste. The distance between the needle tip and the bottom was 2[mm]. The applied voltage was 10kV AC.

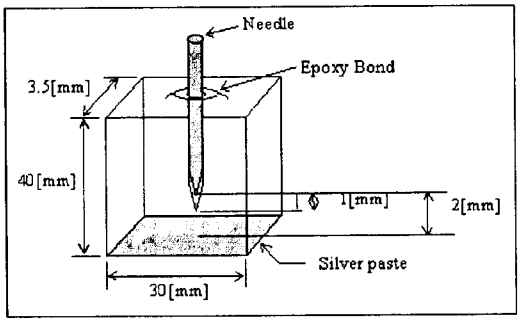

Fig. 1 Electrode composition

Schematic diagram of measurement system is shown in Fig. 2. The acoustic sensor was used PZT converter which has resonance frequency at 480[㎑], it setted up the place where was exactly below at 2[㎝] against a plane electrode, then the original signal of acoustic itself was so weak that we amplified using the differential amplifier about 80[dB], and used the High Pass Filter of 80[㎑]. The system eliminated the noise of maximum to the design, a threshold level obtained sure acoustic signal to 0.003[V] the amplified signal.

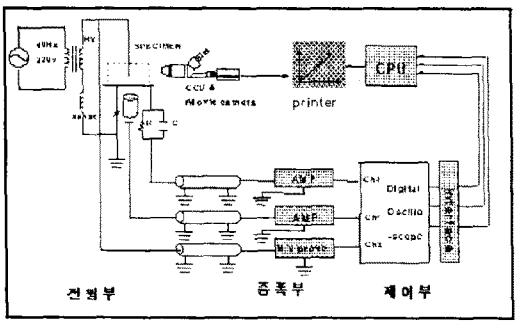

Fig. 2 Schematic diagram of measurement system

The partial discharge detection system to manufactureby oneself is applied to the voltage the same methods, the applied voltage frequency is eliminated using the High-Pass Filter.

In order to see a phase-angle characteristics, the applied voltage is inputted channel 3 of Digital-Oscilloscope (HP54501) to drop the voltage by High-voltage Probe(HP 34300A) and then we measured simultaneously with system which complexity connected acoustic-emission with partial discharge detection system. The acoustic emission pulse which passed the amplifier obtained the phase and pulse magnitude information of each pulse by transferred to the PC through an interface to input channel 1 of Digital-Oscilloscope the pulse in a period of the applied voltage through synchronized process.

Partial discharge pulse which done filtering is transferred to the PC through an interface to input channel 4 of Digital-Oscilloscope in the same method.

The values of electrical charge amplitude and A.E. pulse amplitude were measured at 44 phase angle regions in every cycle of the applied voltage for 3 minutes. The three-minute average values at each phase angle region were used for establishing the correlation [2,3,4,5].

3 . Experimental results and discussion

3.1 Breakdown prediction by G, C parameters

In this paper,we investigated the validation of breakdown prediction, defined the G-parameter(center of gravity)and C-parameter(the gradient of the discharge distribution), appeared the shape of PD as parameters. The discrimination standards of breakdown prediction by parameters will be occurred the minor of discharge when G-parameter was increased and C-parameter was reduced, then will be presaged phenomenon[6].

Because of the thin specimen, the data by experimental results was predicted the breakdown to the standards its values to think that the specimen comes to the breakdown at the short-terms after the tree was occurred to the small group of discharge.

As the figure 3 is presented to the graphy the time variation of G-parameter between PDA and PDN, it is occurred that the first the small group of discharge between 7 to 10 in the graphy, then will be predicted the breakdown based on the Regression Analysis used parameters of various kinds.

According to the degradation progressed, the small group occurred more several times considered that it was independent of the discharge each and every branch to be wide the area of degradation, and as the g-parameters reduced and the C-parameters increased,there was the results verified the be appeare the middle of degradation.

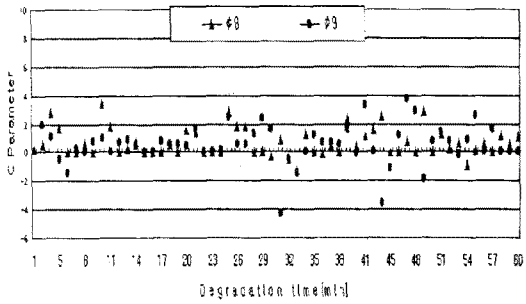

Fig. 3 The variation of C-parameter between PDA and PDN in each phase(no void)

As the figure 4 is presented to the graph the time variation of C-parameter between PDA and PDN, such as figure 3 the phase region is presented C-parameter between 8 to 9, it is verified to reduce C-parameter value between 7 to 10 in the graph.

This is showed contrast well with comparing to the G-parameter. Therefore it is possible for us to breakdown prediction by reduce of C-parameter at the presage of breakdown in this figure. Though C-parameter and G-parameter are the parameter for grasp the small group of the same discharge, C-parameter abounds the case to clearly indicate the small group than G-parameter.

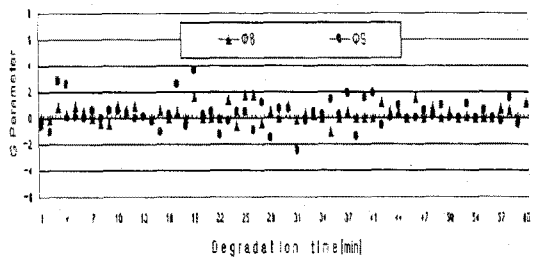

Fig. 4 The variation of G-parameter between PDA and PDN in each phase(no void)

3-2 Lifetime Prediction by Regression Analysis Method [5]

In this paper, we have predicted lifetime of insulator by regression Analysis Method with parameters and time correlations of obtained data(20 results) of which 7 to 10 minutes after voltage applied and the time when breakdown is occurred.

And then, reasons of using parameters of which 7 to 10 minutes after voltage application are as follows ;

(1) As a result of experiment, although same specimen each of them has different lifetime when the breakdown is occurred. Therefore various parameters are used efficiently to predict the breakdown.

(2) After shortly voltage applied, there are many different discharge characteristics come out due to condition of specimen, temperature, humidity and etc. and so, discharge characteristics are varied randomly. But the transient state of directly after discharge changes into steady state nearly 7 to 10 minutes after voltage applied. Hereafter we will abbreviate following terms which lifetime deeply concerned i. e. PDA, AEA, PDA_S, AEA_S, PDN_S, AEN_S, PDA_K, AEA_K, PDN_K, AEN_K.

Figure 5 and 6 illustrate correlations between lifetime and statistical magnitudes according to regression analysis method. In these figures, PD pulses relate to lifetime correlate with positive and high PD pulses mean that specimen lifetime is short. They also show that skewness S has positive correlations with lifetime. Because the electrode system used in this experiment has phase characteristic which seated distribution shape, skewness S should have positive values. Therefore, the higher skewness of distribution, the lower S. As mentioned above, the relations of them have positive correlations but the significance of them is that the higher skewness of distribution, the shorter lifetime.

(a) The statistical magnitudes of PDA with lifetime according to regression analysis method

	coefficient	standard error	t-statistical quantity	p-value
Y-intercept of regression curve	58.339868	9.5471939	6.110682	0.000176838
gradient of regression curve	-0.3127918	0.2685119	-1.164908	0.274002644

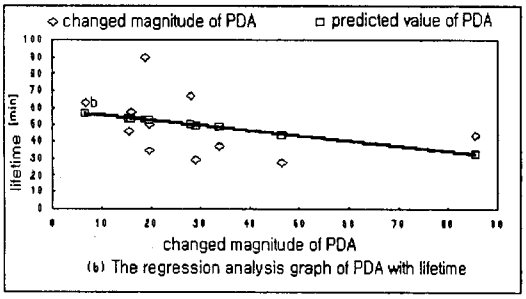

Fig. 5 The statistical table(a) and graph(b) of correlations between PDA and lifetime according to regression analysis method (no void)

(a) The statistical magnitudes of the skewness of PDN with lifetime according to regression analysis method

	coefficient	standard error	t-statistical quantity	p-value
Y-intercept of regression curve	58.339868	9.5471939	6.110682	0.000176838
gradient of regression curve	-0.3127918	0.2685119	-1.164908	0.274002644

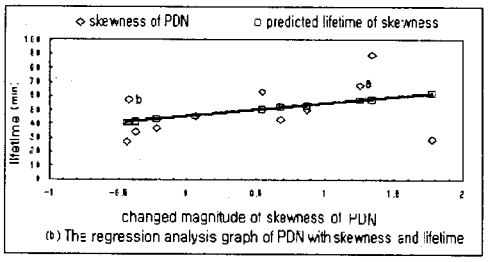

Fig. 6 The statistical table(a) and graph(b) of correlations between the skewness of PDN and life time according to regression analysis method (no void)

The first regression analysis formulas are as follow, respectively ;

$$L_1 = 58.33987 - 0.3128PDA \quad (1)$$
$$L_2 = 45.00793 + 9.28631PDN_S \quad (2)$$
$$L_3 = 50.5668055 + 1.67246PDA_S \quad (3)$$
$$L_4 = 65.222261 - 3.05717PDN_K \quad (4)$$
$$L_5 = 53.4977531 - 0.4703757PDA_K \quad (5)$$
$$L_6 = 49.8543802 + 0.97228886AEN_S \quad (6)$$
$$L_7 = 50.40207862 + 2.305954AEN_K \quad (7)$$
$$L_8 = 51.3389 - 0.33596AEA_K \quad (8)$$

Examples of predicted lifetime with those formulas are listed in Table 2. Actually measured lifetime of (a) and (b) are 67 minutes and 63 minutes, respectively, and refer these results to predicted lifetime using formulas (1) to (8). Considering results from comparing measured lifetime with predicted one, the values predicted by PD pulses were relatively agreed to the others well and although values have some differences in their results from actual values, regarding on additional accumulation of data in the future it seems that there is a possibility to progress accuracy of lifetime prediction. And it is expected that a proper prediction of lifetime at the very beginning of degradation will have effect being carried out degradation diagnosis.

Table 2 Predicted lifetime by regression analysis method

	a	b
actually measured lifetime (Life[time])	67	63
predicted lifetime(PDA)	50	59
predicted lifetime(PDN_S)	57	51
predicted lifetime(PDA_S)	46	48
predicted lifetime(PDN_K)	51	52
predicted lifetime(PDA_K)	49	63
predicted lifetime(AEN_S)	49	59
predicted lifetime(AEA_S)	43	56
predicted lifetime(AEN_K)	50	50

4. CONCLUSION

We have obtained as follows results using the complex system of partial discharge detection system and acoustic emission detection system which were developed by ourselves, respectively, in automating measurement on degradation of LDPE with degradation diagnosis and lifetime prediction.

1. C and G parameters for lifetime prediction

(1) The standard of the breakdown prediction using parameters is that small group of discharge appears when the value of G goes up and just then the value of C goes down, we could find that it is forecasting appearance of breakdown.

(2) And also, when the value of G goes down and the value of C goes up, we could predict that it seems to be middle aged degradation.

2. Lifetime prediction using regression analysis method

(1) Actually measured lifetime of (a) and (b) are 67 minutes and 63 minutes, respectively, considering results from comparing measured lifetime with predicted one, the values predicted by PD pulses were relatively agreed to the others and although values have some differences in their results from actual values, regarding on additional accumulation of data in the future it seems that there is a possibility to progress accuracy of lifetime prediction.

(2) It is expected that a proper prediction of lifetime at the very beginning of degradation will have effect being carried out degradation diagnosis.

5. REFERENCES

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