PD Occurrence Characteristics according to Voltage and Time in Solid Insulator

Sung-Hee Park*, Dal-Woo Shin*, Kee-Joe Lim*, Young-Guk Park and Sung-Hwa Kang*****

Abstract - The occurrence of partial discharge (PD) in solid dielectrics is very harmful because it leads to the deterioration of insulation by electrical, chemical, and thermal reactions as a combined action of the discharged ions bombarding the surface and by the action of chemical compounds that are formed by the discharge. Consequently, if any defects are present in the solid insulation system, performance decreases until the system breaks down. Therefore, removing or suppressing the defect is very important. Voids are a typical defect in the solid insulation system and are very harmful because they deteriorate insulation. As a basic step, studying the properties of PD in voids is important because an accurate knowledge of these properties is required to estimate the deterioration of voids. In this paper, the correlation between the size of voids and internal PD is discussed as a function of the time of the applied voltage and its magnitude. Magnitude, repetition rate, average discharge power, and average discharge current of PD in specimens with large voids were found to be larger than the others in this experiment. The smaller specimens had voids when the magnitude and number of PDs were reduced.

Keywords: Partial discharge(PD), solid dielectric, inception voltage, void

1. Introduction

Solid dielectrics have good insulation properties. However, when a void occurs in bulk, the electric field needs to be reinforced. Dielectric strength becomes degraded at this point and breaks down [1–3]. Thus, detection and classification of defects in solid insulation system are important [4–6].

Voids are the most common defect in a solid insulation system. Because of internal voids were deteriorated internal PD of solid insulation system to generate. It is important to study the characteristics of the relationship of PD and voids [7].

2. Experiment

The specimens used in the study consisted of three LDPE sheets. The size of sheets is 80×80 mm^2 and the thickness is 1mm. The LDPE sheets were hot-pressed with a void sheet within two side sheets by 110℃. The diameters of the voids were 1mm, 2mm and 3mm, and the height was 1mm.

The PD inception voltage, v_i, was defined. The PD inception was influenced greatly by electric strength and the arrangement of defects in the actual field. Though the same voltage was applied, the electrical stress across the specimens varied. The same conditioned specimens had different PD inception voltages. So PD was defined as the inception voltage, v_i, i.e., a voltage having PD pulses over 5 pC. Applied voltages were 1.0 v_i, 1.1 v_i, 1.2 v_i, and 1.3v_i.

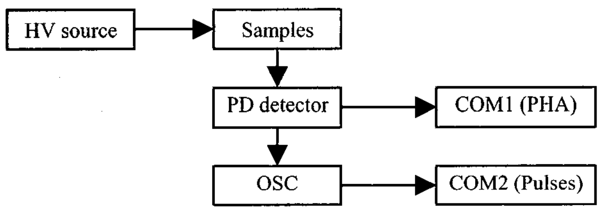

Fig. 1 needs a caption.

3. Results

Fig. 2 shows examples of PD pulses of 2mm void specimens. The pulses are superimposed for five cycles. The magnitude of PD pulses in voids is s normalized with a value of 0.5, and the number of pulses is about 150n/sec. The PD pulses occur at applied voltage phases 45°–60° and

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225°–260°, and the average phase angle was 50°, 225° for each half cycle.

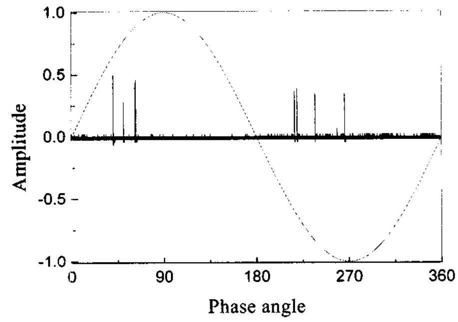
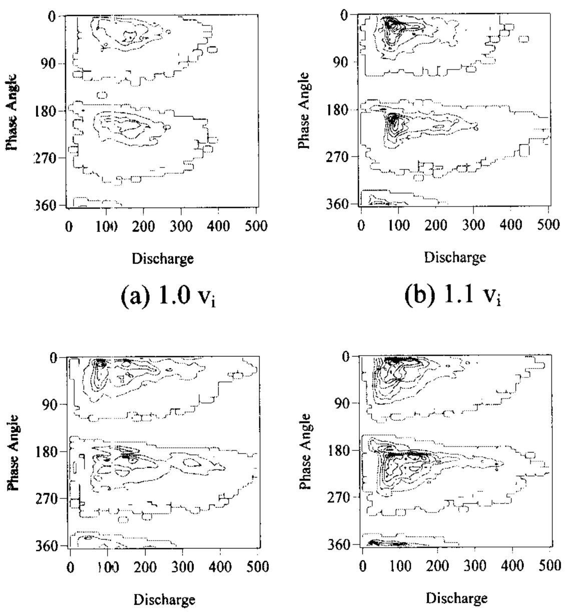


Fig. 2 Examples of PD pulses of 2mm-void specimens.

Fig. 3 shows the average Φ - q - n patterns of 3 ㎜-void specimens as a function of applied voltage. The PD pulses are detected for 300 cycles. The data have an average value of 20 specimens. In the figure, each contour line has 0.5 PD pulse.



(a) 1.0 v_i (b) 1.1 v_i

(c) 1.2 v_i (d) 1.3 v_i

Fig. 3 Average Φ - q - n patterns of 3mm-void specimens as a function of applied voltage.

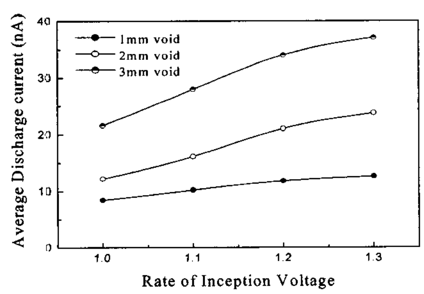


Fig. 4 ADC of PD pulses as a function of applied voltage.

Figs. 4, 5, and 6 show the average discharge current (ADC), average discharge power (ADP), and peak discharge (PED) of PD pulses as a function of applied voltage. The parameters increase as voltage is applied. The parameter's rate of increase is greatest in the 2mm void specimen.

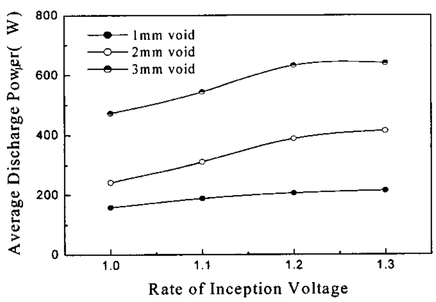


Fig. 5 ADP of PD pulses as a function of applied voltage.

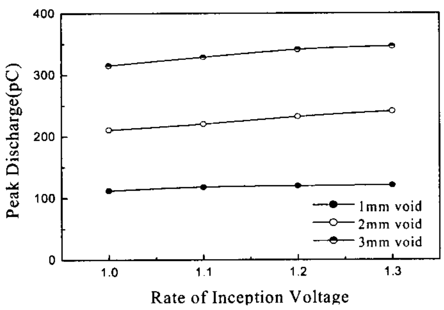
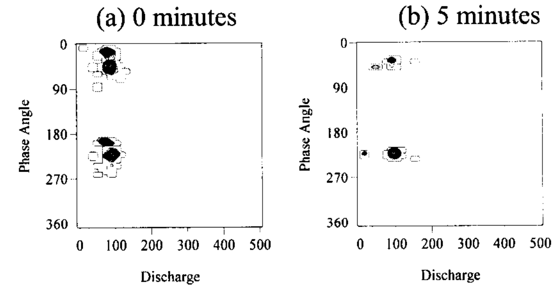


Fig. 6 PED of PD pulses as a function of applied voltage.



(a) 0 minutes (b) 5 minutes

(c) 10 minutes (d) 15 minutes

Fig. 7 Average Φ - q - n pattern of 3mm-void specimen as a function of the time of applied voltage.

Fig. 7 shows an average Φ - q - n pattern of a 3 ㎜-void specimen as a function of the time of applied voltage. The PD is extinguished 18 minutes after the voltage is applied.

Figs. 8, 9, and 10 show ADC, ADP, and PED of PD pulses in void specimens. Table 1 presents the parameter variation of PD pulses in voids after a 3-minute applied voltage. In the smaller void specimens, the speed is reduced. The peak discharge is most slowly reduced

Table 1 The Para meter variation (%).

	ADC	ADP	PED
1mm void	2.50	4.2	42
2mm void	22.0	30	52
3mm void	36.6	42	59

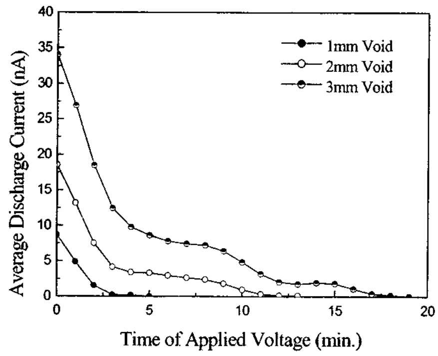


Fig. 8 ADC of PD pulses as a time of applied voltage.

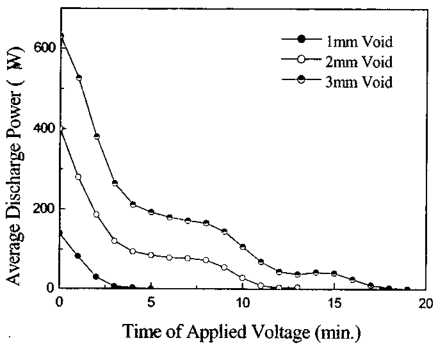


Fig. 9 ADP of PD pulses as a time of applied voltage.

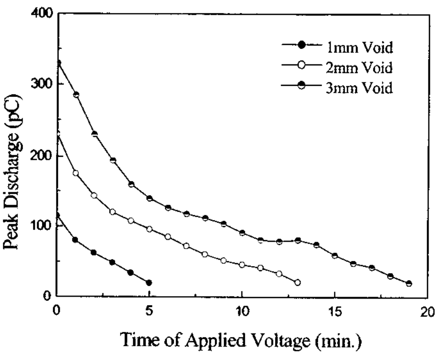


Fig.10 PED of PD pulses as a time of applied voltage.

Fig. 11 shows Hn (q), Hqn (ϕ), Hn (ϕ), and Hq (ϕ) distributions of PD pulses of 3mm-void specimens, and Tables 2, 3, and 4 present the rates of variation distributions in PD pulses in voids.

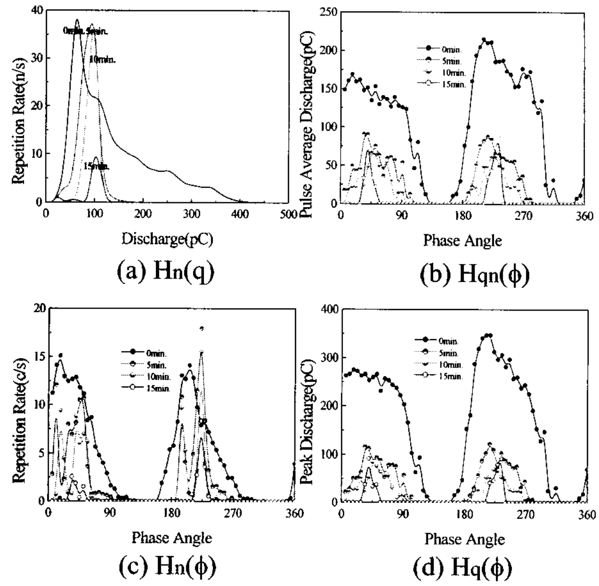


Fig. 11 Hn (q), Hqn (ϕ), Hn (ϕ), and Hq (ϕ) distributions of PD pulses of 3mm-void specimens

Table 2 Rate (%) of variation on distributions of 1mm void.

No. of minutes	Hn(q)	Hqn(ϕ)	Hn(ϕ)	Hq(ϕ)
1	80	79	80	61
2	6	6	6	5
3	5	5	5	4

Table 3 Rate (%) of variation on distributions of 2mm void.

No. of minutes	Hn(q)	Hqn(ϕ)	Hn(ϕ)	Hq(ϕ)
3	29	20	29	15
6	13	18	13	12
9	6	4	6	3

Table 4 Rate (%) of variation on distributions of 3mm void.

No. of minutes	Hn(q)	Hqn(ϕ)	Hn(ϕ)	Hq(ϕ)
5	44	26	44	21
10	27	15	27	11
15	7	6	7	4

The average peak discharge of the 1mm-void is reduced by 72% after 1 minute, and the repetition rate is more rapid than that of the peak discharge of PD pulses. The value of the Hn (ϕ) and Hq (ϕ) distributions shows that the average magnitude of PD pulses is more easily reduced than the number of PD pulses. The PD pulses are extinguished in about 5 minutes.

In the case of the 2mm-void, the average of Hn (ϕ) and Hq (ϕ) is reduced below 10% within 9 minutes. The PD pulses are extinguished in about 10 minutes (see Table 2). The value of the Hn (ϕ) and Hq (ϕ) distribution is 1.99 after 3 minutes. The PD pulses are extinguished in about 12 minutes.

In the case of the 3mm-void, the average of Hn (ϕ) and Hq (ϕ) is reduced below 10% within 15 minutes. The PD pulses are extinguished in about 18 minutes. The value of the Hn (ϕ) and Hq (ϕ) distribution is 2.09 after 5 minutes.

4. Conclusion

The results of characterizing void discharge as a function of the time of applied voltage are summarized as follows. The PD pulses occurred at 45°–60° and 225°–260°, and the average phase angles were 45°, 225° for each half cycle. The parameter and the magnitude of the PD statistical distribution in specimens with a large void were larger than in those with a small void. The smaller the void that occurred in the specimens, the faster the integrated parameters, such as ADP, ADC, and PED, and reducing the number of PDs. Hq (ϕ) distributions of PD pulses were reduced more quickly than those of Hn (ϕ), and this tendency is serious when the void is small. Finally, these PD characteristics are applicable in classifying the defect aspects and diagnosis of deterioration in solid insulation systems using off-line PD methods.

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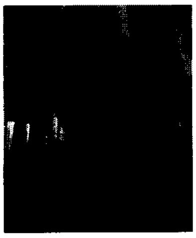

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