

진공 중에서 알루미나의 플래쉬오버

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Pre-Flashover of Alumina in Vacuum

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Abstract : The flashover of insulators in vacuum is the main factor to limit the performance of insulation in vacuum insulation system. It is believed that the pre-flashover phenomena would play a very important role in the procedure of the flashover in the interface between the insulators and vacuum. This paper is mainly concerned on the pre-flashover phenomena of Alumina insulators in vacuum. There are 24 different types of alumina insulators were tested with a 0.7/4 μ s pulsed voltage under a 1×10^{-4} Pa vacuum. The observed pre-flashover phenomena were classified and the pre-flashover characteristics were concluded. It is useful to study further on the flashover mechanism in vacuum.

Key Words : Flashover, Vacuum insulation, Pre-flashover phenomena, Alumina insulator

1. Introduction

The flashover of insulators in vacuum has been studied for many years. However, it is difficult to develop an unabridged reasonable model for explaining the flashover of insulators in vacuum. For the published researches, most of them were mainly concerned on the flashover developing procedures of insulators [1], and recently there was few research reports on the pre-flashover procedures with the application of advanced test and measurement technology. As we know, the flashover procedures are successive procedures under the application of voltage, all of the phenomena with the voltage application are very important for the flashover of insulators. Therefore, it should pay attention to the pre-flashover phenomena when we investigate the flashover of insulators in vacuum

This paper is mainly concerned on the observed pre-flashover phenomena of alumina insulators in a vacuum. Based on the test with 24 different types of alumina samples, the observed pre-flashover phenomena will be classified and its characteristics will be concluded. It is helpful to understand the role of pre-flashover phenomena and the mechanism of flashover in vacuum.

2. Experimental Setup

The test insulator samples studied are with the shape of right circular cylinders about 5mm thick and 20mm in diameter. The first category is using a 99.9% alumina formula prepared with four different sintering conditions (Table 1). The second category is using different formulas (99.5% alumina with varied additives) under the same sintering condition (Table 2). In order to get different surface roughness test samples, the surface of the first category samples was treated using four different granularities

abrasives respectively. Therefore there are total 24 different types of samples.

Table 1. Samples prepared with different conditions.

Test Sample	Sintering Temperature	Soaking Time
Sample A	1873K	2 hours
Sample B	1923K	2 hours
Sample C	2013K	2 hours
Sample D	1923K	4 hours

Table 2. Samples prepared with different additives.

Test Sample	additive	Sintering condition
Sample E	TiO ₂	Same sintering procedure with 1648K sintering temperature and 3 hours soaking time
Sample F	SnO ₂	
Sample G	ZnO	
Sample H	Nb ₂ O ₅	

The test sample and the electrodes were cleaned ultrasonically for 30 minutes before assembled on the sample holder, and then the assembly was located into the vacuum chamber. The vacuum chamber was evacuated to about 1×10^{-4} Pa and allowed to remain several hours. The sample was subjected to impulse voltage beginning at about 8kV. At each voltage level the sample was subjected before the voltage application.

The sample was subjected to impulse voltage beginning at about 8kV. At each voltage level the sample was subjected to 5 shots. If the sample did not undergo a flashover, the voltage was increased by 2.0 kV. The procedure was continued until the sample underwent a flashover. Detailed voltage applications can be found in [2]. During the voltage

applications, the impulse voltage, current and luminosity signals were always recorded in order to observe the surface pre-flashover and flashover phenomena.

3. Results and Discussion

Fig. 1 is the typical waveforms with non pre-flashover phenomena when the voltage applied to the test alumina sample. V, I and L in figures is the applied voltage, the corresponding current and the signal of luminosity respectively. In Fig. 1, V is the complete applied voltage on the test sample, I is the corresponding current (here is the displacement current), L is the luminosity signal (no luminosity observed in this figure, the oscillation at the first part of L is the interference by the ignition impulse of the Marx generator).

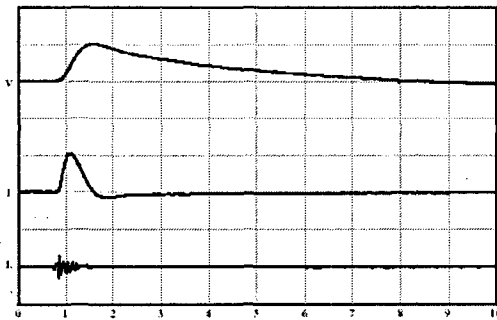


Fig. 1. Typical time-coordinated voltage, current and luminosity waveforms without pre-flashover ($V=10.4\text{kV/div}$, $I=25\text{mA/div}$, $L=1\times 10^{-5}\text{lm/div}$, time $=1\mu\text{s/div}$).

Fig. 2 is the typical waveforms with the most common pre-flashover phenomena. In this figure, there are two little current pulses (named as pre-flashover current) corresponding to the peak value of applied voltage, there also could be observed luminosity signals (named as pre-flashover luminosity) at the corresponding time. This kind of phenomenon is the most frequently observed pre-flashover.

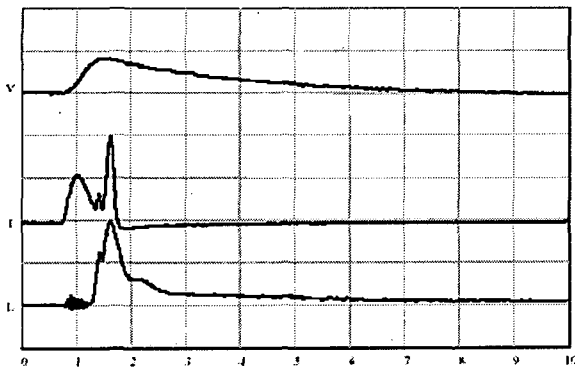


Fig. 2. Typical pre-flashover waveforms the peak value of applied voltage ($V=20.7\text{kV/div}$, $I=25\text{mA/div}$, $L=1\times 10^{-5}\text{lm/div}$, time $=1\mu\text{s/div}$).

In our investigations, the pre-flashover current pulse could be one or two, sometimes would be many more pulses. However, the most frequent occurs with one pre-flashover current pulse. Corresponding to the pre-flashover current pulses, there usually have luminosity signals (at the same time tag).

It could observe the pre-flashover current pulse and luminosity signals at the tail of the applied voltage. Fig. 3 shows one of the typical waveforms which the pre-flashover occurred at the tail of the applied voltage.

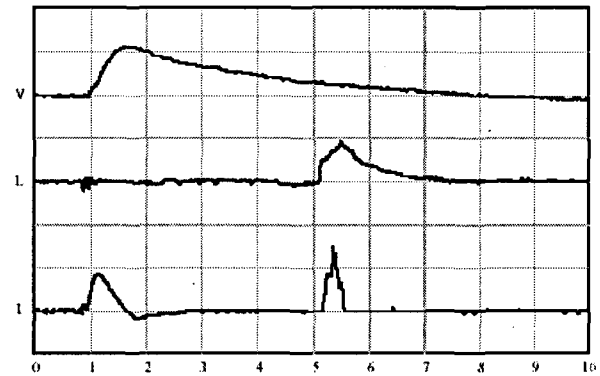


Fig. 3. Typical pre-flashover waveforms at the tail of the applied voltage ($V=20.7\text{kV/div}$, $I=50\text{mA/div}$, $L=2\times 10^{-5}\text{lm/div}$, time $=1\mu\text{s/div}$).

4. Conclusions

This paper presents the observed pre-flashover phenomena with 24 types of alumina samples in vacuum, the pre-flashover phenomena were also be classified, and the characteristics of pre-flashover phenomena were concluded. To study the pre-flashover phenomena is very helpful to understand the mechanism of flashover of insulators in vacuum. The mechanism of the pre-flashover phenomena and its role on flashover procedure have been analyzed, it will be released soon.

Acknowledgement

This work was finally supported by MOCIE program (I-2006-0-092-01).

References

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