

진공중에서 알루미나의 플래쉬오버 현상

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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 system, Alumina

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 [2-3].

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. Experiment

The vacuum system consists of a stainless steel vacuum chamber with a molecular pump. The vacuum chamber has a cylindrical shape about 200mm high and 200mm in inner diameter. The vacuum chamber can be evacuated up to a pressure of 1×10^{-5} Pa. Its pressure was usually maintained at 1×10^{-4} Pa in our investigations. A grounded electrode support arm and an electrostatic probe holder were arranged around the circumference at the center height of the vacuum chamber. The employed electrodes system consists of finger shape stainless steel electrodes which are placed on a flat

surface of the insulator sample using a sample holder made of Teflon [4].

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 8 kV. At each voltage level the sample was subjected before the voltage application.

3. Result and Discussion

In this paper, the pre-flashover phenomena are defined as not only all of the observed phenomena occurred at the right before a flashover developed, but also the observed phenomena without a flashover developed when the voltage was applied. The observed pre-flashover phenomena include the little current impulse and/or the shimmer luminosity under a voltage application.

Fig. 1 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.

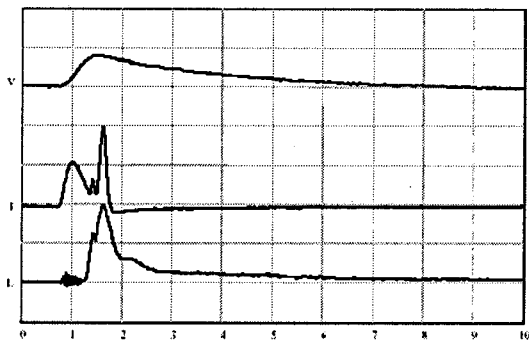


Fig. 1. Typical pre-flashover waveforms the peak value of applied voltage ($V=20.7\text{kV/div}$, $I=25\text{ mA/div}$, $L=1 \times 10^{-5}\text{lm/div}$, time $=1\mu\text{s/div}$).

The pre-flashover is featured as the pre-flashover current pulses and the corresponding luminosity signals would be observed at the right before a developed flashover, and the large flashover current (which corresponds to the crush of applied voltage) is subsequently to the pre-flashover current. Fig. 2 is the typical waveforms for this kind of pre-flashover.

The pre-flashover phenomena only occur at the first several voltage applications with a same applied voltage. And it will repeat the same trend after the applied voltage is increased. The pre-flashover current pulses and the corresponding luminosity signals will become smaller and

smaller along with the continuously voltage application at a same voltage.

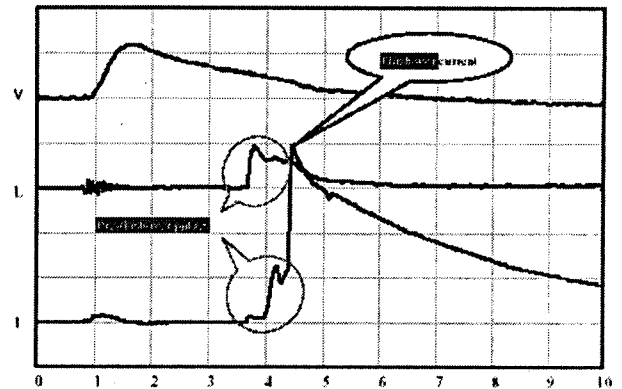


Fig. 2. Typical pre-flashover waveforms at the right before a flashover ($V=20.7\text{kV/div}$, $I=250\text{mA/div}$, $L=2 \times 10^{-5}\text{lm/div}$, time $=1\mu\text{s/div}$).

4. Conclusion

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.

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