진공중에서 Al의 플래쉬오버 현상

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Investigation of Pre-Flashover of Alumina in Vacuum

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Abstract – 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 μs 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.

1. Introduction

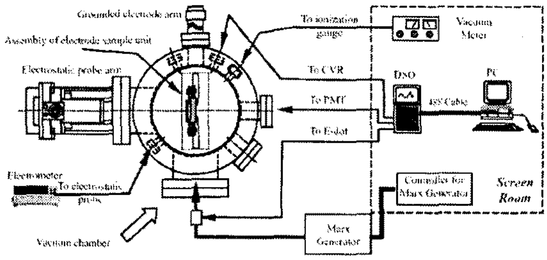
The flashover of insulators in vacuum has been studied for many years. However, it is difficult to develop an unabridged reasonable model for explaining the flashover of insulators in vacuum. For the published researches, most of them were mainly concerned on the flashover developing procedures of insulators [1], and recently there was few research reports on the pre-flashover procedures with the application of advanced test and measurement technology [2-3]. 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. Experiment

Fig. 1 is the test arrangement diagram of the experimental system. 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.



<Fig. 1> Test arrangement diagram of the experimental system.

<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.

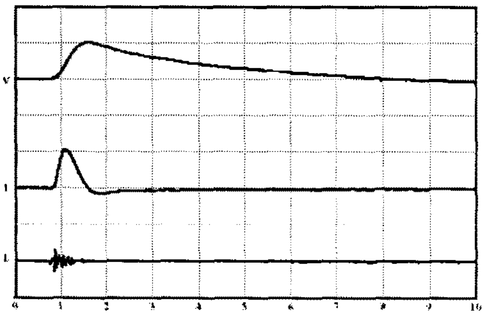
Test Sample	additive	Sintering condition
Sample E	TiO_2	Same sintering procedure with 1648K sintering temperature and 3 hours soaking time
Sample F	SnO_2	
Sample G	ZnO	
Sample H	Nb_2O_5	

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.

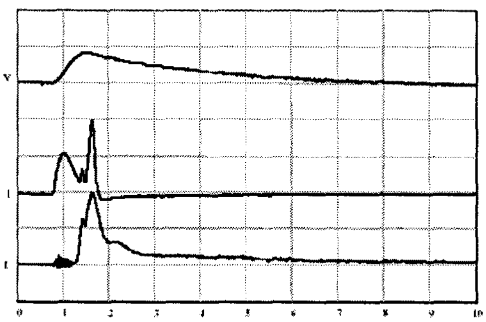
3. Result and Discussion

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=10.4kV/div, I=25mA/div, L=1×10^{-5}lm/div, time =1μs/div).

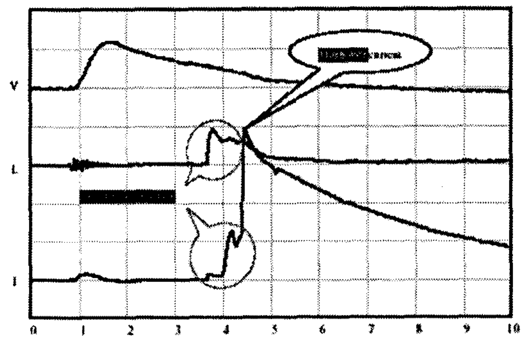
Fig. 2 is the typical waveforms with the most common pre-flashover phenomena In this figure, there are two little current pulses (named as pre-flashover current) corresponding to the peak value of applied voltage, there also could be observed luminosity signals (named as pre-flashover luminosity) at 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=20.7kV/div, I=25 mA/div, L=1×10^{-5}lm/div, time =1μs/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).

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. 3 is the typical waveforms for this kind of pre-flashover.



<Fig. 3> Typical pre-flashover waveforms at the right before a flashover (V=20.7kV/div, I=250mA/div, L=2×10^{-5}lm/div, time =1μs/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.

[Acknowledgement]

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[References]

[1] H. C. Miller. "Flashover of Insulators in Vacuum:Review of the Phenomena and Techniques to Improve Hold-off Voltage", IEEE Transactions on Electrical Insulation, Vol. 28, pp. 512~527, 1993.

[2] L. Ding, C. Li, J. Wang, Z. Wang, "Experimental Investigation of Surface Charge distribution on Insulator in Vacuum under Impulse Voltage", Conference Record of the IEEE International Symposium on Electrical Insulation, pp. 77~80, 2000.

[3] T. Asokan, T. S. Sudarshan, "Pre-flashover Luminosity along an Alumina/Vacuum Interface", IEEE Transactions on Dielectrics and Electrical Insulation, Vol. 1, pp. 1180~1185, 1994.

[4] Lijian Ding, C. R. Li, Jingchun Wang, Zezhong Wang, "Experimental Investigation of Surface Charge distribution on Insulator in Vacuum under Impulse Voltage", Conference Record of the IEEE International Symposium on Electrical Insulation, pp.77~80, 2000.