Influence of Partial Discharges on ZnO Varistors

M. Jaroszewski*
Wrocław University of Technology, Institute of Electrical Engineering Fundamentals
Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland
* E-mail: maciej.jaroszewski@pwr.wroc.pl

Abstract: The varistors used in HV overvoltage limiters are constantly exposed to operating voltage and environmental hazards and also to transient hazards associated with, among others, overvoltages or pollution. Pollution exposures and the associated partial discharges (PD) are a major problem in the operation of overvoltage limiters. The discharges degrade the electrical properties of varistors which results in an increase in the conduction current active component below the varistor continuous operation voltage. This may lead to loss of thermal stability. To determine the effect of partial discharges on the varistor elements in HV overvoltage limiters, the service exposures were simulated on single varistors in laboratory conditions.

INTRODUCTION

During service all the electric power system devices are subject to various loads and exposures. Overvoltage limiters as protection devices are subject to both environmental and electrical exposures, which may adversely affect the durability of the limiters, causing, among others, reduction in their resistance to the action of working voltage and loss of thermal stability. A common cause of damage to HV overvoltage limiters in porcelain hollow insulators is the conductive pollution forming a deposit on the insulator's surface [1]. If the intensity of pollution is high, the absolute leakage current value may significantly exceed the limiter's capacitance current value. This may result in non-uniform, time-variable voltage distributions on the insulator's outer surface, significantly different from the typical capacitive distribution along the stack of varistors. The potential difference between the stack of varistors inside the insulator and the latter's outside surface may result in intense partial discharges inside the limiter. The partial discharges degrade the electrical properties of the varistor's material and its housing. As a result the conduction current active component below the continuous operation voltage increases which may lead to loss of thermal stability [2-4].

EXPERIMENTAL PROCEDURE

To determine the effect of partial discharges on the varistor elements in HV overvoltage limiters, the service exposures are simulated on single varistors in laboratory conditions. Taking into account the natural conditions, discharges are usually generated between an electrode and the varistor's side wall or between two electrodes situated close to the varistor. The former way of discharge generation reproduces the actual service conditions more faithfully: both the effect of the products catalysed by the discharges and the direct erosion effect of the discharges are reproduced.

The setup in which partial discharges were generated between a discharge electrode and the lateral surface of the varistors was used for ageing. The tested varistor and the discharge electrode were placed in a special cylindrical glass chamber. The varistor was additionally exposed to alternating voltage. A schematic diagram of the ageing setup is shown in Fig. 1.

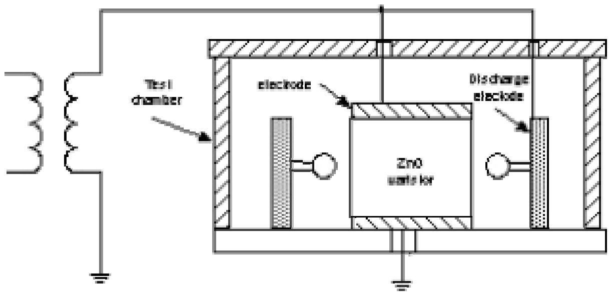

Figure 1. Test setup

Commercial varistors used in the production of HV limiters were tested. The varistors had the shape of disks with a diameter of 70 mm and a height of 20 mm and their continuous operation voltage was Uc=2.1 kV. Flashovers between the discharge electrode and the varistor and proper intensity of ageing were ensured by adjusting the electrode-varistor distance.

TEST RESULTS AND THEIR DISCUSSION

The varistors were aged by subjecting them to 300 h long cycles of continuous partial discharges. After each cycle the U-I characteristics of the varistors were measured and compared with the ones measured prior to ageing. The measurements were performed under respectively direct current voltage and alternating voltage. For the obtained exposure severity the varistor total conduction current measurements performed under alternating current practically did not indicate any changes caused by ageing (Fig. 2). But this does not mean that no such changes occurred. The changes are

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manifested by the increase in the conduction current resistance component. They are observable in the measurements performed under direct current voltage (Fig. 3). One can notice a large increase in the conduction current in the case when the varistor was additionally subjected to the action of alternating voltage. This is in agreement with previous reports [4,5].

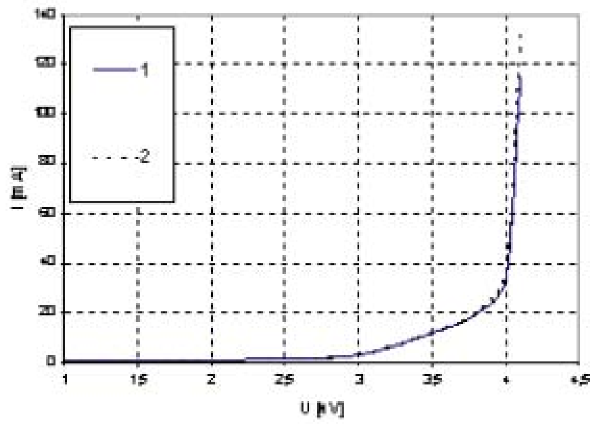

Fig. 2. Typical U-I characteristics measured under alternating voltage for respectively: new (1) and aged (2) varistor.

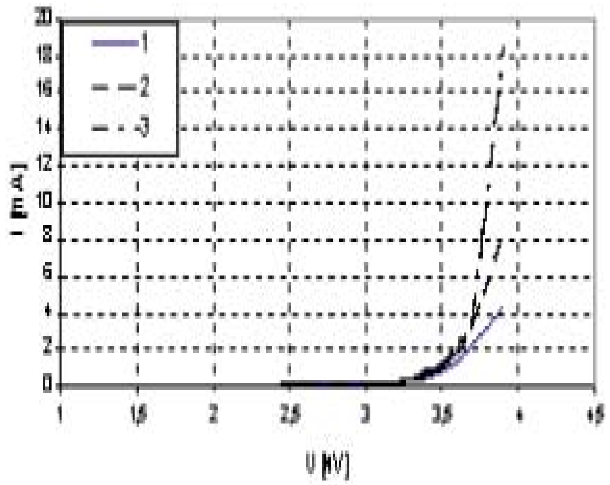

Fig. 3. Typical characteristics U-I measured under direct current voltage for respectively: new (1), aged without voltage application (2) and aged with voltage application (3) varistor.

CONCLUSIONS

- Partial discharges cause changes in the U-I characteristic which consist in an increase in the varistor conduction current in the low-voltage range of the characteristic (U<Uc).
- The observable changes in the conduction current value apply to the conduction current resistance component (measurements under direct current voltage).
- Higher conduction current values were obtained after ageing the varistor by partial discharges combined with voltage exposure.

REFERENCES

[1] Bargigia A., De Nigris M., Pigini A., Sironi A.; "Definition of testing procedures to check the performance of ZnO surge arresters in different enviromental conditions"; CIGRE 1992 Session, pp. 33-206, 1992

[2] Kourdi M. B., Bui A., Loubiere A., Khedim A.; "Bechaviour of metal-oxide-based varistors subjected to partial discharges in air"; J. Appl. Phys. 25, 548-551, 1992

[3] Bui A., Loubière A., Hassanzadeh M.; "Electrical characteristic degradation of ZnO varistors subjected to partial discharges"; J. Appl. Phys. 65(10), pp.4048-4050, 15 May 1989

[4] Izumi K., Honma H., Tanaka J.; "Deterioration of metal oxide surge arrester element caused by internal discharges under polluted conditions"; Proseedings of the 3rd International Conference on Properties and Applications of Dielectric Materials; Tokyo, Japan, pp517-520, July 8-12, 1991

[5] M. Jaroszewski, J. Pospieszna, K. Wieczorek, „Partial discharges influence on ZnO varistors", Przegląd Elektrotechniczny 10s'2002, VI Ogólnopolskie Sympozium Inżynieria Wysokich Napięć, , pp. 124-126, in Polish, Poznań-Kiekrz, Poland, 20-22 maja 2002

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