IJCTA, 9(32), 2016, pp. 183-188 ISSN: 0974-5572

Thermal Behavior of Metal Oxide Surge Arrester Block

Leela A.M.[1], V. Muralidhara[2], K.N. Ravi[3], N. Vasudev[4] and R.S. Shivakumara Aradhya[5]

ABSTRACT

This paper presents study on the characteristics of ZnO arrester blocks at different temperatures. Experiments were conducted to find the thermal characteristics of arrester blocks. The temperature rise of the arrester block affects the operating characteristics of the arrester. Deviation in the V-I characteristics results in thermal ageing of the arrester blocks. This helps in further study on arrester performance and ageing.

Keywords: ZnO block, V-I characteristics, Thermal ageing.

1. INTRODUCTION

Power system equipments are protected by surge arresters from over voltages. The metal oxide surge arrester has highly nonlinear V-I characteristics. The surge arrester provides a low-impedance path to the ground for the current from surge voltages and then restores to a normal operating conditions. In addition it must not allow any Power follow current to flow. The arrester has two functions; first, it must provide a point in the circuit at which an over-voltage pulse can pass to ground and second, to prevent any follow-up current from flowing to ground.

If the protection fails, the lightning that strikes introduces thousands of kilo volts that may damage the transmission lines and can also cause damage to other devices in the power system. Surge arresters are subjected to continuous operating voltages which causes leakage current to flow which will be less than a milliamp. The leakage current increases as the temperature of the arrester blocks increases. As the temperature increases, further increase in leakage current takes place and it may ultimately lead to thermal runaway or degradation of the arrester blocks thus affecting the life of the arrester.

In the present study experiments were conducted to find the thermal characteristics of the arrester blocks, also V-I characteristics at different temperatures.

2. BEHAVIOR OF LEAKAGE CURRENT

Since the arrester is continuously energized a small current of the order of a fraction a milliamps flows through the arrester blocks. This current raise above its value at ambient, if its temperature raises. The temperature rise may be due to the occurrence of a surge or a rise in ambient temperature. The dynamic change in the voltage distribution, which may be due to the surface conditions of the arrester, also causes an increase in the leakage current. This action is ultimately resulting in thermal runaway of the arrester. Even

[1] Research Scholar,Jain University (SCE, VTU), *Email: leelaam@sapthagiri.edu.in*

[2] School of Engg & Tech., School of Engg., and Technology, Jain University Bengaluru, India.

[3] EEE Dept. Sapthagiri college of Engineering VTU Belagavi, Bengaluru, India.

[4] High Voltage Division, CPRI, Bengaluru, India.

[5] EEE Dept., Acharya Institute of Tech., VTU Belagavi, Bengaluru, India.

if the thermal runaway does not occur, the increase in temperature results in thermal degradation of the arrester blocks due to which the arrester ages i.e. its life span reduces.

In the low voltage region of the arrester V-I characteristic, the leakage current is capacitive in nature. As the voltage is increased the current changes from capacitive to resistive. This behavior is also observed from the waveforms recorded at different voltages and temperatures.

3. EXPERIMENTAL SETUP AND PROCEDURE

In order to understand the thermal characteristics of arrester block various experiments have been carried out on the arrestor block at different temperatures. The arrester block was placed between two aluminum plates and kept inside an oven as in Fig.1. The complete arrangement for temperature measurement and voltage application is shown in Fig. 2. The circuit arrangement is as in Fig. 3. The circuit is supplied through a transformer of 230V/50kV, the primary of which is supplied from an auto transformer.

The arrester is heated to different temperatures. The temperature was measured using a contact type thermometer and the leakage current is measured by measuring voltage across a 120k Ohm resistor in series with the arrester block. The voltage applied and leakage current is recorded for different temperatures. The waveforms of supply voltage and leakage current also recorded as in Figures 5 through 10.

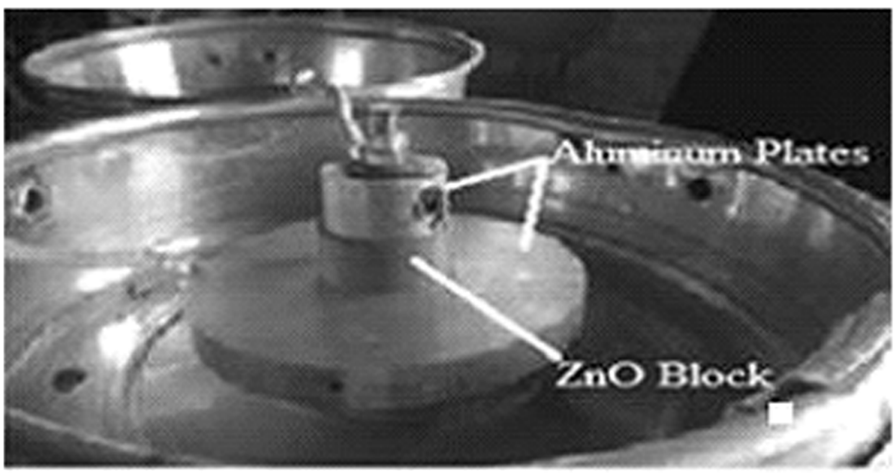

Figure 1: Oven with ZnO Block

Figure 2: Complete arrangement

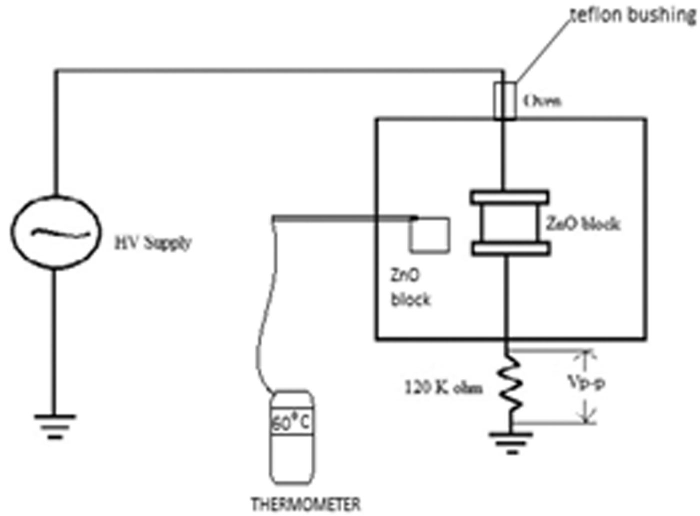

Figure 3: Circuit Diagram

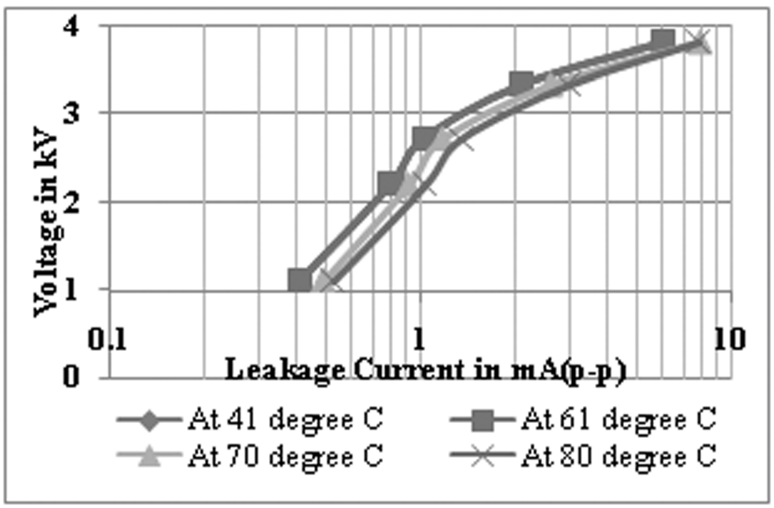

Figure 4: V-I Characteristics at different temperatures

Table 1
Peak to Peak of Leakage Current in mA

Voltage applied in kV	41°C	61°C	70°C	80°C
1.108	0.144	0.152	0.172	0.184
2.195	0.282	0.3	0.324	0.364
2.717	0.36	0.38	0.416	0.475
3.326	0.74	0.77	0.926	1.054
3.804	2.12	2.36	2.808	2.768

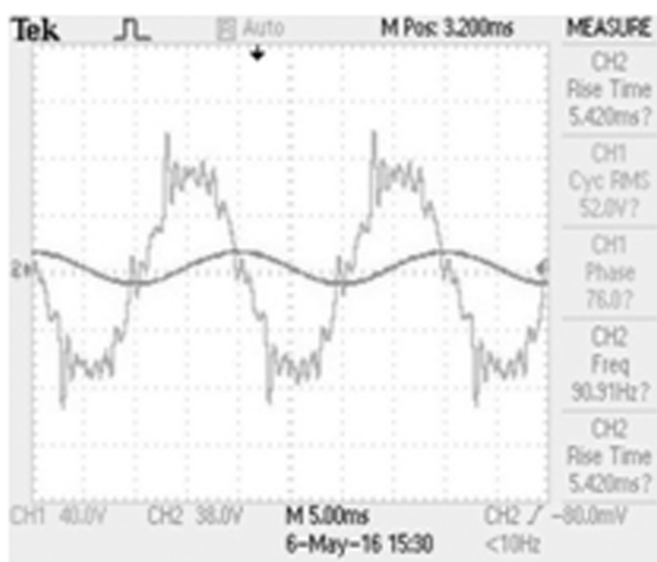

Figure 5: Supply Voltage and Leakage current waveforms at 48°C and 0.434kV

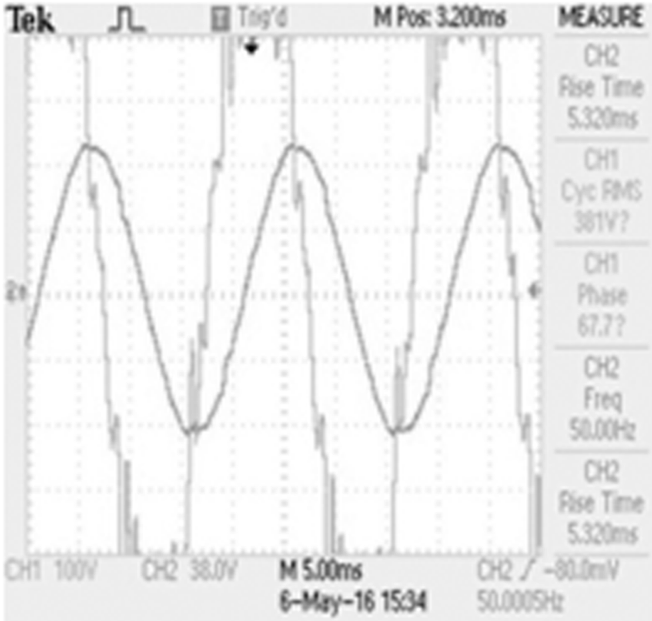

Figure 6: Supply Voltage and Leakage current waveforms at 48°C and 3.043kV

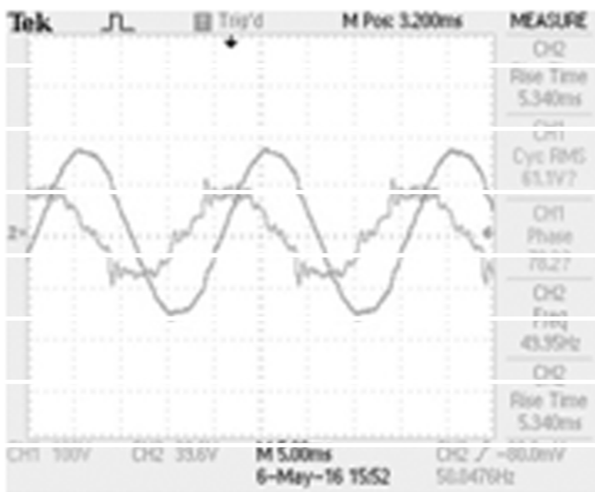

Figure 7: Waveforms of supply Voltage and Leakage current at 60°C and 0.434kV

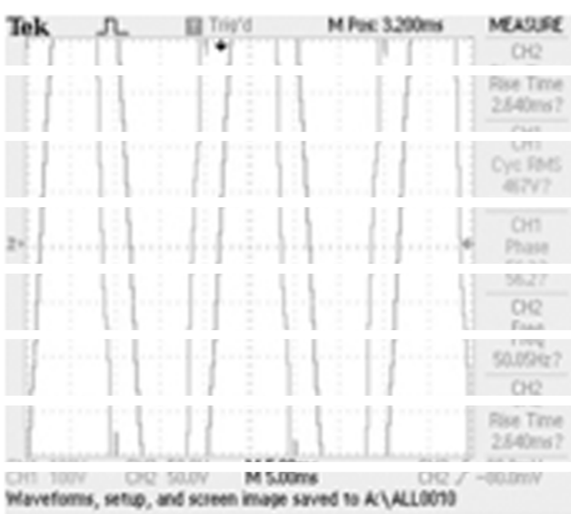

Figure 8: Waveforms of supply Voltage and Leakage current at 60°C and 3.043kV

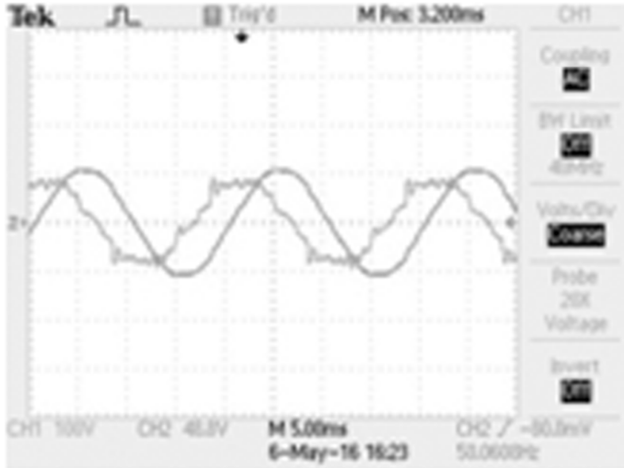

Figure 9: Waveforms of Supply Voltage and Leakage current at 80°C and 0.434kV

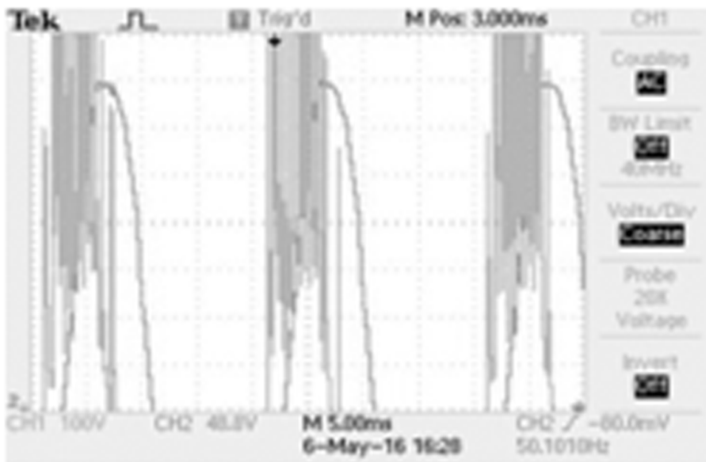

Figure 10: Waveforms of supply Voltage and Leakage current at 80°C and 3.043kV

4. RESULTS AND DISCUSSION

The V-I characteristics at four different temperatures are plotted and they are as shown in Fig.4. It is observed that the leakage current increases as the voltage increases and the increase is from a higher level at higher temperatures. For example, from Table.1, at 41°C the increase in leakage current is from 0.144mA to 2.12mA (p-p), whereas at 80°C it is from 0.184 to 2.768mA(p-p) as the voltage increases from 1.108kV to 3.804kV. This clearly indicates that the effect of rise in temperature of the arrester block increases the leakage current which is the cause for thermal degradation and ageing of the arrester blocks.

The waveforms of leakage current and supply voltage at different temperatures as shown in Figures 5 to 10 indicates that the leakage current shifts from capacitive to resistive as the voltage is increased. For example consider the waveforms at 60°C as in Fig.7 and Fig.8. The phase angle between the supply voltage and leakage current decreased at 3.043kV compared to that at 0.434kV. Similar observation can be made from waveforms at other temperatures. It is also observed that at higher temperatures the leakage current waveforms indicates the presence of harmonics. It is well known that harmonics, especially the third harmonic current is responsible for heating of the arrester blocks.

5. CONCLUSION

Experiments were conducted to verify the temperature dependence of the leakage current. It is observed that a rise in temperature is causing a rise in leakage current through the arrester. While the arrester is in use, the voltage distribution across the arrester changes due to pollution on the surface of the arrester which causes the leakage current to increase. This in turn results in temperature rise of the arrester blocks. From the experiments conducted it is confirmed that an increase in temperature causes an increase in leakage current and hence proving the converse.

Under normal conditions the leakage current is capacitive in nature and as the voltage raises it becomes more resistive. This shift from capacitive to near resistive occurs at a lower voltage if the block temperature is high. This indicates that a raise in temperature of the arrester blocks brings the arrester to conduction state at a lower voltage. Also as the temperature of the block increases the harmonic content of the leakage current increases. This is observed from the waveforms of leakage current at higher temperatures.

6. FUTURE SCOPE

In the present work the V-I characteristic of the arrester block obtained at different temperatures and the leakage current waveforms are also observed. The frequency analysis of the leakage current can be carried out to detect the dependency of the temperature rise with the third harmonic component, especially of the resistive component.

ACKNOWLEDGEMENTS

The author would like to express gratitude to the Jain University for giving an opportunity to carry out the research work and Sapthagiri College of Engineering for providing all the facility and support for carrying out the research work.

REFERENCES

[1] George R. S. Lira, Edson G. Costa, *"MOSA Monitoring Technique Based on Analysis of Total Leakage Current"* IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 28, NO. 2, APRIL 2013

[2] Wagner A. M. Ursine, José L. Silvino et.al. *"Metal-Oxide Surge Arrester's Leakage Current Analysis and Thermography"* 2013 International Symposium on Lightning Protection (XII SIPDA), Belo Horizonte, Brazil, October 7-11, 2013

[3] A Haddad and D F Warne "*Advances in High Voltage Engineering*" IET Power and Energy Series 40