BEHAVIOR OF POLYMERIC HOUSED METAL OXIDE SURGE ARRESTER UNDER POLLUTION

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ABSTRACT

Surge arresters play an important role in the insulation coordination of the power system. Polymeric housed surge arresters are widely used due to their superior performance compared to the porcelain housed surge arresters. Surge arresters are exposed to adverse weather conditions. The polymeric materials get affected more easily by ageing due to partial discharges and leakage currents on the surface.

Ageing of the surge arresters is an important issue that should be looked into. There are various factors which contribute in accelerating the ageing of the surge arresters. Pollution is the main cause for ageing of the surge arresters. The pollution causes surface leakage current to flow in the form of scintillations. These scintillations may couple with the internal arrester blocks. This may results in increase in the volume current through the blocks which in turn increases the temperature of the blocks and hence thermal ageing of the arrester.

In the present work the metal oxide surge arrester with polymeric housing is tested with pollution coating. Different weather conditions are simulated with coating arrester with different severity artificial pollution and wetting the surface. The pollution is with three different severities. The arrester with pollution coating and at different conditions is subjected to a variable voltage. The results show that the more the severity and moisture on the arrester, the arrester was tripping at a lower voltage and also there is considerable increase in volume and surface currents. Also an effort to understand the linking of the surface current with the volume current for the polymeric housed arrester is done.

Keyword: - *Polymeric housing, Pollution, Volume current, Surface current*

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1. INTRODUCTION

Electric power supply should ensure reliability and continuity to the utility concerns. Hence the power lines and substations are to be protected and operated against over voltages such that the number of failures is as few as possible. Substation contains transformers, switchgears, and other valuable equipments with non-self-restoring insulation, which have to be protected against failures and internal destruction. Surge arresters form the primary protecting devices for all equipments of transmission and distribution systems, from the effects of lightning and switching over voltages.

The surge arrester provides a low-impedance path to ground for the current from a lightning strike or transient voltage and then restores to a normal operating conditions. When a high voltage due to lightning strikes on the line, the arrester immediately furnishes a path to ground and thus limits and drains off the excess voltage. The arrester must provide this relief and then prevent any further flow of current to ground. If the protection fails or is absent, 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. Thus, arrester has two functions, it must provide a point in the circuit at which an over-voltage pulse can pass to the ground and second, to prevent any follow-up current from flowing to the ground.

A number of technical developments have been carried out in the arrester design and manufacturing since 1980's and today polymeric housed metal oxide surge arresters are extensively used. The distinctive feature of metal oxide surge arrester is its extremely non linear V-I characteristics. The current passing through the arrester within the range of applied power frequency voltage is so small that it behaves like an insulator. If, however, surge currents in kilo amps are injected into the arrester, such as the case when lightning or switching over voltages occur, then the resulting voltage across its terminals, will remain low enough to protect the insulation of the associated device from the effect of over voltages.

Failures of porcelain arresters are often associated with explosion and shattering of sheds of porcelain, resulting in injury to nearby personnel and equipment's. If the polymeric housed arrester happens to fail they do not shatter and hence less safety hazards.

In the polymeric housed arresters the housing fits closely and tightly with zinc oxide column compared to that in porcelain housed arresters. This provides greater resistance to moisture ingress but it increases the capacitance between housing and arrester column[1]–[3]. Due to this close capacitive coupling there is possibility that under contaminated conditions the internal arrester current may be affected by the external leakage current. This may result in heating of the ZnO blocks and eventual failure of the arrester. In the present study in order to evaluate the effect of contamination on the internal current, experiments are conducted by coating polymeric surface with different severity contamination and the behavior of the volume and surface currents with the application of voltage is observed for a 30kV, 10kA polymeric housed arrester unit.

2. EXPERIMENTAL SETUP

The experimental setup and pollution are in general accordance with the standards[4]–[6] .A 230V/50kV, 50mA step up transformer is supplied through an auto transformer. The 30kV arrester unit is connected in series with a 50Ω resister is connected across the secondary of the step up transformer. The current trough this resister represents the volume current and waveform of the volume current recorded by a storage oscilloscope across the resister. A copper strip surrounding the polymeric housing collects the surface current and passes it to ground through another 50Ω resister. The current through this resister is the surface current which is due to the contamination and the waveform across the resister gives the surface current waveform. Experiments were conducted on a 30kV, 10kA single unit arrester. Circuit diagram for measuring the volume and surface currents as in Fig.1. The source consists of a step up transformer 230V/50kV, the primary of which is supplied by an autotransformer. Surge arrester has a 50Ω resistance in series. Volume current is obtained as the voltage across this resistance divided by its resistance. To measure the surface current, a copper strip is connected around the polymeric housing and it is grounded through a 50Ω resister. Surface current is voltage across this resistor divided by its value.

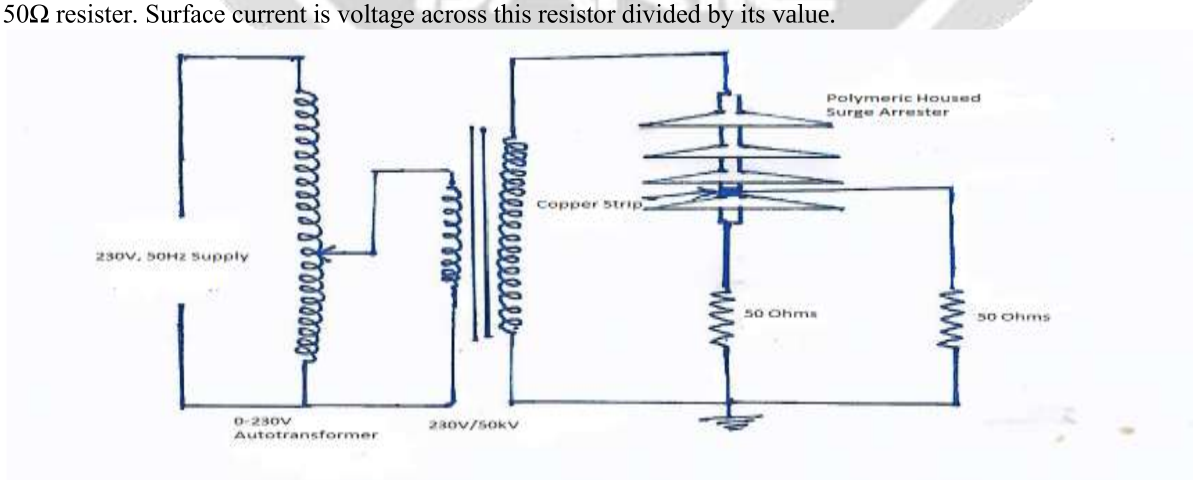

Fig.1. Circuit Diagram

The voltage is gradually applied in steps and surface and volume currents recorded at each voltage. This was repeated until the arrester current rises so as to trip the circuit.

The contaminant consists of slurry of Water-5Liters,Kaolin Powder-400gms and Salt-depending on severity. All the above thoroughly mixed in a container. Pollution severity depends on the salinity level and it is classified as: Low-7 to 14 kg/m^3, Medium-14 to 80 kg/m^3 and High- 80 to 160 kg/m^3.

The contaminant was prepared as required for different cases of the experiment and was stored in a container and thoroughly agitated prior to the application. Since the polymeric housing is highly hydrophobic in nature the slurry was coated on to the surface by a special brush.

TESTING:

The test was conducted for two conditions:

- Unpolluted condition where the polymeric housing surface was uncoated, clean and dry.

- Polluted condition where a Paste is prepared containing the mixture of Kaolin Powder and Table Salt (NaCl) according to the Pollution Severity and applied throughout the Polymeric Housing Surface.

AC voltage was applied gradually till the circuit trips. The volume and surface currents noted for each voltage along with the waveforms of the volume and surface currents. The experiment was first conducted for unpolluted condition and then for polluted condition with different severities (low, medium and high) and tested for different conditions like - Dry, Half wet and Fully wet.
The arrester is said to pass the test if all the following occurs

No unit or arrester flashes over. There is no damage to the internal parts as evidenced by inspection. The arrester demonstrates thermal stability.

3. VOLUME CURRENT

3.1 Under dry condition - Fig.2 shows the variation of volume current with voltage under i) dry and clean surface and ii) low, medium and high severity pollution with dry surface. An increase in volume current is observed with high severity and dry surface.

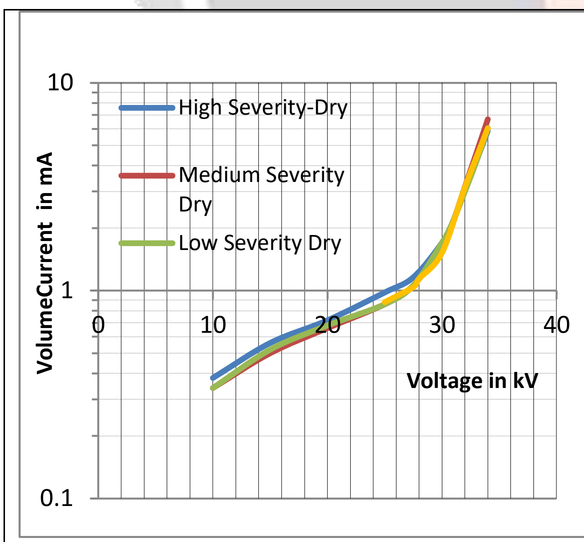

Fig.2 Volume Current Under Dry Conditions and Different Severities

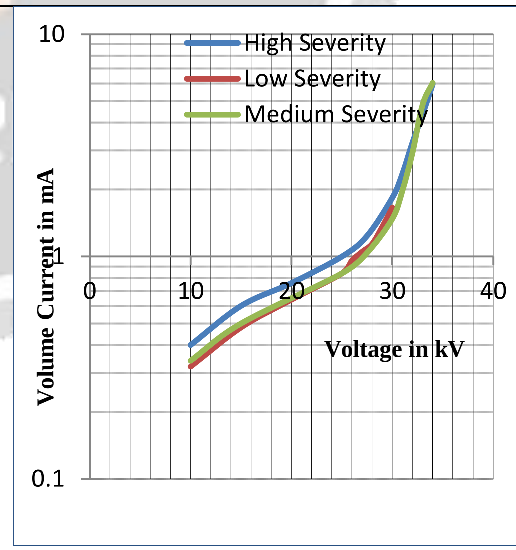

Fig.3 Volume Current Under Half Wet Condition and different Severities

3.2 Under Half Wet Condition- Variation of volume current with voltage and severity conditions of low, medium and high, when the arrester is half wet is shown in Fig.3. Considerable increase in volume current is observed with high severity.

3.3 Under Full Wet Condition- Fig.4 shows the volume current variation at different severities with arrester fully wet condition. With high severity the voltage

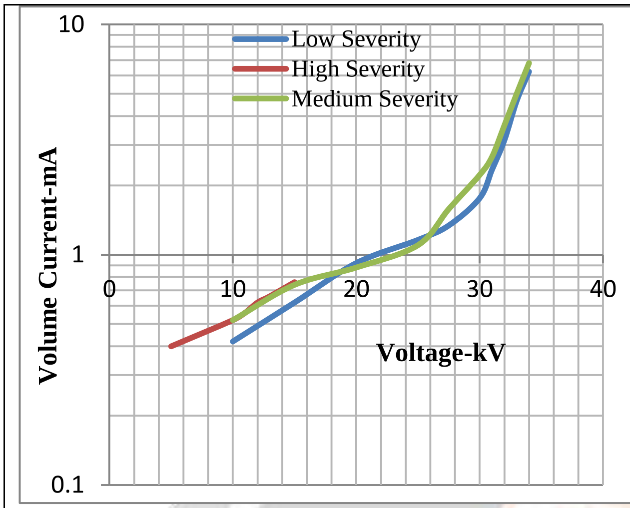

Fig.4 Volume Current Under Full Wet Condition and Different Severities

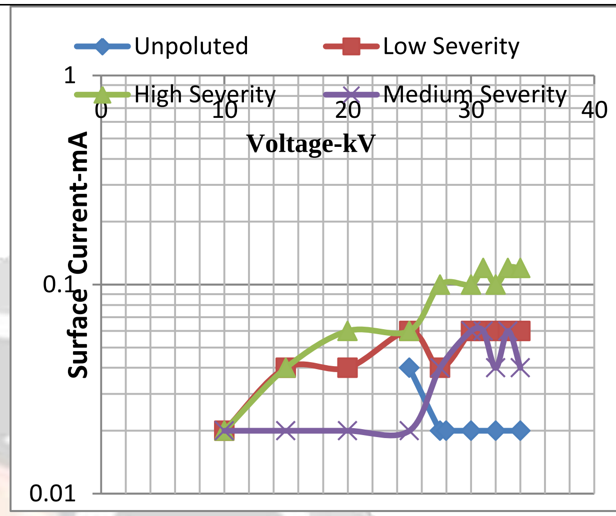

Fig.5 Surface Current Under dry Condition and different Pollution Severities

4. SURFACE CURRENT

A copper strip around the arrester surface collects the surface current and it was made flow to ground via a 50 ohm resister. Voltage across this resister measured to find the surface current.

4.1 Under Dry Condition - Fig.5 shows the surface current variation under dry condition, with different severity pollution and also without pollution. It is observed that there is not considerable increase for unpolluted, low severity and medium severity conditions.

4.2 Under Half Wet Condition- Fig.6 shows the variation of surface current under different pollution levels under half wet condition. The increase in surface current is not much under low severity condition. But the increase is considerable under medium and high severity conditions.

4.3 Under Full Wet Condition- The surface current variation under full wet condition is shown in fig.7. It can be observed that the surface current at low voltage is considerably high compared to dry and half wet conditions of Fig.4 and Fig.5. Under high severity voltage could not be raised above 15kV due to the raise in surface current.

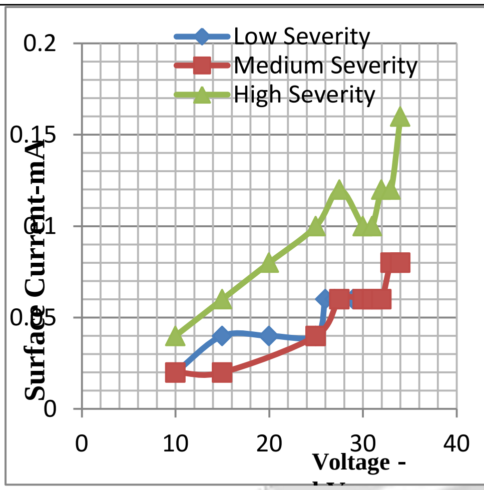

Fig.6 Surface Current Under Half Wet Condition and Different Severities of Pollution

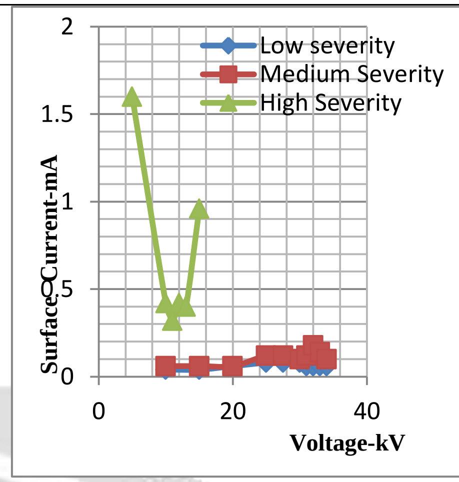

Fig.7 Surface Current Under Full Wet Condition and Different Pollution Severities

5. RESULTS AND DISCUSSION

From Fig.2 it is observed that under dry condition and different severities there is not much increase in volume current as the voltage is increased from 5kV to 34kV. Only a small increase is observed at medium and high severities.

Under half wet condition and different severities a considerable increase in volume current is observed. This is shown in Fig.3.

Fig.4 shows the volume current under full wet and different severities. It can be observed here that the increase in volume current is more than that in half wet condition. Also voltage could not be raised above 15kV at high severity due to an increase in volume current.

From Figures 5,6 and 7 it is observed that compared to dry condition there is an increase in surface current under half wet and full wet conditions.

The increase in volume and surface currents at different pollution levels and surface conditions are tabulated in Tables 1,2 and 3.

Under low severity the increase in surface current is same (0.04mA) under all the 3 surface conditions. With medium severity pollution the increase in surface current is greater than that under low severity. This is evident by comparing the surface currents in Table.1 and 2.

Comparing the surface currents at medium and high severity conditions as in Table.2 and 3 a further increase in surface current is observed. Also under high severity and full wet conditions the voltage could be applied only up to 15kV and the surface current at 5kv is largest compare to all other conditions.

Table.1. Low severity					**Table.2.** Medium severity					**Table.3.** High severity				
Condition on Arrester	Volume Current variation as voltage varied from 5kV to 34kV		Surface Current variation as voltage varied from 5kV to 34kV		**Condition on Arrester**	Volume Current variation as voltage varied from 5kV to 34kV		Surface Current variation as voltage varied from 5kV to 34kV		**Condition on Arrester**	Volume Current variation as voltage varied from 5kV to 34kV		Surface Current variation as voltage varied from 5kV to 34kV	
	From (mA)	To (mA)	From (mA)	To (mA)		From (mA)	To (mA)	From (mA)	To (mA)		From (mA)	To (mA)	From (mA)	To (mA)
Dry	0.34	6.06	0.02	0.06	**Dry**	0.34	6.68	0.02	0.04	**Dry**	0.38	5.88	0.02	0.12
Half Wet	0.32	1.66	0.02	0.06	**Half Wet**	0.34	6.04	0.02	0.08	**Half Wet**	0.4	5.96	0.04	0.16
Full Wet	0.42	6.24	0.04	0.06	**Full Wet**	0.52	6.8	0.06	0.7	**Full Wet (Tripping at 16kV)**	0.4	0.76	1.6	0.96

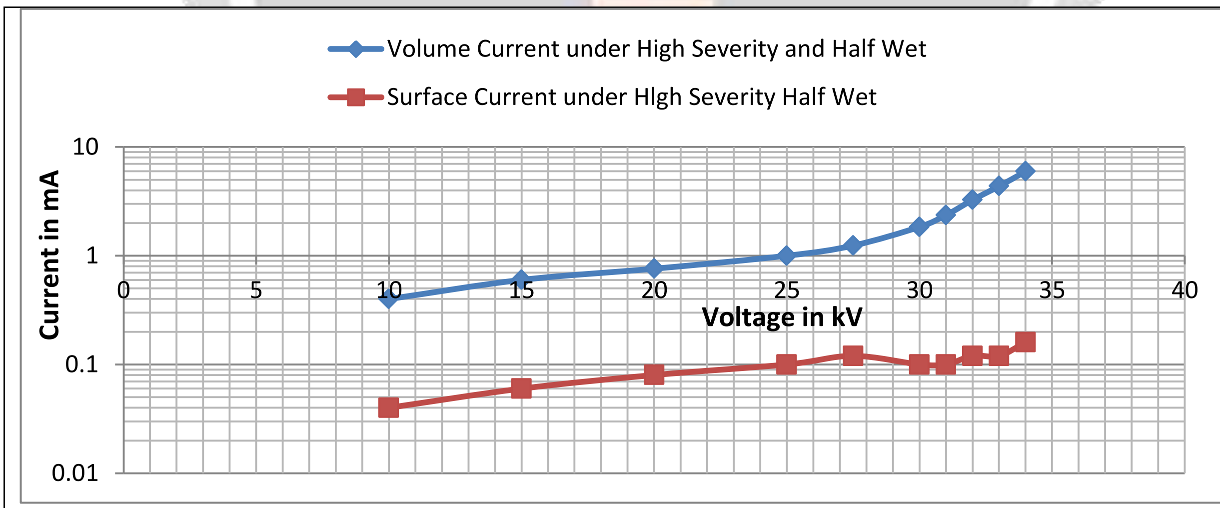

Fig.8. Comparison of Volume and Surface Current Variation

6. CONCLUSION

In the present work an arrester of 30kV and 10kA rating was tested for its behavior under pollution. In order to study the arrester behavior, two important currents viz., Volume current and Surface currents were considered.

Comparing Volume and Surface currents at High severity and half wet condition in Fig.8 shows clearly that there is an increase in volume current with the increase in surface current. This is observed for other conditions and severities also.

Leakage current flows through the arrester under normal operating conditions. Continuous flow of leakage current through the arrester causes deterioration of the arrester blocks and hence ageing of the blocks. The pollution on the surface of the arrester, in the presence of moisture, allows surface current to flow. This surface current increases with severity of pollution as well as the amount of moisture. Under normal operating conditions there is continuous flow of volume current through the arrester blocks due to leakage current and also there is flow of surface current in the form of scintillations of high frequency due to pollution on the surface of the polymeric housing. The arrester housing and the arrester blocks are separated by a dielectric, therefore there is possibility of surface current of high frequency linking with the volume current and affect the volume current which may further add up to the ageing of the arrester blocks. This is also observed from the experimental results, indicating the possibility of surface current coupling with volume current and thus increasing it. Further experimentation and investigations are required to determine the linking of the surface current with the volume current.

7. ACKNOWLEDGEMENTS

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