STUDY AND INVESTIGATION OF MEDIUM VOLTAGE POLLUTED INSULATORS IN ALEXANDRIA DISTRIBUTION GRID

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ABSTRACT

This study was made to investigate the ageing effect and the pollution performance on MV porcelain insulators in service. These insulators were exposed for years to weathering conditions in the west coast of Alexandria distribution network. The atmospheric pollutants such as salts soot, dust, ionic impurities, agricultural and many types of industrial emissions, in different geographical locations. It was possible to understand the mechanism of failure and flashover of insulators in distribution grid at different locations. It was concluded that hand cleaning increases the flasover voltage and reduces the leakage current to 25% of its original value, while wetting may increase it to 150%.The dielectric losses of insulator is drastically increased by pollution accumulation. This would attribute to the advance of arc strike.

Keywords: polluted insulators, Flashover, MV Distribution grids, contamination.

INTRODUCTION

In medium voltage distribution networks, pollution flashover is one of the most important problems for power transmission flashover of insulators caused by combined action of pollution and moisture. It is very common that power system flashover in many cases may cause long interruptions in energy transmitted and therefore results into losses in the national economy.
On porcelain insulators surfaces, wet atmospheric conditions easily lead to the formation of water films. If the contamination is very heavy, salts in the contaminations dissolve into the water films and result in uncontrolled leakage currents, which easily lead to flashover.
Outdoor insulators are subjected to many sources of natural contaminations which may include , depending on their locations , sea salts , road salts , cement , dust , fly ash , bird dropping ,agricultural fertilizers and many types of industrial emissions .

FORMATION OF CONTAMINATIONS

1-Insulators polluted with marine pollution

It can be explained as small water droplets released from the tips of the sea waves during stormy weather and then smaller droplets of brine are found on insulators. During dry weather, water evaporates leaving dry crystalline salt particles. Insulators in regions of sea shore are exposed to direct salt water spray during periods of strong wind .The sun dries the water leaving salt layer on its surface. These salt particles are deposited and stucked to the surface of the insulator.

Inland Pollution

The sources of insulator pollution inland include soil dust fertilizer deposit , industrial emissions , fly ash bird dropping and construction activities in that area. Winds drive this air born contaminated particles onto the insulator surface. Also due to heavy traffic, tar like carbon deposits are accumulated on insulator surface .The continuous deposition of these particles increase the thickness of these deposits.
Occasionally, rain washes part of the pollution away and self cleaning by airflow also removes some types of contaminant. After a long time the deposits are stabilized and a thin layer of solid deposit will cover the insulator. Because of the cleaning effects of rain, deposits are lighter on the top of the insulators and heavier on the bottom.
Some of the insulators have combined contamination of the two above types. Fig (1)shows polluted insulators.

Fig.(1). Polluted Insulators

EXPERIMENTAL WORK &METHODOLOGY

The flashover voltage was determined for the field polluted samples then the samples were cleaned by clean cloth and tests were repeated , after that the samples were washed out with tap water and then retested, In all cases, the leakage currents were recorded using the circuitry shown in Fig (2). The deposits cleaned from insulators were collected to be chemically investigated using micro chemical analysis methods The washed salty solution was collected then derided and chemically analyzed and the equivalent salt deposit density (ESDD) was determined. The conductivity

of the salty solution was determined using the circuit shown in fig (3).
Mains suppressor was used to eliminate any surges or fluctuations in the mains of the H.V source .A blocking capacitor was provided with the test samples to eliminate voltage of high frequencies when testing at 50 Hz .The R-C detection circuit was added in series with the samples for detection and measurements.
The leakage current was recorded with a chart recorder of high resolution and sensitivity in parallel with a melli-ammeter.A double beam storage oscilloscope was incorporated and the circuit was connected to a personal computer for analysis. Samples were mounted in place and the H.V electrode was made from a hollow polished aluminum tube of proper diameter to eliminate corona .The high voltage was applied in steps of 1 kV/ minute until the flashover occurs. In parallel with that the leakage current is recorded after 3 minutes of voltage application to eliminate transient state. Each test was repeated for five times and the average value was reported. During testing arcing was eliminated and the values of leakage current was recorded for different percentage of flashover voltage applied to the samples as shown in fig (4).
Contaminants were wetted with water and were pressed to be in the form of discs .All specimens were applied in the test cell of fig (3). Good contract was ensured and the surface conductivity was measured using an accurate electrometer in parallel with a chart recorder .The results are shown in fig (5).
The samples were tested in a H.V Schering bridge to determine the dielectric losses (tanδ) both for polluted and clean insulators. The capacitance of samples was measured.

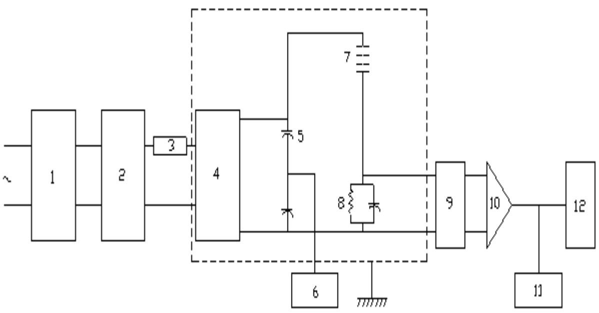

Fig.2 Experimental Circuit

1 : Mains Suppressor.2 : H.V. AC source.3 : H.V. water resistor.
4 : Low Pass Filter. 5: Blocking H.V. capacitor.
6 : High Voltage measuring instrument. 7: Test Sample.
8 : Detection R-C Circuit.9 : Matching Impedance.
10 : Pulse Shaping Amplifier.
11 : Double Beam Storage Oscilloscope.
12 : Leakage Current Detector.

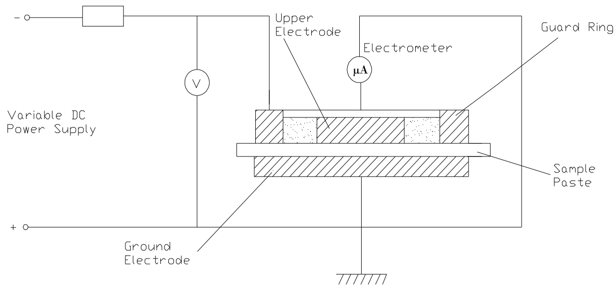

Fig.3 Measurement of Conductivity

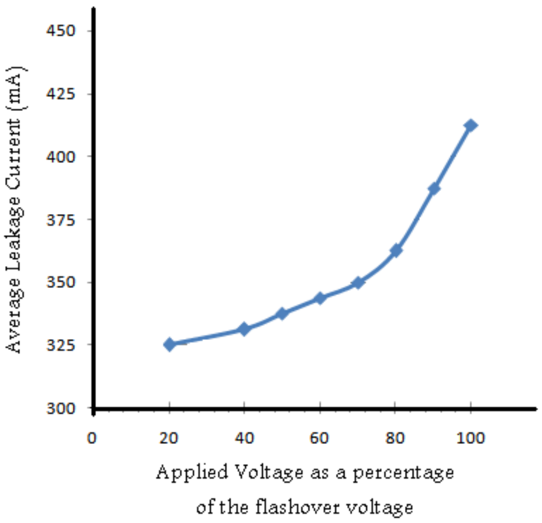

Fig.4 Leakage Current Measurements

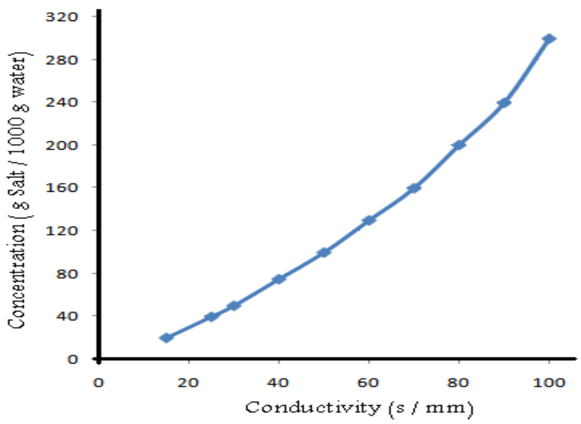

Fig.5 Conductivity Measurements

After the electrical investigations were made, the contaminants were washed with water and deried and chemically analyzed and the equivalent salt deposited density (ESDD) was found. Tests were performed to determine the density of the deposited amount of soluble salts in it.

RESULTS AND DISCUSSIONS

(i) The flashover voltage of contaminated insulators with the measured leakage current is shown in Table I.
It can be observed that flashover usually occurred when the leakage current reaches 300 to 450 mA.
It can be seen that the higher the salt deposited density on the insulator, the greater the leakage current
It is clear from the results of the flashover measurements that the hand cleaning of outdoor insulators drastically increases the flashover voltage and reduces the leakage currents by almost 75% of its original value while wetting the contaminations reduces the flashover voltage and increases the leakage current to about 150%.
ii) the dielectric losses (tan δ) and the capacitance of samples is shown in table II the results show that the dielectric losses are increased by the degree of pollution also the capacitance of the samples is almost doubled by pollution.
The pollution increases the conductivity on the insulator surface This may be attributed to the increase in the contaminations permittivity and loss tangent which adds to the dryness of the leakage path which advances the strike of arcs.
iii) It is clear that the leakage current increase by increasing the flashover voltage as shown in fig (4).
(iv)The results showed an increase in conductivity according to the salt concentration in the contaminant and vice versa. This may be attributed to the mobility of main charge carriers compared to the mobility of minor carriers. It has been noted that the conductivity of the deposited pollution depends on the type of salt in this location and the thickness of the deposited layer. It also depends on the shape and dimensions of the insulator (leakage path) fig (5).
(v) Tests indicated 9.8% of calcium sulfate (ca so_4), sodium chloride (Na cl) about 4% and potassium chloride (K cl) about1.5%.Traces of calcium oxide and sulpher dioxides were detected.

MECHANISM OF FLASHOVER

Flashover on polluted insulators is due to the formation and growth of pre-discharge due to the formation of an electrolyte film on the surface and the ignition of pre-discharges may lead to the ionization of ambient air to produce atomic ozone which oxidizes atmospheric nitrogen in the existence of water vapors forming nitric acid which attacks the surface of insulator and decomposes its chemical structure This may increase the leakage current and the conductivity of the path The leakage current produces dried areas and the formation of electric arc in the dried areas which enhance tracking of arc and raise the surface temperature that a drastic decrease in the conductivity which leads to the formation of carbonized paths , erosions and final flashover

Table I: Flashover Voltage and leakage Current. Location: Marabilla on the West Coast of Alexandria.

Sample Number	Circuit Number	Tower Number	Flashover Voltage (kV)	Leakage Current (mA)
1	I	82	P: 114 C: 129	495 340
2	I	84	P: 110 C: 125	426 364
3	II	74	P: 117 C: 141	416 374
4	II	78	P: 118 C: 130	400 350
5	I	68	P: 115 C: 127	446 362
6	I	70	P: 120 C: 127	396 364
7	II	87	P: 117 C: 127	400 374
8	II	89	P: 112 C: 129	396 370
9	II	93	P: 115 C: 128	445 350
10	II	91	P: 118 C: 128	407 350

P: Polluted. C: Clean

Table II: Loss Tangent and Capacitance Measurements. Location: Marabillaon West Coast of Alexandria

Sample Number	Circuit Number	Tower Number	Loss Tangent (x 10^{-4})	Capacitance (pF)
1	I	82	P: 74 C: 36	43.5 32
2	I	84	P: 80 C: 34	55 36
3	II	74	P: 70.3 C: 33.3	50.1 25.1
4	II	78	P: 70 C: 33	50 26.2
5	I	68	P: 70 C: 34	50 24
6	I	70	P: 60 C: 33.2	45 28
7	II	87	P: 85 C: 28	63 23
8	II	89	P: 75 C: 42.5	53 30
9	II	93	P: 81 C: 35	44
10	II	91	P: 70 C: 30	50.5 28

CONCLUSIONS

- Insulator contamination has become a major problem in the operation of electrical power systems which decreases the flashover performance of the insulator and sometimes causes the complete failure. This can be overcome by increasing insulator leakage path by either adding additional units.
- Surface leakage currents are considered one of the most serious problems of insulators in service.
- Leakage currents lead to dry band arcing and this sometimes results in a flashover which could cause power outage.
- Pollutions deposited on insulators become a conductive electrolyte when the insulators surface is wetted by either rain or fog which increases the leakage current on the surface and decreases the electrical withstand voltage of the insulator.
- The mechanism of flashover and final breakdown of polluted insulators can be explained in the light of the type of contamination and the environment which is strong related to the location. It will be possible to choose the most suitable insulators for certain region and the factors of inhibition of insulators flashover.
- It was concluded that the conductivity of the contaminant depends upon the chemical constituents of the materials, the percentage of salt, the thickness of deposited layer ambient temperature and humidity i.e. the environmental conditions. It also depends upon the shape of insulator.
- It was generally observed that natural pollution is increased in regions where chemicals and metals are manufactured also in coastal areas on the sea side.
- It was observed that the problem of flashover is severe in marine environments where salt particles can deposit on the insulator surfaces. These deposits decrease the surface resistance of the insulator and increase the leakage current.

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