

Technique of dry washing of the insulators of the electrical nets of distribution

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Abstract.

This article has for objective a technological innovation that will make possible the cleaning the dry one, of the insulators used in the electrical system, substituting the fluid used in the cleaning of the insulators of the water for air. The current cleaning of insulators of glass and porcelain is made with water. The cleaning of the polymeric insulators is not recommended by the conventional method in view of its main characteristic that is the hygroscopic property (capacity to absorb humidity of air). Computational simulations had been used for the verification of the behavior of the fluid used in the cleanness in one determined surface (surface this that is the insulator). The simulations had been made through called software CFD. Through this software the profile of the surface is chosen to be attacked by the fluid. With this it can be gotten the adjusted levels of pressure for the experiment. The insulators used in the tests had been polluted artificially in two ways, through a saline mist chamber and a manual method. The methods of cleanness used had been two. The first one uses an air compressor and the other uses gas cylinders nitrogen.

Key words

Dry washing, insulators, pollution, flashover, water.

1. Introduction

Pollution and oxidation are phenomena that create aggressors and degrading agents of the electrical materials, mostly the insulators of the electrical nets.

The environmental pollution generates, mostly, the decreasing of the dielectric capacity of the insulators, reducing its isolating performance, consequently increasing the occurrence of the “flash over” discharges and reducing the mechanical resistance of the insulator and other materials [1].

To ensure the continuity of the electrical system the maintenance companies use specialized equipments and technical procedures where we can point out the washing services of the energized lines, nets and substations.

The convectional washing system, that uses treated water, it is not only a very expensive process but also an environmentally inadequate. The water, one of the most valuable patrimonies that human kind owns nowadays, after the washing process is totally disposed. At the northeast this problem occurs mostly in the coastal cities forcing the electrical companies to make the washing process only after the raining period.

Currently are used 8000 liters of treated water to wash the amount between 60 and 70 medium tension structures.

This article brings a new and environmentally correct technique of cleaning the insulators without the use of water, with an insulator dry washing procedure. This technique is being developed by a partnership between the department of electrical engineer of the Universidade Federal do Ceará and COELCE.

2. Simulation

For the definition of the pressure, distance and angle of attack of the cleanliness nozzle was developed a three-dimensional computational model of the system insulator-nozzle. The system used the CFD (Computational Fluid Dynamics), package of programs of the ANSYS for a computational solution involving the fluids dynamics, being used the method of the finite volumes. It has two ways of solution. Steady-state solution and solution of transient state. The steady-state solution is fast, however it does not possess allegiance with the reality until the moment where it converges. The solution of transient state is slow, however it possess allegiance of time in the resolution. Analyzing all the simulations that converged, we verify that the simulations for the lesser pressures lasted around 24 hours and for the biggest pressures, lasted around 96 hours to stabilize. The simulation was made in the Laboratório de Eficiência Energética em Sistemas Motrizes Industriais LAMOTRIZ – DEE. Specifications of the computer: Processor Intel Core2Duo E4300 2,2 Ghz; Mother-Board Intel Essential Series; 2 Memory cards Kingston 1Gb 667Mhz.

The simulations have been made for nozzles with diameters: 0,5mm, 1,0mm, 2,0mm and 3,0mm. The used attack angle was 30° and a distance of 6 cm of the nozzle to a point in the insulator's surface. The insulator's dry washing technique was simulated for the following pressures: 2 bar, 5 bar, 10 bar, 15 bar, 20 bar, 30 bar, 40 bar and 50 bar, so with that is possible to obtain the dragging force. For the validation of the results, laboratory tests were made with an industrial alternative compressor, which did not presented a good pressure control. With the intention of obtaining better pressure control, a system with 6 nitrogen gas cylinders was used to make the cleanliness of the insulators. By the results, it was observed that the pressure to be used in the exit of the nozzle must be bigger that 30 bar. Only from this pressure, the simulation presented a significant field of forces acting on the surface of the insulator. In the simulation was given priority to the nozzle of 2 mm of diameter, since the nozzle used in the cleanliness tests also had this diameter. The image of the simulation can be seen in Figure 1.

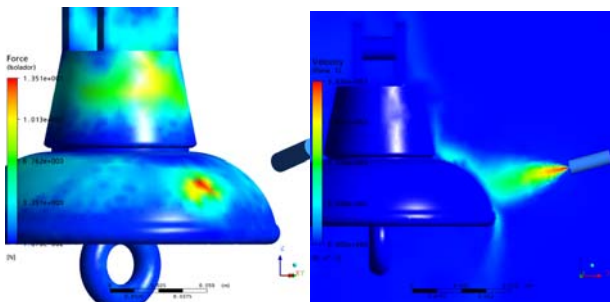


Fig. 1. Simulation for pressure of 30 bar and nozzle of 2mm

3. Methodology

A. Current method of Cleanness (water)

The accompaniment in a line of sub-transmission of 69 kV was made. The washing was made in a structure of anchorage through a robot installed in a hydraulical arm of a truck, operated remotely of the ground for two electricians (Fig. 2).

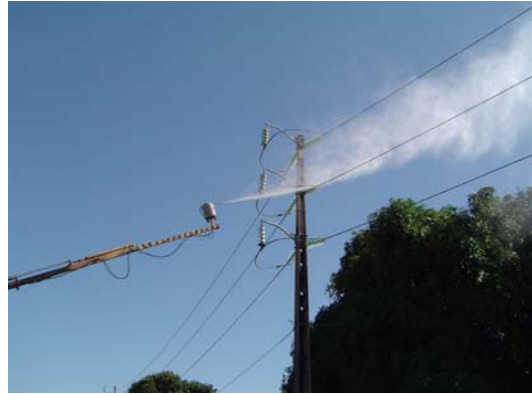


Fig. 2. Washing with robot

For the structures of suspension, a different method was used. An electrician scales the structure and manually effects the service of washing of the insulators with a pistol. The other electrician follows the procedure of the ground (Fig. 3).



Fig. 3. Washing with pistol

It was observed that in the two methods the line was off, however normally when the robot is used, the washing can be made with the energized installations and it is not necessary treatment for the water. But the water must be potable. In the method where the electrician scales the structure the washing is made with the treated and demineralized water. Therefore, this shows the great waste of water in the cleaning of

insulators, and the care with the quality of the water to perform the service with the line energized.

B. Methods of Artificial Pollution

Before the first salinization was measured the leakage current of insulators completely clean, to use these measures as a reference. This test was done in B & Q Eletrificações LTDA. Initially the test in saline mist chamber was used as a method of salinization. A manual method was used later.

- 1) *Saline Mist Chamber.* Tests of artificial pollution in saline mist had been made with chains of 3 insulators type suspension. The test was made in the division of chemistry of the NUTEC. The insulators remained for 6 hours in the chamber subjected to a mist generated by a solution of sodium chloride (NaCl) with salinity of 5%. It was also tested to keep the insulators with the same concentration of saline solution, but for a time of permanence in the chamber biggest, 24 hours. Another configuration for the test was to increase the concentration of the solution for 10% and to keep the insulator in the chamber for 6 hours. The chain of insulator, after the cleanness procedure, must be in an environment free of pollution until the moment of the test of leakage current. Some tests in the saline mist chamber have been made with a bigger concentration of the saline solution (of 30%), with the objective to become the pollution on the surface of the insulator most intense. It can be concluded that it did not have a significant increase of the salt concentration on the surface of the insulator for this method of salinization.
- 2) *Manual Method.* There is another method of artificial pollution that differs from the method of salinization in the saline mist chamber. This method is made in manual mode, through a sprinkler (Fig. 4). The concentration of salt used in solution was 35%, value next to the saturation condition of the solution of NaCl that is of approximately 35.8%. The procedure for the application of the saline solution in the insulators is simple and fast. The insulators are suspended for hooks that are part of a wooden box used for the transport and sustentation of the chains of insulators. With the chain settled in the support, the sprinkler is used. It contains the saline solution of 35%, which is applied two or three times on each insulator. After the first application the chain is placed to the sun to dry. In case of rainy weather an electric dryer is used. It is kept away not to drag the solution that is on the insulator. After that

another application of the solution is made, as well as made in the first application. The drying process is made in the same way.



Fig. 4. Manual method of pollution

C. Method of Dry Washing

Two methods of dry washing have been used. First an industrial compressor was used and at another moment was used a system of cylinders of nitrogen gas to clean the insulators. The insulators used in the tests are insulators of suspension of the disc type of porcelain. These two methods have been used for use in laboratory and proof of the method of cleanness. After this stage will be specified a compressor with the characteristics adjusted for the process of cleanness in the electric net.

- 1) *Compressor.* The compressor used in the tests of cleaning has 12 bar pressure. The flow of air from the compressor is very low and it does not have a reservoir of air. The average level of pressure reached in the tests was 10 bar. The tests have shown that the air has capacity to drag the pollution of the insulator, but with these conditions of the compressor the cleanness is not very efficient. In function of the difficulty of providing high-pressure compressors, plus the high cost, a change in the method of dry washing was proposed. The proposal was the use of pressurized nitrogen gas.
- 2) *Cylinders of Nitrogen Gas.* Exists in the local market the trade of industrial gases (including the nitrogen) that are distributed in cylinders of 10 m³ and with a pressure of 200 bar. A system supplied by nitrogen (our air is composed of 78% nitrogen) was mounted through six cylinders in series to perform the tests. This avoids the purchase of a compressor for testing. The structures used such as pipes and supports have high mechanical strength to withstand the operating conditions at high pressure. The insulator must be in the vertical position to simulate a very common configuration in the

electric net. The positioning of the hose is made in manual mode. The system has a regulating valve of pressure in the outlet and a flexible hose in stainless steel that serve to direct the jet of nitrogen in insulators (Fig. 5).



Fig. 5. Valve of pressure

The high-pressure system feeds the nozzle of cleanliness through a circuit of metallic pipes without sewing and a flexible metallic hose. The chain of insulators was adapted in a system of sustentation that facilitated a turn of 360°, with the objective to apply the gas in the pressure adjusted in all the surface of the insulator getting cleanliness uniform. The cleanliness nozzle is fixed in a mechanical lever to facilitate its handling. Several tests were performed in chains of glass insulators to provide a safe and accurate operation (Fig. 6).



Fig. 6. System of sustentation

These tests have as objective to validate the results numerical of the simulations and to verify the capacity of cleanliness of air (in this test with nitrogen) for diverse levels of pressure and pollution of the insulators in

laboratory, allowing with this to specify accurately the equipment to be used in field. The cylinders are connected to a register that possess 6 entrances (Fig. 7). The register possesses a valve for pressure control, a valve for control of the outflow and a manometer (measuring of pressure).



Fig. 7. System of nitrogen

The fixing of the hose is made through a structure with a metallic base (like a table) with a rotating mechanism on the base and a metallic bar tied to the rotating mechanism. The hose is stuck on the side of the metallic bar so that it can move laterally and up and down (Fig. 8).



Fig. 8. Fixing of the hose and rotating mechanism

With the use of this structure of cleanliness in laboratory some tests have been carried through and some results have been gotten.

4. Results

With the values of the leakage current of the chains of insulators totally clean as reference, these chains have been polluted and then measure its leakage current. After this measurement was used the method of cleanliness with gas nitrogen. With the measurement of leakage current after cleaning this value was compared with the value of the chain of polluted

insulators and was verified that the leakage current was reduced. Some results are shown below.

TABLE I. – Insulator 1 completely clean

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
CLEAN	5	12,80	-
	10	30,50	-
	15	48,30	-
	20	66,10	-
	20T	70,10	3

TABLE II. - Insulator 3 completely clean

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
CLEAN	5	12,80	-
	10	28,70	-
	15	46,30	-
	20	64,00	-
	20T	61,90	3

TABLE III. - Insulator 1 salinized manually

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
SALINIZED	5	33,70	-
	10	66,70	-
	15	98,60	-
	20	133,50	-
	20T	137,30	3

TABLE IV. - Insulator 3 salinized in saline mist chamber

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
SALINIZED	5	22,50	-
	10	44,10	-
	15	65,30	-
	20	85,50	-
	20T	84,90	3

TABLE V. - Insulator 1 clean with nitrogen gas

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
CLEAN	5	16,00	-
	10	33,00	-
	15	52,00	-
	20	70,00	-
	20T	69,00	3

TABLE VI. - Insulator 3 clean with nitrogen gas

Condition	Applied Voltage (kV)	Leakage Current (uA)	Test Time (Minutes)
CLEAN	5	15,00	-
	10	31,00	-
	15	48,00	-
	20	64,00	-
	20T	64,00	3

5. Conclusion

It was observed a decrease in leakage current after cleanness, but was not reached a level of complete cleanness. This limitation is also due to insufficient flow. With an increasing flow the pressure can be reduced and more satisfactory results will be gotten.

References

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