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Corona Degradation On Insulators

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Abstract: **With the ever increase in the demand of power, there is a need to transfer bulk energy from the generating end to transmission end y means of transmission line. As demand increases, there is a need for transmission of power in high voltage. Hence outdoor insulators play an important role. Insulators are subjected to corona over a long time in its lifespan sometimes even under clean condition. This may be due to lack of proper design or due to faulty manufacturing. In this paper a comparative study of effect of corona has been made on newly emerging polymeric insulators and already existing porcelain insulators.**

Keywords: *Polymeric, Corona discharge, porcelain.*

I. INTRODUCTION

An electrical insulator is a material whose internal electric charges do not flow freely; very little electric current will flow through it under the influence of an electric field. When subjected to a high enough voltage, insulators suffer from the phenomenon of electrical breakdown. When the electric field applied across an insulating substance exceeds in any location the threshold breakdown field for that substance, the insulator suddenly becomes a conductor, causing a large increase in current, an electric arc through the substance. Electrical breakdown occurs when the electric field in the material is strong enough to accelerate free charge carriers (electrons and ions, which are always present at low concentrations) to a high enough velocity to knock electrons from atoms when they strike them, ionizing the atoms. These freed electrons and ions are in turn accelerated and strike other atoms, creating more charge carriers, in a chain reaction. Rapidly the insulator becomes filled with mobile charge carriers, and its resistance drops to a low level. The insulation specifications of gaseous, liquid, and solid insulating materials are very important in high voltage technology. For many years research has been done on the types of materials that are used for electrical insulation. The research has revealed that the best material for electrical insulation is the polymeric material. Over the past many years, insulators were made of porcelain and glass. These were the best before the invention of the polymeric insulating materials since they had very little effects on the environment and were also stable. However, these insulating materials proved to be so heavy in weight hence their installation was so hard and involving. They were also expensive and brittle and so were so liable to breakages under small stress and pressure. As a solution to all these, the polymeric insulators came to the market with the advantages of being so light, affordable and very flexible to breakages. It also has the advantage of resistance to vandalism and poses better dielectric properties.

The most commonly found insulators are

- Pin type
- Suspension type
- Strain type
- Shackle type insulators

Pin type insulator: Pin insulator normally consists of non conducting material like glass, wood, plastic or polymer. This insulator can be used for voltages up to 33KV.

Suspension type insulator: For voltages beyond 33kv it is in practice to use this type of insulator consisting of number of porcelain disks connected in series by metal links in the form of string. The conductor is suspended at the bottom of this string and other end is secured to the cross arm of the tower. Each unit or disk is designed for low voltage of 11kv.

Strain type insulator: This type of insulator is used when there is dead end in the line or if there is a sharp curve or if there is corner. This is because at such conditions the line is subjected to greater stress. This type of insulators relive such stresses and strain.

Shackle type insulators: This type of insulators were used in earlier days as strain insulators. But nowadays they are used for low voltage distribution lines. Such insulators can be used either in a horizontal position or in a vertical position. This type of insulators can be directly fixed to the pole with a bolt or to the cross arm.

II. CORONA DISCHARGE

A **corona discharge** brought on by the ionization of a fluid such as air surrounding a conductor that is electrically charge. Corona can be observed in various forms such as glows and halos , spots, brushes and streams. The potential at which corona originates is called corona threshold voltage.
Above this voltage, there is a limited

region, in which current increases proportionately with voltage. This is called the **Ohm's law regime**. After this region the current rise will be more rapid, which leads to breakdown, sparking or arcing. If Q is the total charge stored in a conductor and $\boldsymbol{r}$ is its radius of curvature, the electric field intensity E is inversely proportional to the radius, as given by the following equation, where ε0 is the permittivity of free space (and air) and is equal to 8.852 x 10-12 F/m.[1]

$$E=Q\backslash 4\pi\varepsilon 0r$$

Considering a transmission line, when an alternating current is made to flow through them, they will be subjected to stress. When the voltage is low the stress due to voltage will be low. But when the voltage is high, the stress also increases. If the potential is increased beyond 30Kv/cm known as critical disruptive voltage, the air surrounding it will experience enough stress to dissociate into ions which makes the surrounding air conductive. There will be an electric discharge around the conductor due to flow of ions which results in giving rise to a faint luminescent glow and hissing noise accompanied by liberation of ozone.[2]

Corona can reduce the reliability of the system by causing degradation of insulation. Although corona is a low voltage process, it can cause substantial degradation of insulators and can lead to failure of system due to dielectric breakdown. The effects of corona are permanent and if not taken care can cause failure without any warning[3].

Corona calculations are as follows:

For Concentric Cylinders in Air:

• Corona will not form when RO / RI < 2.718.

(Arcing will occur instead when the voltage is too high.)

For Parallel Wires in Air: • Corona will not form when X / r < 5.85. (Arcing will occur instead when the voltage is too high.)

For Equal Spheres in Air: • Corona will not form when X / R < 2.04. (Arcing will occur instead when the voltage is too high.)[4]
• Arcing difficult to avoid when X / R < 8

Where

• RO = Radius of outer concentric sphere

• RI = Radius of inner concentric sphere

• R = Sphere radius
• r = wire radius

• X = Distance between wires or between spheres
Corona discharge has the following disadvantages :

- Corona is accompanied by a loss of energy. This affects the transmission efficiency of the line.
- Ozone is produced by corona and may cause corrosion of the conductor due to chemical action.
- The current drawn by the line due to corona is non-sinusoidal and hence non-sinusoidal
- Voltage drop occurs in the line. This may cause Inductive interference with neighbouring Communication lines.

Corona discharge has following advantages

- Due to corona formation, the air surrounding the conductor becomes conducting and hence virtual diameter of the conductor is increased. The increased diameter reduces the electro-static stresses between the conductors.
- Corona reduces the effects of transients produced by surges

III. EXPERIMENTAL SETUP

The experimental setup for our experiment was carried out as follows:

Point to point configuration

Figure 1: Setup for point to point configuration

The setup was made by using two point electrodes in which one of them was connected to high voltage source while the other electrode was grounded properly. A gap of 35mm was kept between the electrodes. High voltage will be applied and breakdown of gap occurs. The setup is as shown in Figure 1.

porcelain insulator

Figure 2: Setup for transformer to porcelain insulator

A porcelain insulator was connected to a transformer by means of wire .The rating of the transformer is 50KV,50mA.

Voltage was applied by means of control panel. The setup is as shown in Figure 2.

Transformer to polymeric insulator

Figure 3: Setup for transformer to polymeric insulator

A similar setup which is same as that of "Transformer to porcelain insulator" was made for polymeric insulator . The only change made here is that instead of porcelain insulator a polymeric insulator was placed instead. The setup is as shown in Figure 3.

IV. TEST RESULTS AND ANALYSIS

Point to point configuration

Figure 4: Corona formation on point to point configuration at 22KV

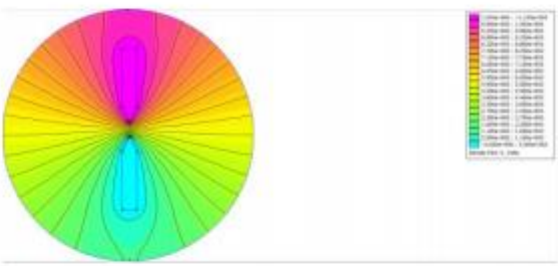

Figure 5: FEMM analysis of point to point configuration

The test was conducted under dry condition. The spacing between the electrodes is 35mm. Corona was formed at 22KV and breakdown of gap occurred at 28KV. Figure 4 shows the corona formation and Figure 5 shows the FEMM analysis of the same.

Transformer to porcelain insulator

Figure 6:Corona formation on 11KV porcelain insulator at 50KV under wet condition

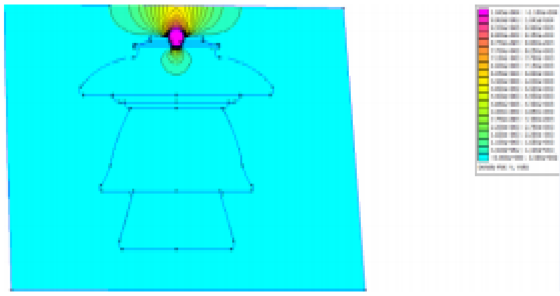

Figure 7: FEMM analysis of 11KV porcelain insulator

The test was conducted under wet condition where water was sprinkled on the insulator and high voltage was applied to it. The applied voltage is 50KV. Figure 6 shows the corona formation and Figure 7 shows the FEMM analysis of the same.

Transformer to polymeric insulator

Figure 8: Corona formation on 11KV polymeric insulator at 50KV under wet condition

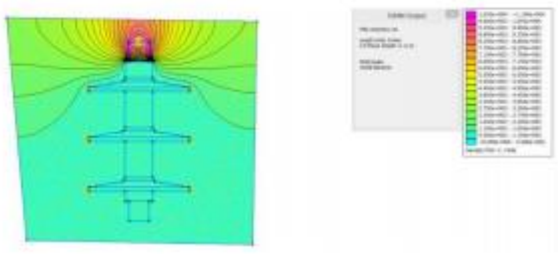

Figure 9: FEMM analysis of 11KV polymeric insulator

This test was also conducted under wet condition where water was sprinkled on the insulator and high voltage was applied to it. The applied voltage is 50KV. Figure 8 shows the corona formation and Figure 9 shows the FEMM analysis of the same. A test on above insulators was also conducted under salt water condition. About 500 grams of salt was added into approximately 5 litres of water. Both the insulators were dipped in the salt water solution for two days and dried in sunlight. Also salt water was also sprinkled on the insulator again. Salt deposition on insulators causes corona formation on insulators at lower voltages. This test was done in order to simulate insulators installed near coastal areas Once salt water is sprinkled, high voltage is applied to it. The applied voltage is 50 KV. Figure 10 and Figure 11 shows the corona formation on both the insulators.

Figure 10: Corona formation on 11KV porcelain insulator under salt water condition at 50KV

Figure 11: Corona formation on 11KV polymeric insulator under salt water condition at 50KV

The laboratory condition during the test is as follows: Lab temperature: 32°C Humidity: 69%.

V. CONCLUSION

we can conclude that porcelain insulators are more susceptible to corona formation than polymeric insulators. Corona formation leads to degradation of insulators on the long run. Over time the insulators lose their withstanding property, thus causing failures in the power system. For testing purposes we have applied a voltage of nearly 5 times that of insulators designed voltage. The application of such high voltage was made to both porcelain and polymer insulators The property of porcelain insulators are such that, if the environment contains pollutants like dust, micro particles or any other pollutants, then corona formation occurs faster than when in normal environment. On the other hand, polymeric insulators which are made of polyethylene materials, has better withstanding capacity in polluted environments. Thus by using polymer type insulator we can reduce corona significantly. Also polymer insulators are light weight and they have better flashover performance when compared to porcelain insulator. Polymer can be a good substitute for porcelain because of its various advantages it has over porcelain.

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