Investigation into Effects of Corona on Insulators

Ramesh E
Asst.Professor
Dept. of E&EE
Canara Engg. College

Udita joshi
UG Student
Dept. of E&EE
Canara Engg. College

Sashank
Student Dept. of E&EE
Canara Engg. College

Madan Kumar J
Student Dept. of E&EE
Canara Engg. College

B H Charan Raj
Student Dept. of E&EE
Canara Engg. College

***Abstract*: With ever increasing energy demand, transmission of the bulk electrical energy from generation to consumers is a challenging task, for which the outdoor transmission insulators have a significant role. Insulators can be subjected to corona when used for long periods of time even under relatively good condition due to localized high electric field brought about by design and/or manufacturing deficiencies. Corona has been identified as one of the major factor in degradation of insulators. Polymeric insulators are the newly emerging insulators and it has been significantly used in transmission system because of its advantages. In spite of the better advantages the degradation of polymeric insulators is not completely understood, also the standard testing methods to evaluate the polymeric materials have not been completely evolved. In the present work the Corona Degradation studies are conducted on different types of insulator samples. A specially designed HV source along with the Corona chamber is employed and same is being simulated using FEMM. Results of the experimental investigation obtained for various samples are analysed.**

Keywords: Artificial raining, corona discharge.

General Terms: Polymer, Porcelain, Corona, FEMM.

I INTRODUCTION

As there was increase in demand for power, there was need for transmission and distribution lines throughout the world. Most efficient way to make it happen was to transmit HVDC and HVAC. These transmission lines has insulators to protect these conductors from abnormal conditions. An insulator is a material whose internal electric charges do not flow freely. A very little electric current will flow through it when electric field is applied. When subjected to a high voltage, insulators suffer from the phenomenon of electrical breakdown. When the electric field applied across an insulating substance exceeds the threshold breakdown voltage, it instantly becomes a conductor causing a large increase in current, an electric arc through the substance.

This failure of insulator with a hissing noise due to ionization of surrounding air is called as Corona. 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.

Insulators are mainly classified as

- 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

When p.d.is applied between the conductors, potential gradient is set up in the air which will have maximum value at the conductor surfaces. Under the influence of potential gradient, the existing free electrons acquire greater velocities. The greater the applied voltage, the greater the potential gradient and more is the velocity of free electrons. When the potential gradient at the conductor surface reaches about 30 kV per cm (max. value), the velocity acquired by the free electrons is sufficient to strike a neutral molecule with enough force to dislodge one or more electrons from it. This produces another ion and one or more free electrons, which is turn are accelerated until they collide with other neutral molecules, thus producing other ions. Thus, the process of ionization is cumulative. The result of this ionization is that either corona is formed or spark takes place between the conductors.

When an alternating current is made to flow across two conductors of the transmission line whose spacing is large compared to their diameters, then air surrounding the conductors (composed of ions) is subjected to dielectric stress. At low values of supply voltage, nothing really occurs as the stress is too less to ionize the air outside. But when the potential difference is made to increase beyond some threshold value of around 30KV known as the **critical disruptive voltage**, then the field strength increases and then the air surrounding it experiences stress high enough to be dissociated into ions making the atmosphere conducting. This results in electric discharge around the conductors due to the flow of these ions, giving rise to a faint luminescent glow, along with the hissing sound accompanied by the liberation of ozone, which is readily identified due to its characteristic odour. This phenomenon of electrical discharge occurring in transmission line for high values of voltage is known as the **corona effect in power system**. If the voltage across the lines is still increased the glow becomes more and more intense along with hissing noise, inducing very high power loss into the system which must be accounted for.

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

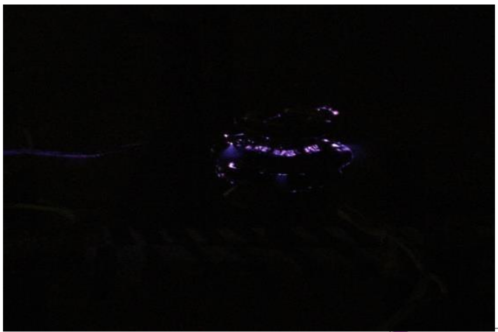
The experimental for our experiment was carried out as follows:

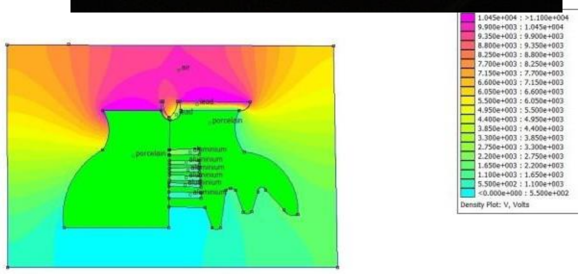
Transformer and porcelain insulator connection

Figure 1: Setup of transformer connected to porcelain insulator

A porcelain insulator was connected to a transformer by means of aluminium wire .The rating of the transformer is 50KV, 50mA. Voltage was applied by means of control panel. The setup is as shown in **Figure 1**

Figure 2: Corona formation on 11KV porcelain insulator when 50KV was applied





Transformer to porcelain insulator

Figure 3: FEMM analysis of 11KV porcelain insulator

The test was conducted under wet condition where water was sprinkled on the insulator (artificial raining) and high voltage was applied to it. The maximum voltage to be applied is 50KV.Voltage is varied from 0KV till hissing noise is heard and increased till the visual corona occurs and hence channel formation on the surface of insulator is observed. **Figure 2** shows the visual corona formation and **Figure 3** shows the FEMM analysis of the same.

ISSN: 2278-0181
ICRTT - 2018 Conference Proceedings

Transformer and polymeric insulator connection

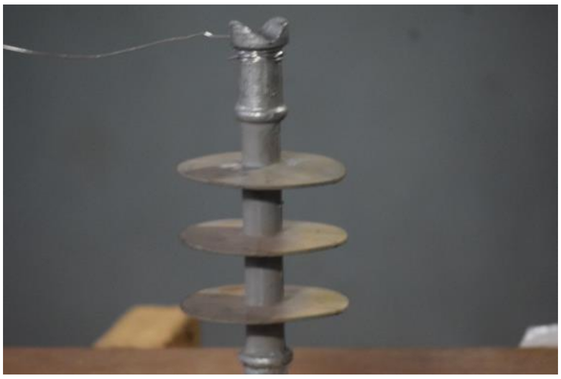


Figure 4: Setup of transformer connected to polymeric insulator

A similar setup which is same as that of **"Transformer connected to porcelain insulator"** is made for polymeric insulator .The setup is similar to that of **Fig 1** **.**The only change made here is that instead of porcelain insulator a polymeric insulator is placed. Same steps were followed for polymeric insulator until visual corona occurred and channel formation was observed. **Fig 5** shows the visual corona formation and **Fig 6** shows the FEMM analysis of the same.

Figure 5: Corona formation on 11KV polymeric insulator at 50KV

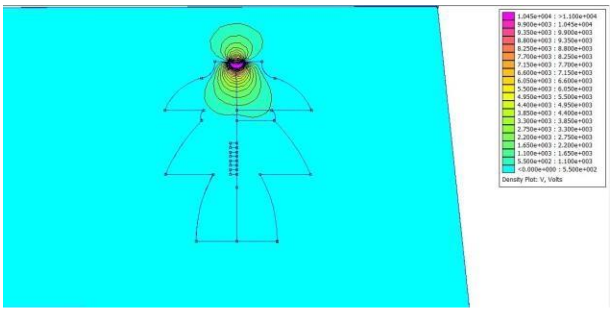


Figure 6: FEMM analysis of 11KV polymeric insulator

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 and
The laboratory condition during the test is as follows: Lab temperature: 45ºC
Humidity: 69%

IV. OBSERVATIONS

I) <u>Under normal conditions</u>,

porcelain insulator

- Hissing noise was heard at **8KV**
- Starting point of visual corona occurred at **28KV**
  - Channel formation was observed at **45KV**

polymeric insulator

- Hissing noise was heard at **22KV**
- Starting point of visual corona occurred at **35KV**
- Channel formation was observed at **45KV**

II) <u>Under artificial raining conditions</u>,

porcelain insulator

- Hissing noise was heard at **10KV**
- Starting point of visual corona occurred at **35KV**
  - Channel formation was observed at **50KV**

polymeric insulator

- Hissing noise was heard at **28KV**
- Starting point of visual corona occurred at **38KV**
- Channel formation was observed at **50KV**

V. CONCLUSION

It can be concluded from the observations made after the experiment that porcelain insulator is more susceptible to corona in comparison to polymeric insulator for a given test voltage under both normal and artificial raining conditions. Polymeric insulator is a good substitute to porcelain insulator and is also light weight in comparison with porcelain insulator. The corona is more severe in porcelain insulator than polymeric insulator. Corona is more likely to happen in humid climatic conditions.

VI. REFERENCES

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