International Journal of
Science and Engineering Investigations vol. 2, issue 15, April 2013
ISSN: 2251-8843

Electric Field Distributions around Silicon Rubber Insulators in Polluted and Cleaned Area

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Abstract- This paper presents electric field and potential distribution calculations by using Finite Element based computational software along a 9-unit silicon rubber insulator string that is used in polluted and clean area with corna ring.

Generally, the field distribution of a composite long rod insulator set is more non-linear than of a set with conventional insulators.

This is caused by missing intermediate metal parts and by the dielectric material characteristics of the polymeric materials used for composite insulators.

The field distribution along composite insulators is mainly influenced by the earth and high voltage (hv) capacitances. The real situation can only be calculated numerically e.g. using the Finite Element Method (FEM). [3,4,5,6]

Keywords- *Corona ring; FEM; FRP; Insulator; Pollution*

I. INTRODUCTION

Composite insulators have been increasingly used by utilities to replace porcelain and glass insulators because of their advantages coming from lower weight, ease of handling, Hydrophobicity, high violet ray resistance , reduced installation and maintenance costs, etc.[7-10]

Hydrophobicity of any material is its resistance to flow of water on its surface. A material is highly hydrophobic if it resists to flowing water dropped on it and is least hydrophobic if dropped water flows in form of tracks on its surface. The hydrophobic surface is water repellent, in contrast with a hydrophilic surface that is easily wetted.[11-13] The number of units of an insulator string depends on several factors such as operation voltage, mechanical strength, sea level (of alignment), lightning strength, and contamination level of the environment.

Due to the coupling capacitance between disc insulators and conductors around them, the potential distribution of insulator string is uneven greatly.

The voltage and electric field on the insulators is variable.

And somewhere is greater than others, which may easily lead to corona, insulators' surface deterioration and even flashover.

These problems will seriously affect the operation safety of transmission lines. So the calculation of the electric field and voltage distribution in and around high voltage insulators is a very important factor in the design of the insulators.

This paper presents the results of 2D Finite Element calculations of the electrical field distribution along a 25 kV suspension insulator in polluted and clean condition with field control devices(corna rings)in Dry and Wet state .

This pollution is one of the main causes of flashover in the insulators. The insulator begins to fail when the pollutants that exist in the air settle in the surface of the insulator and combine with the humidity of the fog, rain, or dew. The mixture of pollutants, plus the humidity form a layer that can become conductor and allow passing currents that will facilitate the conditions of short circuit. This is due to a decrease of the resistance of the insulator surface. Unless there is a natural cleaning or an adequate maintenance, the electrical activity will be affected by a possible flashover in the insulator.[6]

1.1 CORONA RING EFFECT

The purpose of corona rings is to reduce the electrical field stress at the end fittings. They are required at the line end of all 230KV suspension insulators and at both ends of all 500KV polymer suspension insulators. Corona rings are designed for each manufacturer insulators. They are not inter-changeable.[6,14,15]

II. MODELLING OF INSULATOR STRING AND CORNA RING

Typically a composite insulator comprises a core material, end fitting, and a rubber insulating housing. The core is of FRP to distribute the tensile load. The reinforcing fibers used in FRP are glass (E or ECR) and epoxy resin is used for the matrix. The portions of the end-fitting that transmit tension to the cable and towers are of forged steel, malleable cast iron, aluminum, etc. The rubber housing provides electrical insulation and protects the FRP from the elements [6]. Figure 1 shows the structure of a composite insulator.

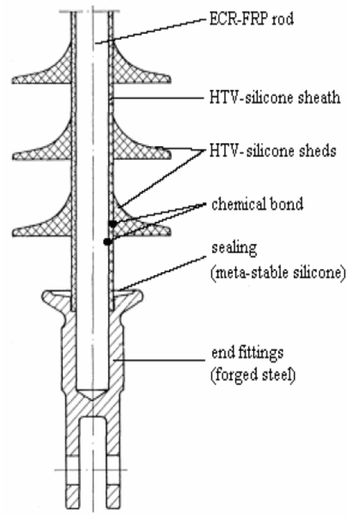

Figure 1. Structure of composite insulator

2.1 RELATIVE PERMITTIVITY CONSIDERED

Relative permittivities considered are given in below:

Air= 1, Silicon Rubber=3.45, FRP=7, Dry Salt= 5-6, Silt= 5-30, Water= 80. [17]

III. SIMULATION RESULTS

In this part the simulation result for clean condition, polluted condition and polluted condition with corona ring is presented. This result shows the effect of pollution and corona ring. Dry sand is used as pollution with relative permittivity 5.

3.1 Without pollution condition

In this part the insulator without pollution and without corona ring is simulated. Figure 2 shows the electrical field intensity distribution and electrical potential on surface of insulator without pollution.

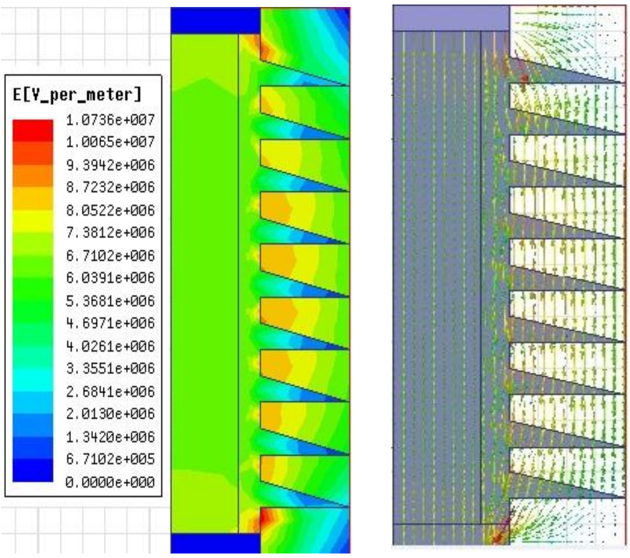

Fig. 2 A: Electrical field intensity

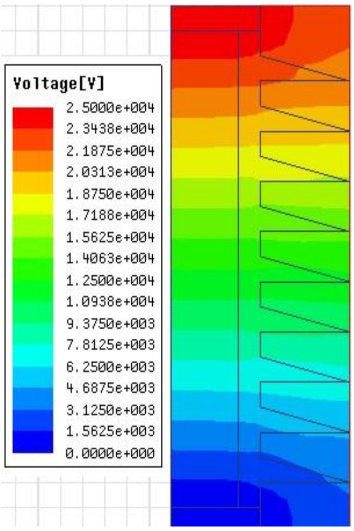

Fig. 2 B: Electrical potential distribution

3.2 Pollution condition

Figure 3 shows the electrical field intensity distribution and electrical potential on surface of insulator with pollution on the surface of insulator. To shows pollution condition and effect of that on electrical field intensity distribution and electrical potential, a layer of pollution is used on the surface of insulator. The pollution is layer of Dry sand and its relative permittivity is 5.

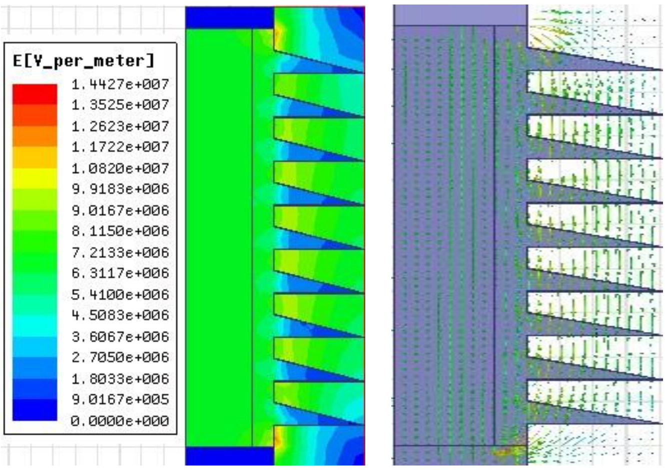

Fig. 3. A: Electrical field intensity

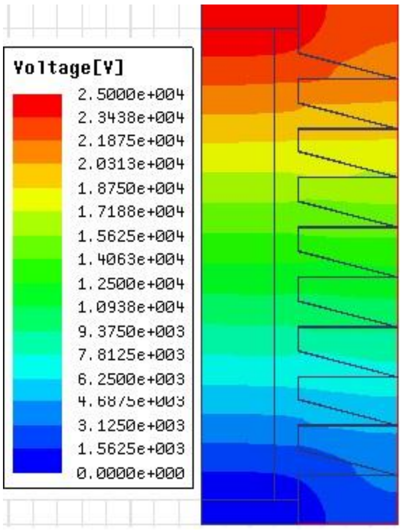

Fig. 3. B: Electrical potential distribution

Fig. 3. Electrical field intensity and electrical potential of insulator with pollution

We can find out of this figure the electric field to compare with clean condition intensity is increased[1] , so the probability of electrical break in polluted condition is more than the condition without pollution.[6]

3.3 Pollution condition with corona ring

At this case we can see the effect of pollution condition with corona ring on electric field and intensity and electrical potential on surface of insulator. Figure 4 shows the electrical field intensity and electrical potential distribution insulator with pollution on the surface of insulator with corona ring. From this figure we find out corona ring reduce the probability of electrical break down.[14,15]

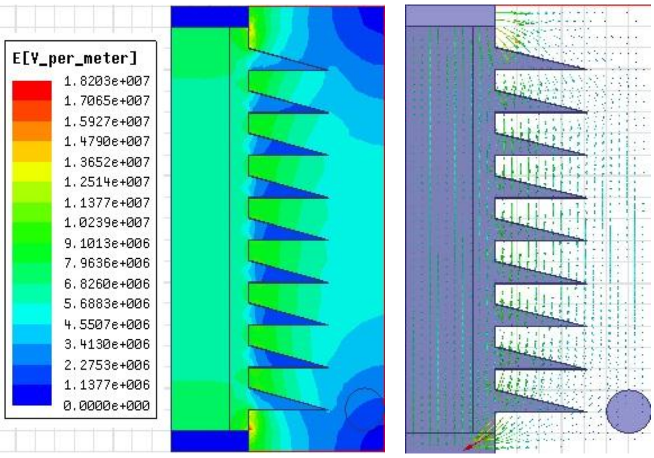

Fig. 4. A: Electrical field intensity

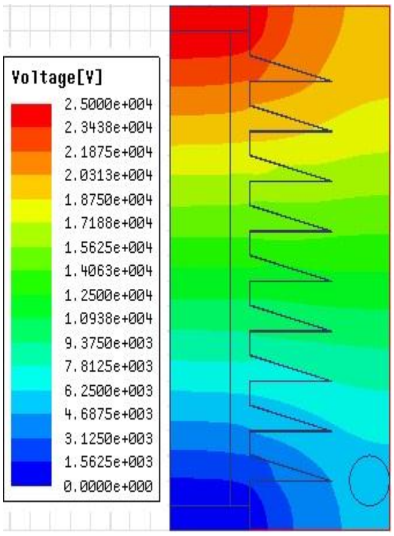

Fig. 4. B: Electrical potential distribution

Fig. 4. Electrical field intensity and electrical potential of insulator with pollution and corona ring

3.4 Pollution condition with spot hydrophobicity effect

At this case we can see the effect of pollution condition with spot Hydrophobicity effect on electric field and intensity and electrical potential on surface of insulator. [6,11-13]

Figure 5 shows the electrical field intensity and electrical potential distribution insulator with pollution on the surface of insulator with spot Hydrophobicity effect.

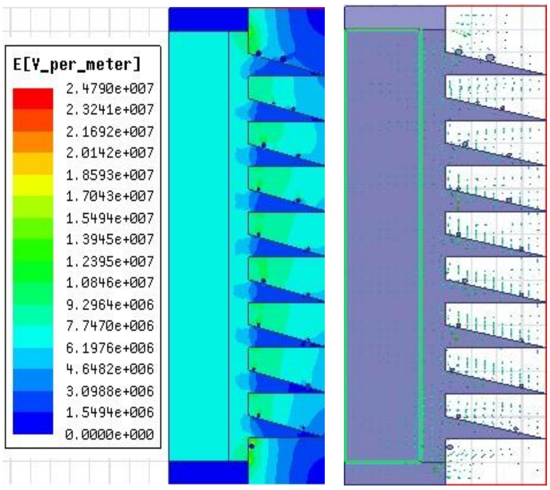

Fig. 5. A: Electrical field intensity

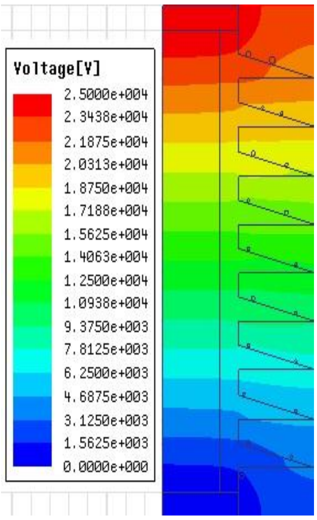

Fig. 5. B: Electrical potential distribution

IV. CONCLUSION

Here we study several cases, such as clean and pollution condition, effect of corona ring and finally the Hydrophobicity Effect of silicon rubber insulators. And we could see that the chance of electrical break down in polluted condition is higher of clear condition, and also we find out corona ring reduce the probability of electrical break down.

Finally we consider combination of pollution and humid on the surface of silicon rubber insulators and we find out chance of electrical break down in this case is higher of another cases.

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