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E-distribution of Composite Insulator

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ABSTRACT: Outdoor insulators are major elements of overhead transmission lines. They provide transmission line support as well as insulation between the overhead conductor and the supporting structure. Because of their advantages over traditional porcelain or glass insulators, polymeric or silicon rubber insulators are widely used in high voltage transmission and distribution systems. The electric field distribution within and around the high voltage insulator is a key factor of insulator design. Knowledge of the electric field distribution and other electrostatic properties are useful for detecting insulator problems. The electric field distribution on the surface and within the composite insulators is depends on various parameters such as applied voltage, design, tower configuration, and so on. In this work, a 33kv insulator is used to analyse the electric field on silicone rubber using the finite element analysis in ANSYS software, which is a suite package for 2D and 3D electrostatic field analysis. The finite element approach is used to solve the partial differential equations that describe the behaviour of the fields. To examine changes in electrical field distribution, a defect is generated on the surface of the insulator. In this investigation, straight shed and alternate shed insulators with a leakage distance of 380 mm were utilised.The potential and electric field effects of the actual insulator profile with and without defect are analysed and presented. The result shows that the suggested modified alternate shed design produces less electrical field than the standard shed design and that potential distribution in both insulators varies linearly with leakage distance. The effects of water droplets on the shed and sheath region of composite insulators can be studied for electric field distribution.

KEYWORDS: ANSYS, Polymer Insulators, Potential Distribution, Electric Field Distribution, Finite Element Method.

I. INTRODUCTION

Traditional insulators made of glass and porcelain (ceramic insulators) used in power transmission and distribution systems ruled the market till the introduction of polymeric insulators which have potential to replace the ceramic insulators because of light weight, aesthetic, hydrophobic properties, and superior anti-contamination performance. For the performance of a power system the reliability of power grids and devices is very significant. Insulators made of porcelain and glass have been used for over a century [1]. Despite the fact that these materials have been shown to withstand environmental ageing, their pollution performance is poor due to the hydrophilic surface of porcelain and glass materials.

Polymer insulators have been introduced and widely employed in recent decades due to their superior pollution performance. Polymer insulators currently account for 60-70 percent of all new high voltage insulator sales in the United States. Composite or non-ceramic insulators are insulators built of polymer materials [3].

However, because the field experience with polymeric insulators is limited, more research into their performance under actual and simulated environmental conditions is required before they can be used in full scale on real power systems. Insulators are one of the most important components of electric power transmission networks. They are used to support, segregate, or confine high-voltage cables. Insulators must endure not only regular and over voltages, such as lightning and switching events, but also diverse environmental pressures such as rain, snow, and pollution. The effect of design parameters like shed diameter, rod diameter and shed angle on surface resistance and hence on current density were calculated for non-ceramic profile based on circuit theory by Young.

The key benefits of silicon rubber polymer insulators: First, silicon rubbers have low surface tension energy and hence preserve a hydrophobic surface characteristic, resulting in greater insulating performance in polluted and damp environments. Second, as compared to porcelain or glass insulators, polymer insulators offer superior mechanical strength to weight ratios. Third, polymer insulators are less sensitive to major vandalism, such as gunshots [5].

The following are the drawbacks of polymer insulators: For beginning, because polymer insulators are formed of organic components, they are sensitive to chemical changes on the surface. Second, polymer insulators are susceptible to erosion and tracking, which can lead to insulator failure [7].

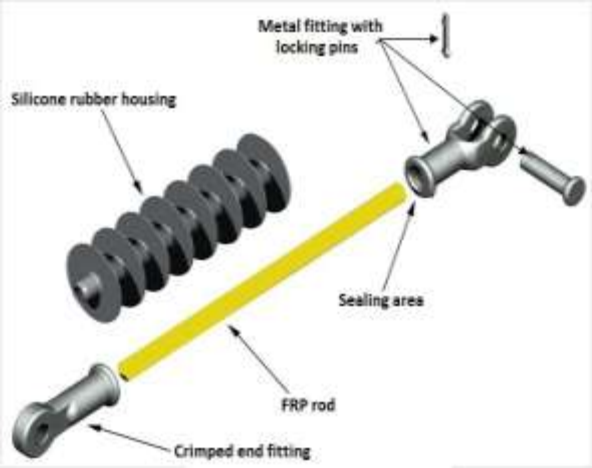
In this work an attempt has been made to simulate the potential and electric field under different insulator design using a commercially available software package [2].

II CONSTRUCTION OF INSULATORS

Composite insulators as a great option to ceramic and glass insulators were presented. After over 30 years of startup and design improvements and depleting materials of the first type of composite insulators.

Composite isolators are composed of at least two isolating materials, one for the supply of electrical property and the other for mechanical characteristics. As seen in Fig., composite insulators are made up of components such as:

1. Core
2. Sheath
3. Shed
4. End Fitting
5. Couple zone



COMPONENTS OF COMPOSITE INSULATORS

1. Core - The core is the composite insulator's interior isolating element. It is meant to bear the mechanical load. It basically consists of glass fibers placed in a resin matrix in order to bear maximal stress.
2. Shed - The housing is outside the core and protects against the weather. It can be fitted with weather shelters. Certain designs of composite insulators have an isolating material sheet between the sheds and the core. This sheet belongs to the housing.
3. End fitting - The mechanical load is passed to the core by the end fitting. Usually they are composed of metal.
4. Coupling Zone — The connecting zone is the end fitting part of the load that is transferred to the line, to the tower or to another insulator. The interface between the core and the fitting is not included.
5. Interface - The surface between different materials is an interface. Examples of the composite isolator interface are the following:

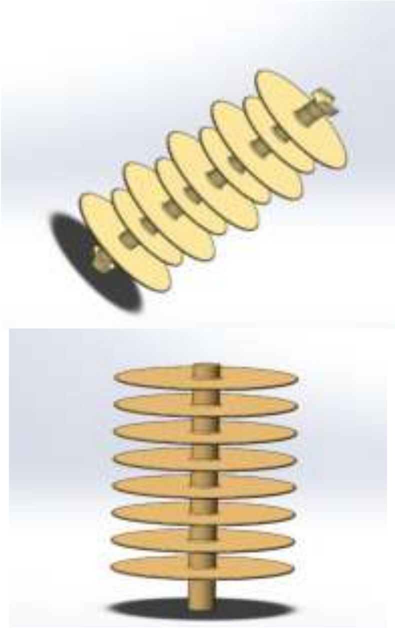
a. Glass fiber/Impregnating
b. Filler/polymer
c. Core/housing
d. Housing/sheds
e. Housing/end fitting
f. Core/end fittings.

III METHODOLOGY

For the analysis, such as potential and electric field distribution, we use 33kv insulators with the dimensions specified in the table which are designed in solid work software, and the models are depicted in the figure

	Straight Shed	Alternate Shed

Creepage Distance	900mm	900mm
Diameter of Rod	16mm	16mm
Thickness of shed	3mm	3mm
Dry Arc distance	380mm	380mm
Length of FRP	425mm	425mm
No of Large shed	8	5
No of small shed		4
Diameter of long shed	110mm	110mm
Diameter of small shed		71mm

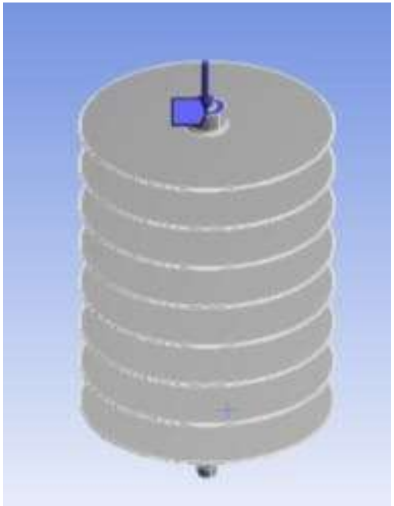


CAD MODEL OF 33KV INSULATORS

Partial differential equations, such as the Laplace and Poisson equations, can be solved using a variety of approaches. In this study, a numerical methodology is applied with the help of the ANSYS WORKBENCH software. There are various solvers available in the Ansys Workbench tool. An electric solver is used to perform electrical analysis. As stated in the table, silicon rubber, FRP materials, and their parameters were assigned.

	FRP Rod	Silicon Rubber
Tensile Yield Strength	3.43e+09 Pa	1.05e+07 Pa
Isotropic Resistivity	1.5e+14 ohm-m	2.87e+13 ohm-m
Viscosity	1e+12 Pa-s	398 Pa-s
Density	1800 Kg/m^3	1240Kg/m^3

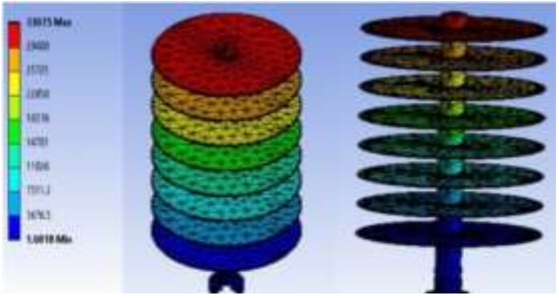
Then it was possible to transport a cad model into a geometry and assign a material to it. The mesh, or finite element model, is generated by defining the shapes of the elements, their sizes, and any variations of these across the model. Following the definition of the geometry, the solid model is discretized into a suitable finite element mesh using a meshing techniques. The meshing must be done with extreme caution. In this stage, the boundary condition and loads are applied. In this case, we apply a voltage of 33kv at the top end of the insulator, and the other end is grounded as shown in the figure to determine the voltage and field distribution.



APPLIED VOLTAGE TO INSULATOR.

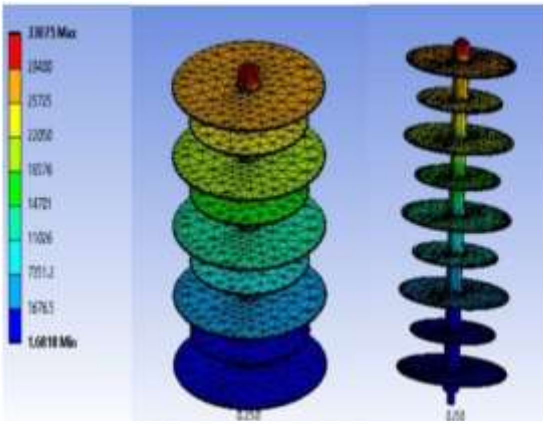
IV RESULTS & DISCUSSION

A 33Kv voltage is given to the insulator in order to analyse its voltage distribution and electrical field distribution throughout its leakage distance throughout its sheath and shed area. The figure depicts the voltage distribution of a straight shed insulator.



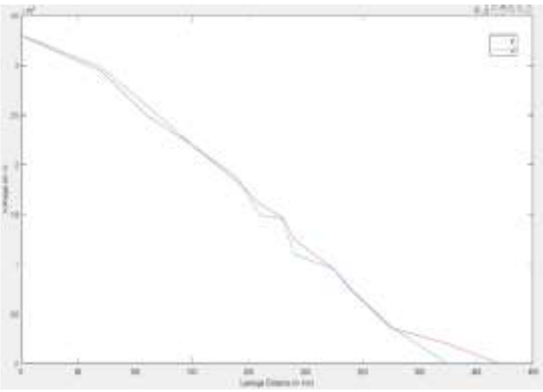
THE VOLTAGE DISTRIBUTION OF A STRAIGHT SHED INSULATOR.

Following figure Depicts the voltage distribution of an alternate shed insulator



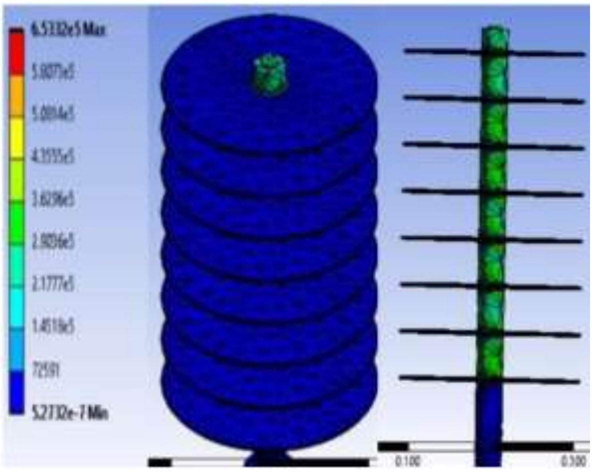
THE VOLTAGE DISTRIBUTION OF A ALTERNATE SHED INSULATOR

Following figure depicts a comparison of two voltages throughout their leaking distance.



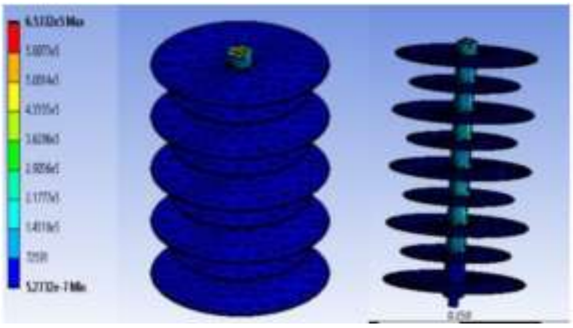
COMPARISON OF VOLTAGES OF TWO INSULATORS ACROSS ITS LEAKAGE DISTANCE

Following figure Depicts the electrical field distribution of an alternate shed insulator.



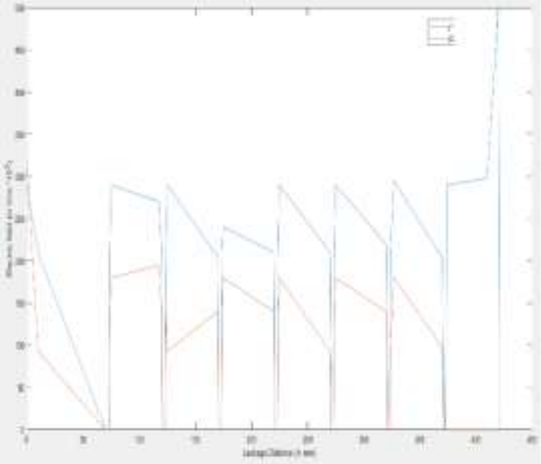
THE ELECTRICAL FIELD DISTRIBUTION OF A ALTERNATE SHED INSULATOR.

Following figure depicts the electrical field distribution of an alternate shed insulator.



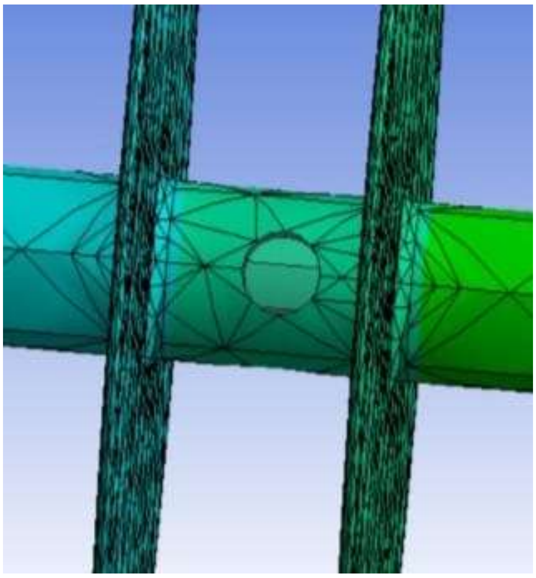
THE ELECTRICAL FIELD DISTRIBUTION OF ALTERNATE SHED

Following figure depicts a comparison of two voltages throughout their leaking distance



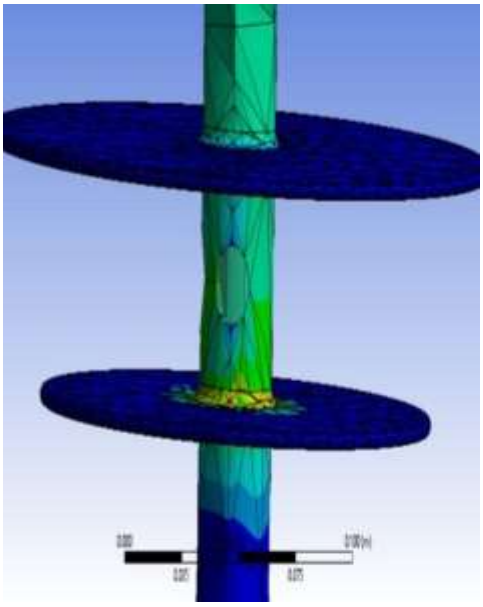
COMPARISON OF ELECTRIC FIELD OF TWO INSULATORS ACROSS ITS LEAKAGE DISTANCE.

A conducting fault created in the insulator sheath area, and the electric voltage across the straight shed insulator is as illustrated.



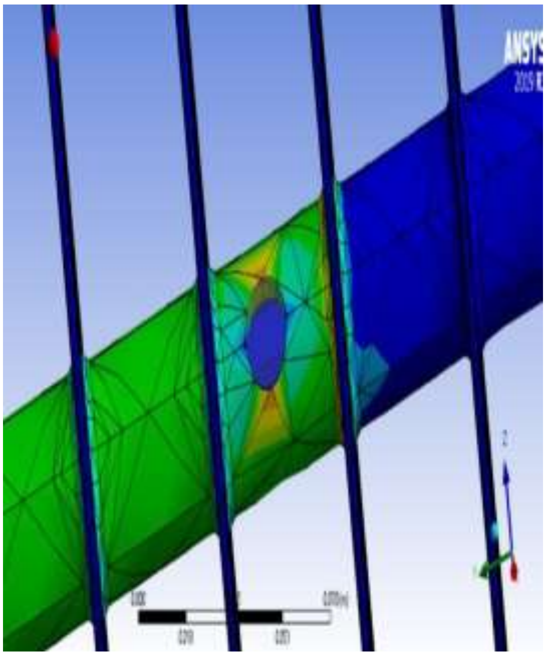
VOLTAGE ACROSS THE STRAIGHT SHED INSULATOR.

As illustrated in the figure, the electric potential across the alternate shed conductive defect insulator is shown.



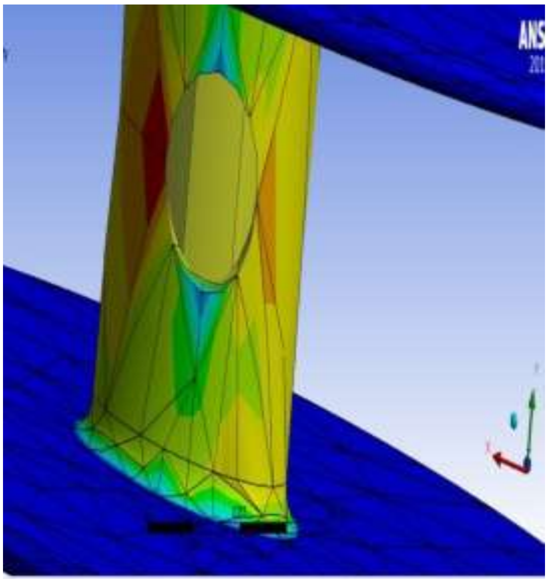
THE ELECTRIC VOLTAGE ACROSS ALTERNATE SHED CONDUCTIVE DEFECT INSULATOR.

Following figure Depicts the electrical field across the straight shed conductive fault insulator.



THE ELECTRICAL FIELD ACROSS THE STRAIGHT SHED CONDUCTIVE DEFECT INSULATOR

Following figure depicts the electrical field throughout the sheath region of the alternate shed insulator.



THE ELECTRICAL FIELD ACROSS THE SHEATH AREA OF THE ALTERNATE SHED INSULATOR

V. CONCLUSION

In this paper, Ansys Workbench was used for the electric field distribution and the potential distribution of polymeric insulator for 33kV straight and alternative sheds.

- When compared to alternate shed insulators, the straight sheds insulator has a greater electric field dispersion and more nonlinear potential distributions, according to Finite Element Method simulation studies.
- The electric stress recorded at the end fitting, on the triple junction point around the first shed, is slightly higher than in other insulator areas.
- First shed receives the more electrical voltages as compared to other regions in straight shed insulator where as in alternate shed insulator electrical voltage is more only at the tip of the insulator.
- Electrical potential gradually decreases as leakage distance decreases in both insulators.
- Maximum electric field intensity in 500*10^3 V/m and 280*10^3V/m straight and alternative insulators respectively.
- The voltage distribution is identical for both isolators in conductive defects, however the distribution of electric fields is less in straight shed insulator.
- When analysed for all these variables, the electric field distribution will provide good performance in normal situation for other shed insulators. Straight insulators provide higher performance in conductive fault conditions.

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