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A Study of Spacers and Defects For A Three Conductor Transmission Line Gas Insulated Busduct

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Abstract:

A Design of Composite Spacers for a three conductor transmission line Gas Insulated Busduct under abnormalities and Gas Mixtures is analyzed and also the design of Functionally Graded Material Spacer for Gas Insulated Busduct under abnormalities and Gas Mixtures is analyzed in this paper. Analyses of Gas Insulated Busduct due to various defects in Gas Insulated Busduct under abnormalities and Gas Mixtures were discussed in this paper.

I. INTRODUCTION

Gas Insulated Busduct (GIB) is becoming the most popular technology in India due to its compactness, ideal use in restricted areas. The high demand for electrical power and energy efficiency in urban areas made it necessary for power consumers to boost the voltage network. Gas Insulated Busducts provides an excellent alternative to the above-mentioned issue and have been operating around the globe for over 30 years. It is also appropriate for use in places with serious weather circumstances (high temperatures, exposure to ocean and altitudes) and Industrial environments (poisonous regions or corrosive environments). Typical GIB layout is usually 10 times lower than the Air-Isolated Substation (AIS). As land becoming scarce in India, GIB has become a more commercially viable solution. Although GIB has been providing high-quality performance for years, there are still some issues affecting the operation of GIB and therefore they need to be investigated. The most challenges faced by the GIB is failure of Insulating spacers as they are the weakest insulating link (weak link) and they can lose their strength due to corona effect or metallic particles [1-4].The rapid rise in the power density of electrical equipment and electronic equipment highlights the need for thermally conductive but electrically insulating products. Polymer materials have been widely used as dielectrics to provide electrical insulation in power equipment and electrical devices because of their low cost and easy processing. However, most of polymer materials have low thermal conductivity, which makes the thermal management of high-power-density equipment and devices become a large challenge. The search for high thermal conductivity materials has inspired multiple studies of polymer

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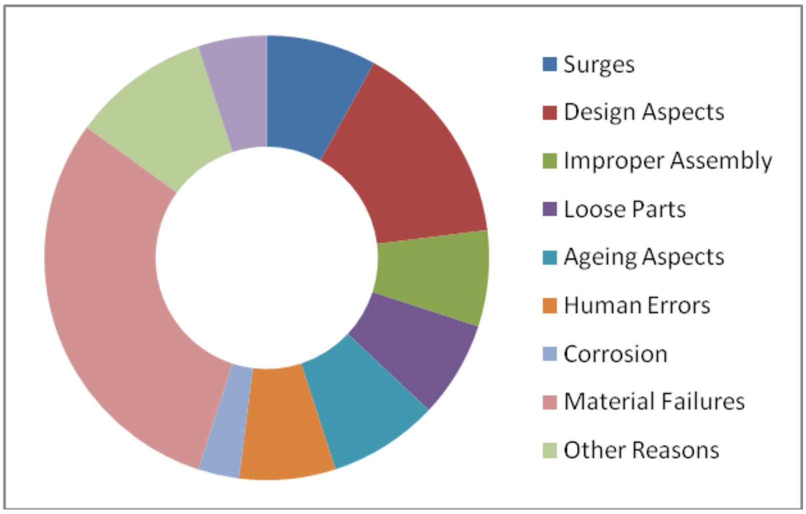
Vol-22-Issue-16-August-2019

composites. However, the simultaneous enhancement of thermal conductivity and insulating properties of polymer composites remains as challenge in materials engineering [5-10]. The surges or any event of flashovers will damage of spacer and hence a spacer material has to be chosen to get rid of these situations in regular testing in plant or onsite. It is enormously essential as SF6 systems should be viewed as self-restoration. Cycloaliphatic resins consist of greater track resistance when compared with biphenyl resins with reduced mechanical strength. Aluminum-based fillers along with epoxy resins are used to create general strength even though they have a demerit of greater allowability and greater thermal expansion coefficient. Due to the defects like protrusions, voids, depressions, cracks, delaminations and poor adherence to electrodes the life of the spacer can be decreased as the conductor is positioned in the middle of the spacer [13]. From Fig.1, the survey of GIB used in the context of India it was observed that the maximum rate of its failures is because of material failures, improper selection of materials. Few other reasons like corrosion , loose particles effects the overall failures in the GIB. Natural abnormalities like surges are also observed as one of the major cause for these failures. The demand for GIB has been increased by considering the overall availability of land in metropolitan cities. As the substations are connected to grid, any fault in substation leads to grid failures and blackout in the power system. In order to do so, the above factors must be dealt with very efficiently. Electrical equipment and equipment efficiency is largely determined by the characteristics of their insulating materials. Insulating materials must operate in energy systems and electrical equipment under extreme conditions that may include variations in elevated temperature, intense radiation, and powerful electrical fields. These circumstances require high-quality insulating materials with superior electrical, thermal and mechanical characteristics and resilience to other environmental pressures. This work focuses on design of Optimal Spacer in GIB using various insulating materials and analysis will be carried by determining electric breakdown strength, thermal conductivity, temperature resistance, corona resistance, and specific energy storage in dielectrics. Later, design of disc type and cone type FGM (Functionally Graded Material) is developed to have regular electric field distribution throughout the spacer by grading with different composite materials [14-19]. Contamination of metallic particles is one of the critical areas of insulation design. Managing and controlling particle contamination is crucial as the industry moves toward higher voltage GIB and long GITL designs using SF6 in some components. In this work, the spacer is intended with separate particles in distinct locations for uniform electrical field stress along the surface [11].



ISSN:0971-1260

Vol-22-Issue-16-August-2019

Fig.1.Observed Failures in GIS

Further study will be carried out with various surges It was also observed that various gases can be used as alternate to SF6 as insulating gases The various gases that can be considered along with SF6 are N2, CO2, CO, CF4, He, Ar, C2F6, N2O, SO2 and other gases like g3, CF3CHCl2, CF3I, Fluroketones, N2+C-C4F8, N2+SO2 can be chosen as alternates to SF6 for the analysis of several defects like particle contamination in various gaseous mixtures [02 - 03].

II.REVIEW OF LITERATURE

Perry, E.R et al reviewed that the behaviors of various insulators with dissimilar shapes like a cone and smooth disc. Disc type seems to have a potential in considerable limits. The dielectric strength decreases due to insulator contamination. [12].

Misaki, T found that electric field stress on a cone-type spacer in SF6-gas-insulated devices creates a major problem and this has been slightly changed by increasing surface shape of the spacer [13]. Till now, a variety of techniques have been applied to improve the insulation capacity of the spacer for reducing the effect of field stress in GIB. However, the above techniques have made the design of spacer more complicated. Currently, a new approach based on grading of materials is anticipated to pick up the break down voltage (BDV) of spacers with its simple configuration. Okubo group have been anticipated a new technique, called FGM in GIB spacer which is prepared through the force of centrifugal and observed that BDV and control of electric field stress has been improved. Some Researchers have investigated the design and analysis of FGM spacer and also obtained optimization techniques to reduce the electric field. However, there are some more issues to be concentrated for fabrication, design and to assess the performance of FGM prior to apply them in industries. Also few types of increasing, decreasing and U shape material distribution can be achieved by using centrifugal forces, it is in urgent requirement to have a flexible method of fabrication for FGM type insulators. [14-15].

The other parameters effecting insulation gas in GIB are low boiling point, low toxity, stability, low flammability and Global warming point. These parameters can be rectified by using gasses like N2, CO2, CO, CF4, He, Ar, C2F6, N2O, SO2 along with SF6 and other alternate gases like g3, CF3CHCl2, CF3I, Fluroketones, N2+C-C4F8,N2+SO2. Also the SF6 gas was considered as good medium for gas insulation with few disadvantages between different gases. Although SF6 releases few emissions than CO2, its Global Warming Potential (GWP) is very high comparatively. Since then, the worldwide electric power industry is searching for a new gas or gas mixture to replace SF6 gas, which has to be done with less impact on environment i.e. with small GWP. Also the Fluroketone based mixtures has less GWP than SF6 and three major contributions to CO2 emissions are Materials, Insulation gas leakages and Energy losses [05 -12].

However some efforts has to be done to get a uniform electric field distribution at the Triple Junctions (TJ’s) by incorporating metal inserts. It was observed that electron emission occurs mostly at TJ’s. It was identified that the field stress has been reduced by adding metal inserts to the spacer with several defects [13]. Further metal inserts also provided an effective

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Vol-22-Issue-16-August-2019

shielding at the triple junction. However these methods have been increased the cost and complexity for the design of spacer. FGM is a new technique by which the spacer can be performed by varying the permittivity values to get uniform electric field stress along the spacer surface. FGM spacers are synthesized practically by varying the diffused fillers in the epoxy with centrifugal forces. Though many efforts had been made to get identical electric field along the surface of the spacer but still the electric field stress has to be minimized at High voltage (HV) and Low voltage (LV) electrodes of GIB and TJ's. [12].

III.ADVANCED METHODOLOGY:

The electric field distribution under ac voltages gets increased in the region of gas due to its low permittivity when compared with solid insulator. But to reduce this field distribution the design of FGM spacer will be an efficient method by varying the permittivity in the solid insulator. The intensification of electric field existing in this region can be decreased by means of permittivity graded-FGM. The significant element is to select the distribution of permittivity in order to improve the utilization factor of the field distribution.

A spacer with a constant permittivity will have a uniform electrical field stress along its surface. However to avoid surface discharges and possible surface flashes at TJs, the electrical field distribution at these TJs must be kept as low as possible since major flashovers reported in the review due to elevated electrical field distribution at TJs. To decrease this electrical field stress, a metal inserter has to be used. FGM support insulators has developed a new trend for the design of insulator with normal forms and with permittivity of different values. By varying the field distribution of permittivity along the spacer, the control of field stress can be obtained as per the requirement. The processing of Permittivity-graded materials is done by applying centrifugal forces by adding different fillers. In continuous material the permittivity of the material is continuous as the density of filler is continuous throughout the material. The high permittivity of filler density in GL-FGM is raised in the centrifugal direction from one end to the other end with small permittivity values. Low permittivity filler are used to produced in GH-FGM to accumulate the process of centrifugal to achieve a small change in the permittivity at the both ends of the spacer. U-FGM, has two fillers of distinct diameters to produce the centrifugal forces to acquire permittivity features to accumulate at either end.

Case 1: Grading to High-FGM (GH-FGM)

Permitivity is the function of the radius and hence rises as the radius rises towards the enclosure as represented in Fig.2.The range of permittivity to be considered is 2.5 to 16. From the calculated electrical field distribution along the spacer surface, is plotted from the enclosure end to the inner conductor, it can be noticed that the electrical field distribution at the enclosure end of the Triple Junction was reduced when compared to inner conductor end of Triple Junction.

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Vol-22-Issue-16-August-2019

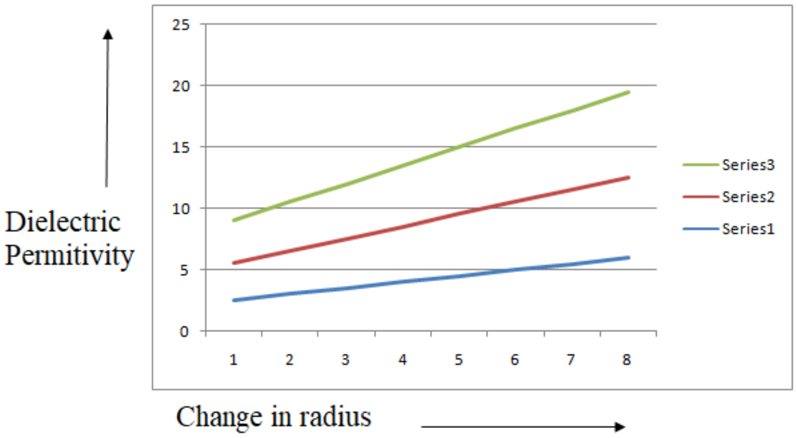

Fig.2: Relation between permittivity and radius in case of GH-FGM [24]

Case 2: Grading to low-FGM (GL-FGM)

High permittivity shall be maintained at the end of inner conductor and shall be gradually reduced by increasing radius in the direction of enclosure end. The permittivity is in the range of 3.5 to 12. Fig.3 shows that with the change in permittivity the electrical field distribution at the Triple Junction is decreased but electrical field stress is still at 0.6 p.u at the inner conductor of TJ and the electrical field is partially uniform along the solid spacer.

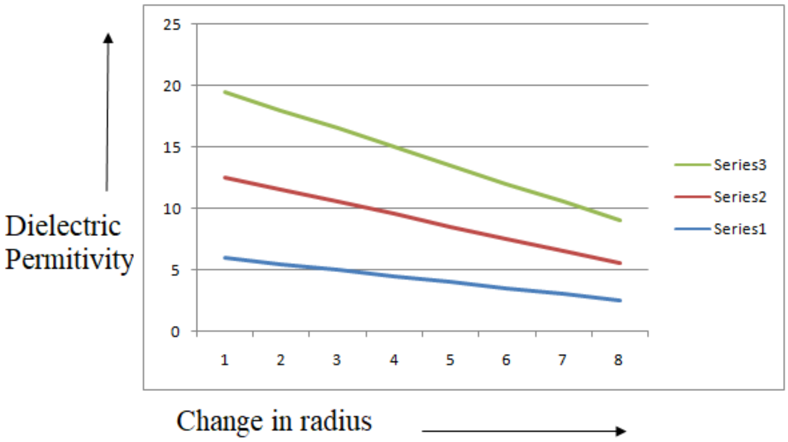

Fig.3: Relation between permittivity and radius in case of GL-FGM [24]

Case 3 : U-FGM

Here, the permittivity is slowly reduced from peak to low value, and further improved by taking unique value towards the enclosure end. Even though the electrical field near outer enclosure is reduced, still the electrical field at the conductor end of triple junction is slightly higher at 0.63p.u with a non-uniform electrical field distribution, as represented in Fig.4.

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Vol-22-Issue-16-August-2019

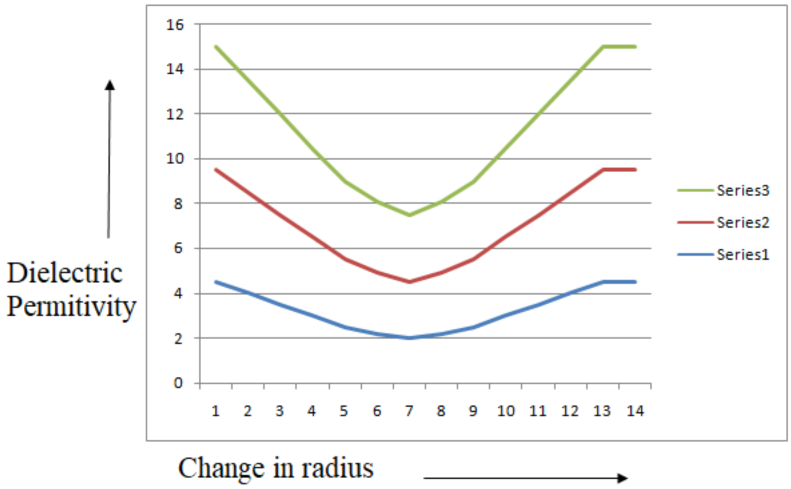

Fig.4: Relation between permittivity and radius in case of U-FGM [24]

Case 4 : Polymeric Spacer

In GIB, insulation clearance between HV and LV electrodes is an important factor. Hence solid insulators are important as mechanical supports to create the insulation clearance. In the GIB, some factors like particle contamination, voids, Protrusion, delamination and E- field stress at TJ are to be taken into consideration are along with the electric field on the spacer's surface. Hence, different techniques were introduced as a solution to the above considered factors.

Designing of insulating spacers was one important aspect to the electrical engineer and so they required keen knowledge on electric field distribution. Epoxy or cast resin finds great application in high voltage systems as insulation. Currently epoxy with nano reinforcement has drawn lot of interest as it improves the properties of epoxy considerably. For analysis a polymer spacer has been designed and different fillers of nitrates, carbides and oxides have been considered. The relative permittivities of break down voltages and electric field distributions are determined and analyzed for the designed cone type spacer with different dielectric coatings of nano nitrides. Finite Element Method technique was used among various techniques to calculate the electrical field.

Epoxy resin is most preferred material for high voltage systems as it has high insulation because of adequate mechanical, electrical qualities as well as chemical stability. Such resins are relatively immune to chemical corrosion and work as effective generally stable to chemical attacks and are excellent adherents with slow shrinkage during curing and no volatile gas emissions. However, these advantages make epoxy use quite expensive. They can also not be expected to exceed a 140ºC temperature. Their use is therefore excluded in high-tech areas where service temperatures are higher [08 - 10].

The primary components of polymer composite spacer are polymer matrix, fillers and area of interaction. Nano composites of epoxy are available in dimensions below 100 nm with less percentage by weight of the total material. Such composites have good thermal conductivity, strong resistivity for temperature and high breakdown Fillers are of one dimensional or three-dimensional and have very good engineering properties including thermal, mechanical and electrical types [10 - 11].

In high voltage apparatus, epoxy resin is extensively in use as insulation. A practical epoxy resin has dielectric permittivity depending on the filler type. Epoxies are expensive and cannot be expected beyond a temperature of 1400C. NMC (Nano / micro composites) is useful in grading of GIB spacer by lower due to reduction in loading. normally less than 10 wt percent, due to their lower r. Lewis was inspired in electrical insulation by polymer nano-dielectrics as nano-dielectric insulation performs better in certain areas compared to conventional materials of insulation [14].

The interaction zone is considered as an independent region for the nano-particles and the polymer matrix. If nano particles are in remote distribution, Carriers are controlled in an interaction zone which diminishes the mobility and density of carriers. The loading of the filler [11-15] increases with the mobility of load carriers. The strength of nano-particles, polymeric matrix has a direct influence on the thickness of the interaction zone. Nano-dielectrics shows some uniqueness caused by the large interaction zone. A structural change is seen when nano-fillers are introduced into the polymer matrix because of the contact of polymer and nano-filler. The use of inorganic fillers such as boron nitride, aluminium nitride reduces costs and improves resistance and mechanical properties like tensile strength. It also increases the permittivity of epoxy nano composite.

IV.CONCLUSION

Thus from the above proposed system it known that the magnitude of electric field is affected by dielectric constant that is with a high dielectric constant, the electric field reduces. The Grading of epoxy resin increases the overall permittivity of the spacer in comparison with simple epoxy . Hence, GIB can prefer Functionally Graded Spacers.

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