International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 9 Sep. 2022, pp: 934-937 www.ijaem.net ISSN: 2395-5252

Improved substation ground electrode Design for Zone 2 Trans Amadi Sub Transmission station, Rivers State. Nigeriausing corrosion resistant conducting ground electrode

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Date of Submission: 15-09-2022 Date of Acceptance: 24-09-2022

ABSTRACT—The structures and kinetics of the exchange reactions of copper, nickel and cadmium electrodes have being seen in large concentration along the Trans- Amadi Axis of the Industrial oil rich Port Harcourt. This metal in large concentration causes degradation and corrosion of copper materials used for the earth electrode design at the Zone 2 Trans Amadi Sub Transmission station, Rivers State. Nigeria known for load shade. This paper seek to design an improve ground electrode for the Zone 2 Trans Amadi Sub Transmission station, Rivers State. Nigeria using Carbon nano coating nanostructures.

Index Terms— Carbon nano coating nanostructures, Cadmium high concentration, NERT Act 2005, Nigeria Government, Niger Delta Region, Nigeria, Solar load shade, TranCos, VIMs, NIPPs.

I. INTRODUCTION

Trans Amadi is a thousand-hectare (2,500-acre) industrial area, Situated at 4°48'53" N latitude and 7°2'14" E longitude, the neighborhood supports a strong manufacturing sector and is considered to be a major industrial zone in Port Harcourt. Mineral like Cadmium (Cd), a metal of Group 12 (IIb, or zinc group) of the periodic table is found at ahiramakara road and there is also a high concentration of nikel a chemical element with symbol Ni and atomic number 28 at the Nkpogu and Elekahia axis of the Trans Amadi industrial area [1].

The study of cadmium and nikel effect on ground electrode processes using relaxation techniques shows the degradation and corrosion of copper materials used for the earth electrode fabrication at the Trans-Amadi industrial area zone 2 substation in Port Harcourt. Rivers state. Nigeria [2].

The level of expected degradation and corrosion of the copper ground electrode material had a significant difference in the result at 95% confidence interval in almost all the fractions of its output at a given interval of five to ten years after installation. This paper seek to design a improved ground electrode for the Trans-Amadi industrial area zone 2 substation in Port Harcourt. Rivers state. Nigeria using corrosion resistant conducting ground electrode

A corrosion-resistant conducting ground rod belongs to the field of conducting circuit connecting devices. The corrosion-resistant conducting ground rod is characterized in that a carbon nano coating layer is coated on the outer surface of a copper plating layer on the surface of the existing iron ground rod, thereby being capable of increasing conducting property and corrosion resistance of the ground rod.

Carbon nano coating nanostructures comprise mainly of grapheme sheets. They are celebrated for exhibiting high thermal conductivities and extremely high tensile strength. Moreover, carbon nano coating are chemically functionalized with nanoparticles to make electrically conductive nanostructures and single-electron transistors.

II. DESIGN MATERIALS AND METHOD

The Material

- Soil was uniform between test point and test locations were out of the influence of any existing underground utilities
- Two –Layer soil model was utilized, average soil resistivity of 64.84 Ω·m was determined
- Total clearing time of a line to ground fault is 0.5 seconds.
- Grid will be buried 18” (0.4572 m)
- Crushed rock layer inside the substation is 4” (0.1016 m)

- Ground rods will be 10' (3.05m)
- Resistivity of the crushed rock layer is 3000 Ω·m
- Switchyard operator is 50kg or heavier
- 230kV line-to-ground fault currents is utilized
- X/R ratio is 10
- Current division factor S_f =0.6
- carbon nano coating

III. DESIGN METHOD

Step 1: Field Data Capturing analysis

The 132kv trans-Amadi substation is oddly shaped. But as stated in the preliminary design suggestions, the biggest rectangle was drawn to determine the area. For the initial design a rectangle of 144m x 120m will be assumed. The area occupied is

A = 17280 m^2

Field measurements were taken in order to determine the soil resistivity. The soil resistivity values were obtained utilizing the Wenner Four pin method. Soil resistivity testing was conducted at six different locations in the vicinity of the transamadi transmission substation.

Step 2: Determine the Conductor size required

To determine and select Earth Conductor Size, using Equation 37 of IEEE 80-2000

$$I = A_{mm2}\sqrt{\left(\frac{TCAPx\ 10^{-4}}{t_e \alpha_r \rho_r}\right) \ln\left(\frac{k_o + T_m}{K_0 + T_a}\right)}$$

Step 3: The Earth Grid Resistance is Determined using Matlab

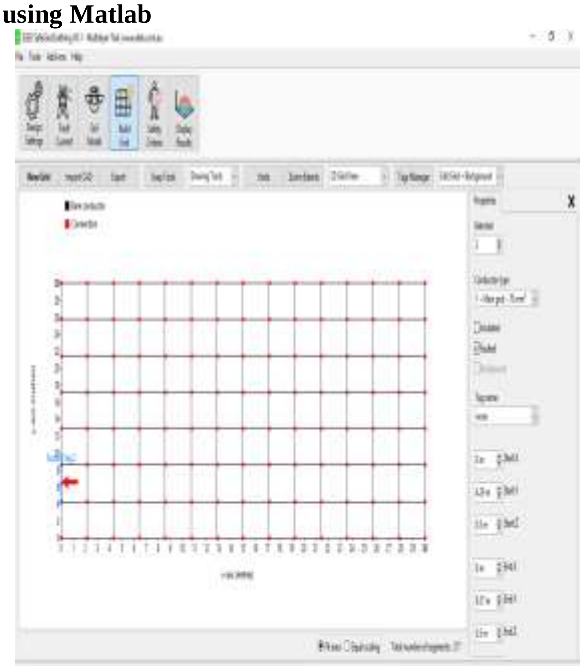

Figure 1: Proposed rectangular earthing grid Trans-Amadi industrial area zone 2 substation in Port Harcourt. Rivers state. Nigeria using carbon nano coating.

For the rectangular earthing grid shown in figure 1. The following parameters was proposed:

- Length of 90m and a width of 50m
- Grid conductors will be 120 mm^2 and buried at a depth of 600mm
- 22 earthing rods will be installed on the corners and perimeter of the grid
- Each earthing rod will be 3.05m long

The following steps were followed to determine the resistance of the earthing grid with respect to remote earth. The Earth Grid Arrangement and parameters to be set are:

- nr or r = No of Rows
- L_g = Length of Row
- nc or c - No. of Column
- W_g - Length of Column, meter
- L_c - Total Length of Earth Conductor, meter

Step 4: Maximum Grid Current is determined

The following steps was used to determine the maximum grid current.

The Maximum Symmetrical Earth Fault Current using the equation below

$I_g = (I_{omax}) \times S_f$

Where:

- I_{omax} = Max Symmetrical Earth fault Current
- S_f - Current Division Factor
- I_g - Symmetrical Grid Current

The DC Time Offset was determined using equation 74 of IEEE 80-2000

$$T_A = \frac{X}{R} x \frac{1}{2\pi f}$$

T_A = 0.04774s

Where:

- $\frac{X}{R} = \frac{X}{R}$ Ratio at Fault
- f = Frequency
- T_A = DC Time Offset Ta

The Decrement Factor was determined using equation 79 of IEEE 80-2000

$$D_F = \sqrt{1 + \frac{T_a}{t_f}\left(1 - e^{\frac{-2tf}{Te}}\right)}$$

Where:

- T_a = DC Time Offset
- t_f = Time duration of Fault
- Df - Decrement Factor

Substituting the respective values of T_a and t_f into equation 3.5 gives 1.1479.

The maximum value of the earth grid current returning to the sources of origin was determined using

$I_G = I_g \times D_f$

Where:

- I_g = Symmetrical Grid Current
- D_f = Decrement Factor

- I_G = Maximum Earth Grid Current

Therefore the Maximum value of the earth grid is I_G = 3.559 KA

Step 5: The Touch and Step Potential Criteria was Determine using

For 50kg: $E_{touch,50} = (1000 + 1.5C_s\rho_s)\frac{0.116}{\sqrt{t_s}}$

For 70kg: $E_{touch,70} = (1000 + 1.5C_s\rho_s)\frac{0.157}{\sqrt{t_s}}$

Where:

- Cs - Surface Layer Derating Factor
- ρ_s - Resistivity of Surface Material, Ω-m
- t_s - Time duration of Fault

The Maximum Step Potential was determined using

For 50kg: $E_{step,50} = (1000 + 6C_s\rho_s)\frac{0.116}{\sqrt{t_s}}$

For 70kg: $E_{step,70} = (1000 + 6C_s\rho_s)\frac{0.157}{\sqrt{t_s}}$

Step 6: Earth Grid Design Verification

The Geometric Factor "∩", was determined using equation 84 of IEEE 80-2000. Where

$\cap = \cap_a \times \cap_b \times \cap_c \times \cap_d$

Where

$$\cap_a = \frac{2L_c}{L_p}$$

$$\cap_b = \sqrt{\frac{L_p}{4\sqrt{A}}}$$

The geometric spacing factor k_m is

$$\frac{1}{2\pi}\left(\ln\left[\frac{D^2}{16hxd} + \frac{(D+2h)^2}{8Dxd} - \frac{h}{4d}\right] + \frac{k_{ii}}{k_h}\ln\left[\frac{8}{\pi(2n-1)}\right]\right)$$

IV. RESULTS AND RECOMMENDATION

Using Etap the improved Trans-Amadi industrial area zone 2 substation in Port Harcourt. Rivers state. Nigeria design is as shown in figure 2 below

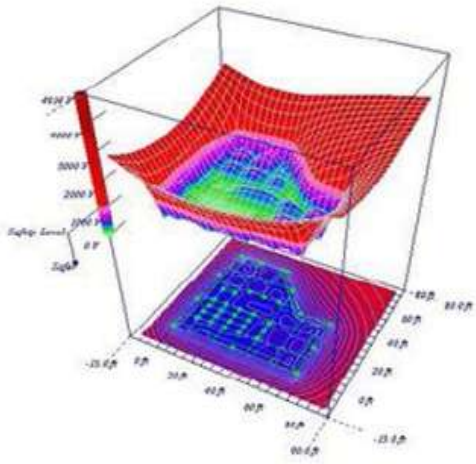

Figure 3: ETAP Groundmat software output

V. SIMULATED GRAPHS FOR SOIL EARTHING CONDITIONS AND INVESTIGATION

The soil existing data for the study case were collected and implemented into standard equations of IEEE std 80, section 16.5). the results are presented in figure 4, 5 and 6

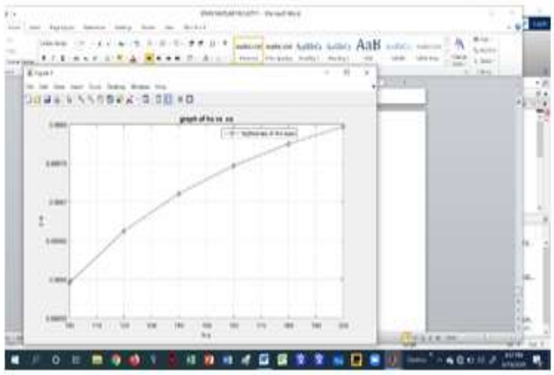

Figure 4: Shows the plot of surface layer derating – factor (Cs) and thickness (h-s) of the surface layer (mm)

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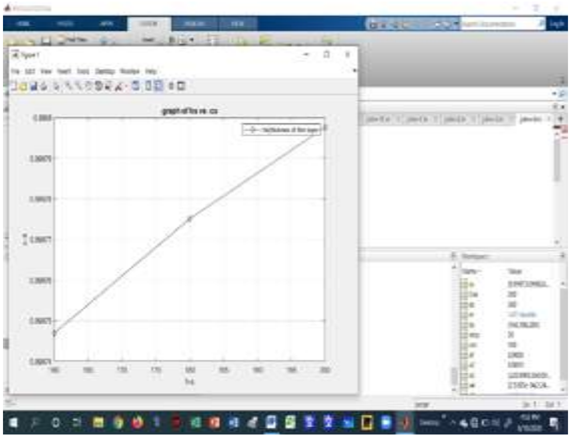

Figure 5: Shows the improved earthing condition for an incidence lightning surges on station.

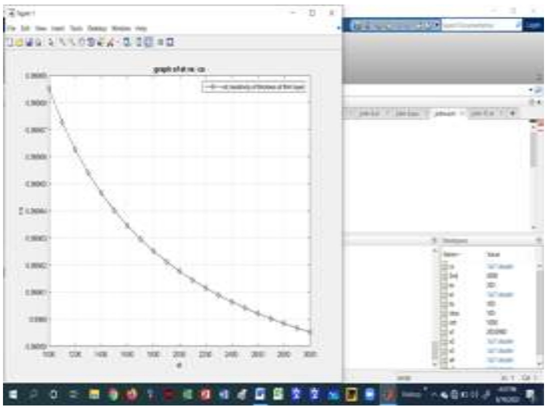

Figure 6: Shows the exponential decreasing down of surface layer (c_s) derating factor and thickness of surface layer materials (h_s)

VI. CONCLUSIONS

The reliability of electric power supply from one level to another required efficient protection of power system equipment to the consumers. This means that continuous improvement of lighting performance can be considered very important in order to avoid huge equipment failures and damage during lightning strike, results into financial losses to the transmission companies etc.

This result was possible because of the nano corrosion resistant conducting ground electrode.The study case was modeled in electrical transient analyzer (ETAP) and MATLAB simulations application tool which described and shows the exponential transient behavior.

Therefore this work have provided the substation with an excellent modified ground electrode design.

VII. RECOMMENDATION

Therefore the following recommendations are considered:

(i) Periodically check the soil structure information to avoid poor diversion of faults current and lightning strike.

(ii) The determined improved parameters for soil investigation can be employed in the prediction of faults occurrence interactions with lightning strike.

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