Research on Soft Grounding Material with High Conductivity in Transmission Line Tower Grounding Network

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Abstract. For the question that the current metal grounding device has poor corrosion resistance, construction difficulties, short life-cycle and other issues, this paper chose graphite as matrix, developed a new type of soft grounding material with high conductivity material based on modification technology of carbon nanotubes. And then the preparation method was given. Compared with traditional metal grounding device, this new soft grounding device with high conductivity have lower resistance, more stable performance, stronger corrosion resistance and electrical conductivity, non-toxic and environmentally friendly, and many other advantages. This material has high practical value.

Introduction

The grounding device is a key factor to protect grid security. With the sustained and rapid development of our national economy, demand for transmission capacity of grid is growing, and the voltage level is rising. Correspondingly transmission lines and substations put forward a higher demand for service life and electrical properties of grounding devices.

Currently, the majority of domestic grounding devices choose galvanized angle iron, galvanized flat steel and other metal materials as a grounding electrode laying in the manner of combination of horizontal grid with vertical piling\cite{1}. However, the corrosion resistance of metal grounding devices is inferior, and difficult welding, bending and other construction aspects are present, it is difficult to ensure the requirements of whole life cycle\cite{2}. At the same time, in order to enhance the discharge capacity of ground grid, a large number of reducing agent is used, which primarily uses of the ionization properties of chemical colloids to promote soil resistance reduction\cite{3}. This requires a certain degree of moisture support. Metal grounding device have poor applicability in arid regions, and a lot of heavy metal pollution will be caused which will accelerate the metal grounding electrode corrosion.

To solve these problems, this paper chose graphite as matrix, and developed a new type of soft grounding material of high-conductivity based on modified technology of carbon nanotubes and then optimized. This grounding material can significantly improve the discharge capacity of the ground grid, ensure the needs of the whole life cycle, improve the current situation of heavy metal pollution in the region of ground grid.

Preparation of Flexible Graphite Material

Flexible graphite is derived through processing natural flake graphite using the method of layer intercalation oxidation. The preparation process was shown in Figure 1.
In the experiment, controlled mass ratio of graphite and potassium permanganate was 1: 0.8, mass ratio of graphite and ferric chloride was 1: 0.2, mass ratio of graphite and sulfuric acid was 1: 3.0, and the reaction time was 60 min. To ensure the smooth progress of the reaction, the reaction must be guaranteed under the conditions of constant stirring. Since the experiment selected concentrated sulfuric acid as an oxidizing agent, the prepared expandable graphite has a high sulfur content, therefore the experiment adopted concentrated sulfuric acid and potassium permanganate as intercalating agents, ferric chloride as a catalyst insert to ensure the resulting flexible graphite sulfur content is less than 500 μg / g.

Flexible graphite layers will occur significantly split and form a plurality of expansion joint state. But the connect between layers was not completely cut, and formed entangled wormlike landscape by several small buds blooming[4,5]. This is due to graphite intercalation compounds decomposed rapidly while the high temperature expanded so that interlayer spacing widened and expanded into many small wedge holes[6]. But these cell walls retains the original hexagonal mesh structure of graphite. Because of these holes, the flexible graphite has excellent absorption, compression elasticity and good strength.

Modified Flexible Graphite Based on Carbon Nanotubes Prepared

Because carbon nanotubes are nanoscale materials with large surface area, in order to reduce the free energy, carbon nanotubes tend to aggregate into groups to reduce the surface energy. And this is a spontaneous tendency of behavior. Carbon nanotube powders of market supply are made of micron-sized particles combined carbon nanotubes, the particle size is generally at 1 ~ 20 μm, the microscopic structures are aggregates. Thus, dispersion treatment is necessary prior to using CNTs. Carbon nanotubes are uniformly dispersed in the matrix of the workpiece by the dispersion treatment to achieve the object of a substantial increase in performance of the components.

First deployed 1g / l of an aqueous solution of an anionic surfactant, and then carbon nanotubes were added in the proportion of 1% of the total amount of solution to subject to ultrasonic dispersion. In order to obtain better dispersion effect, in 20 minutes and 40 minutes of time samples were taken for electron microscopy analysis. The results shown in Figure 2. In 40 minutes this paper found the better dispersion effect, and the effect will be further with time extension, but relatively the cost of processing was increased.
Took 10g flexible graphite prepared in the preceding experiment to add into 100g of water, subjected to ultrasonic dispersion for 20 minutes, followed by addition of predispersed 0.1g of carbon nanotubes and continued ultrasonic dispersion for 20 minutes to obtain the graphite samples with carbon nanotubes dispersed.

Experiments adopted hydrazine hydrate as reducing agent in order to eliminate oxygen-containing functional groups of flexible graphite surface, so improved the conductivity of the graphite layer. And then the hydrazine hydrate is added to the graphite samples with carbon nanotubes dispersed by a certain percentage, heated to a certain temperature, and continue ultrasonic dispersion for some time. When the restore is complete, modified flexible graphite based on carbon nanotubes was got by the method of centrifugal separation, the sheet modified graphite sample was obtained after rolling several times.

Resistance performance of flexible graphite material reduced with the degree of reduction of the graphite increasing, so selected the appropriate reduction time according to the principle. Experimental set reduction temperature is 70, modified graphite in different reducing time had different resistance. Experiments shown that when the reduction time was 40min, the resistance of graphite is $3.75 \times 10^{-5}$ $\Omega \cdot m$, and then the decline of resistance becomes very slow with prolongation of time, indicated that reduction of graphite oxide is substantially complete.

Application of Flexible Grounding Materials Based Graphite

Section Headings. After the preparation of high purity flexible graphite of good electrical conductivity, this material is prepared to become a flexible grounding material requiring to design preparation process according to applications, including the selection of reinforcing fiber material, reliable complex of fiber, hydrosol, expanded graphite, the weave from graphite yarn into the grounding device of meeting the grounding requirements and the selection of grounding devices connection material and methods and so on.

The fiber "skeleton" of composite grounding device is to ensure the mechanical properties, the optional materials are cotton fibers, wire, glass fiber, etc. This paper adopted glass fiber as the main "fiber backbone" to improve the overall mechanical properties of the composite grounding devices. Single strand graphite yarn was made by this process that intermediate layer of bilayer graphite paper laid dipped glass fiber or other fiber, took curing treatment by heating, and then multiple roll forming using roll manner, finally cut volume. Prepared flexible graphite grounding devices after forming a single strand of graphite yarn. Selected coaxial counter of braided molding process and the outer layer of graphite yams adopted reinforced graphite yams, the inner core wire selected 44 fiberglass Graphite yarns, ensured the graphite core wire to maximize electrical conductivity, as much as possible to improve the tensile strength of the outer layer of Graphite yarn.

Performance Testing. Graphite have a good anti-corrosion properties, resist acid and alkali, and graphite-based flexible material have good continuation of the feature. All the components constituting the graphite-based flexible grounding devices have good corrosion resistance, which can withstand chloride saline in coastal areas, sulphate soil in Xinjiang, Gansu, Ningxia, Inner Mongolia,
soda saline soil in Northeast and Shanxi, Karst soil in Guangxi, Guizhou and Yunnan and other types of soil erosion. The life of the graphite-based flexible grounding devices is not less than 30 years. This grounding device can withstand resistance reducing agent, antifreeze, fertilizers and pesticides corrosion and expand the application of resistance reduction technology. graphite-based flexible grounding material and several grounding materials currently used were compared in various aspects through experiments and market research in this paper, the results were shown in table 1.

Table 1. The compare between graphite-based flexible grounding material and other grounding materials.

<table>
<thead>
<tr>
<th></th>
<th>graphite-based flexible grounding material</th>
<th>Round steel</th>
<th>Large flat steel</th>
<th>Copper Clad Steel</th>
<th>Multi-strand copper wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material properties</td>
<td>Bendable, Rotatable</td>
<td>Difficult to bend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connection characteristics</td>
<td>Crimping</td>
<td>Welding</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Excavation</td>
<td>Small excavation, convenient backfill</td>
<td>Backfill required to tamp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price [Yuan/m]</td>
<td>90</td>
<td>12</td>
<td>25</td>
<td>80-300</td>
<td>150-200</td>
</tr>
<tr>
<td>Transportation, construction costs [Yuan/m]</td>
<td>40</td>
<td>80</td>
<td>100</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>Service life [years]</td>
<td>20-30</td>
<td>3-5</td>
<td>3-5</td>
<td>20-30</td>
<td>20-30</td>
</tr>
</tbody>
</table>

The specific density of graphite-based flexible grounding devices is 1/10 of the metals grounding system, so it’s lightweight and easy to transport; serpentine excavation can avoid rocks and trees, less excavation does not destroy the greening; can backfill mud compactly; the grounding devices achieved interconnection through crimping without welding, so the spot welding, power and other requirements does not need.

Summary

In this paper, prepared modified flexible graphite composite grounding material based on carbon nanotubes taking advantage of modified carbon nanotubes technology to solve the prevailing poor corrosion resistance, construction difficulties, short life cycle of metal grounding devices. By contrast with the conventional grounding material, the specific density of graphite-based flexible grounding devices is 1/10 of the metals grounding system, so it’s lightweight and easy to transport; serpentine excavation can avoid rocks and trees, less excavation does not destroy the greening; can backfill mud compactly; the grounding devices achieved interconnection through crimping without welding, so the spot welding, power and other requirements does not need. Good corrosion resistance of this flexible graphite composite grounding material ensured reliable long-term stability of the grounding grid and has a high practical value.

References


