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REDUCING EARTH GROUNDING ELECTRICAL RESISTANCE BY USING METALLURGY INDUSTRIAL WASTE AS BACKFILL MATERIALS

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Abstract: *This paper presents results from experimental research work involving the improvement of the electrical properties of earth grounding using metallurgy waste materials as backfill. It is presented that using this materials, which are this way recycled, decreases the earth grounding resistance improving safety and reducing costs.*
Key words: *grounding grids, materials, grounding electrodes, furnance slag.*

1. PROBLEM DESCRIPTION

The term earthing refers to the procedure of connecting a conductive material to the earth mass. A grounding grid refers to the interconnected network of underground conductive materials that has the purpose of offering a safe passage for the faulty or hazardous currents.

In areas where soil resistivity is high (sandy areas, rocky areas etc.) implementing a grounding system is difficult. There are special backfill materials that are used to implement grounding system in those specific areas. This paper proposes the use of a metallurgy waste material (smelter slag) as a backfill material for decreasing ground resistivity.

2. APPLICATION FIELD

The earth resistance of electrode has three components: the resistance of the electrode conductor, the electrode / soil contact resistance, and the resistance of the soil surrounding the electrode [1]. Typically, the first two components are negligible compared to the resistance of the soil [2]. Thus most analytical formulae for earth electrode resistance usually account for the resistance of the soil only. A rod of radius r buried in the ground to a depth of l is shown in Fig. 1. Assuming that the resistivity is constant, the earth resistance may be derived from the general formula: $R=\rho*l/A$.

3. RESEARCH STAGES

The overall earthing resistance is directly proportional with the ground earthing. Some method simply the replacement of the soil on the area that is to implement the grounding system [3].

Other methods state that the best thing would be to cover the electrodes and the conducting strip with better conducting materials such as benthonite. This paper proposes the use of metallurgy waste materials as backfill for grounding electrodes.

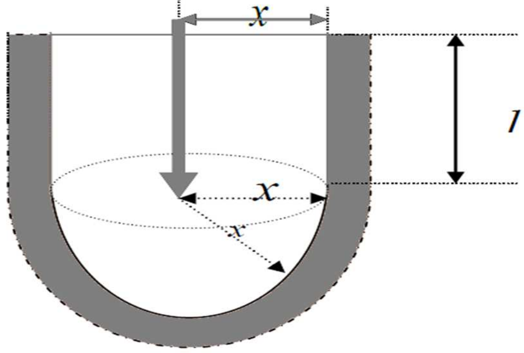

Fig. 1 Electrode description

4. RESULTS.

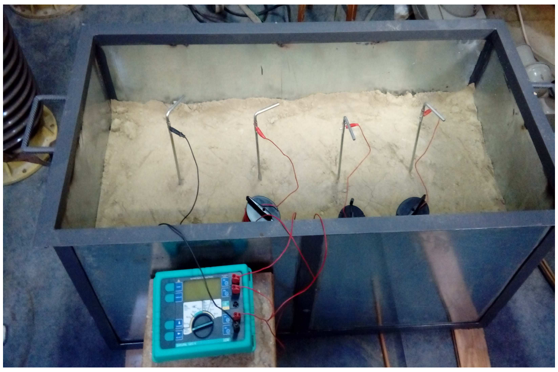

Fig. 2 Laboratory testing stand

For these purposes a laboratory stand was build. It is presented in Fig.2.

Some study has shown that at a distance of about 1.1 times the length of rod electrode from the electrode, the resistance is about 95 % of the total earth resistance and change in resistance becomes negligible. The area within this distance of the rod is the so-called effective resistance area. Measurements have also shown that about 90% of the total earth resistance surrounding an earth electrode is generally within a radius of 2 to 3 m from it.

The soil used in this experiment has a total eart resistance of 69,8 Ωm and it is classified as clay soil.

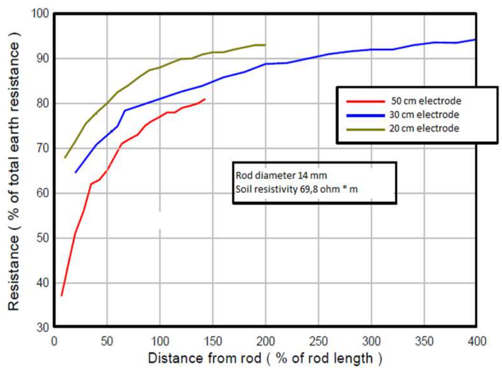

Fig. 3 Soil electrode resistance results

Figure 3 presents the results of the field rod electrode test. There are presented 3 types of electrodes. The first, represented with red is the longest, with blue it is represented the 30 cm electrode and the last is the shortest electrode of 20 cm. The resistance of the earthing system is measured based on the distance from the electrode. It is demonstrated that the longer electrodes have less impact further on the ground, and the short electrodes have higher resistance and that resistance increases as the distance from the electrodes increases.

For the laboratory experiment, first we have to take into consideration the resistance of one electrode that is covered in backfill material. The schematics are represented in Fig. 4.

First the waste material to be used has to be inspected for its properties and the effect of it in contact with the materials used for grounding. The material has to be environmental safe, to have a better conductivity than the replaced soil, permanent and noncorrosive to the electrode.

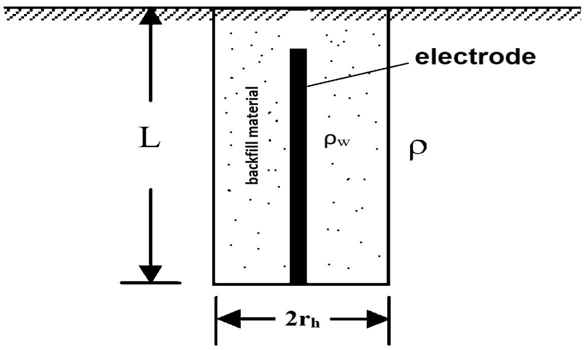

Fig.4 Grounding electrode in backfill representation

The property permanent refers to the effects brought to the grounding system. It was proven that the percentage of material erosion of metal electrode due to corrosion in the presence of metal oxide powder is less than 1% after more than two years in contact.

The method taken into consideration in this paper is using the backfill material to increases the radius and length of the electrode thus the total grounding resistance can be lowered. This type of grounding can be used in regions where the ground has high resistivity like rocky soil, sand soil etc. It can also be used in places where there is not enough space to create a grounding network or parallel grounding. The next step was finding the equation for an electrode totally covered in backfill material.

$$R = \frac{\rho_w}{2\Pi l}\left[\ln\frac{2l}{r}\left(1+\sqrt{1+\left(\frac{r}{2l}\right)^2}\right)+\frac{r}{2l}-\sqrt{1+\left(\frac{r}{2l}\right)^2}\right]+\frac{\rho-\rho_w}{2\Pi l}*\left[\ln\frac{2L}{r_h}\left(1+\sqrt{1+\left(\frac{r_h}{2L}\right)^2}\right)+\frac{r_h}{2L}-\sqrt{1+\left(\frac{r_h}{2L}\right)^2}\right] \quad (1)$$

In the developed equation ρ_w is the resistivity of the backfill material. It was considered that the electrode was covered in backfill material all over except the bottom. Also the hole is in uniform ground and has a radius of r_h and a depth of L. This method is supposed to cover the electrode in backfill material.

For determining the development of the resistance based on the amount of backfill added were made 3 tests. For the first electrode a hole of 30 centimeters in diameter was made.

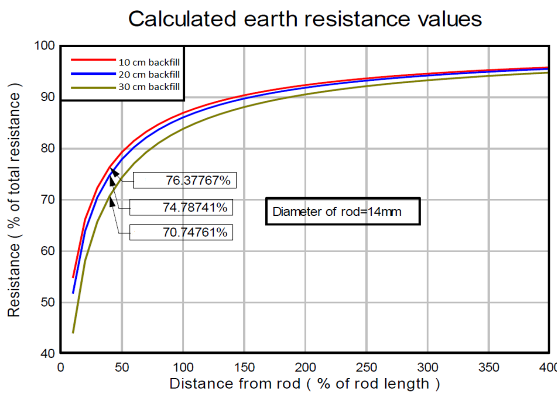

Fig. 5 Grounding resistance for the proposed 3 type electrodes

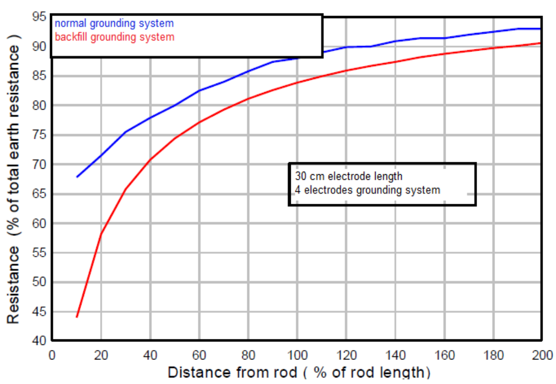

Fig. 6 Grounding system comparison

The electrode was placed inside and the hole was covered with backfill material. Another two electrodes were buried in the same perspective but with the hole diameter of 20 centimeters and 10 centimeters respectively. The earth resistance of each electrode was measured at different distances from the electrodes. The experimental results are presented above in Fig. 5.

The bottom representation from the chart represents the electrode surrounded by 30 centimeters of backfill material, the second and the upper representations are the electrodes with 20 centimeters and 10 centimeters of backfill surrounding them. It can be concluded that the best performing electrode regarding the resistivity is the one that is surrounded by more backfill material**.**

In the figure above it was plotted the resistance values for the two implemented grounding systems. The above representation expresses the resistance behavior of the normal grounding system while the bottom one represents the grounding system implemented 20 centimeters of the backfill material. It can be observed that the one filled with iron waste is the better one. It has almost 20% lower resistance than the normal one.

The same plot is presented in Fig.7 for the grounding system that has the electrodes covered with 30 centimeters of backfill material. For this case the resistance of the grounding

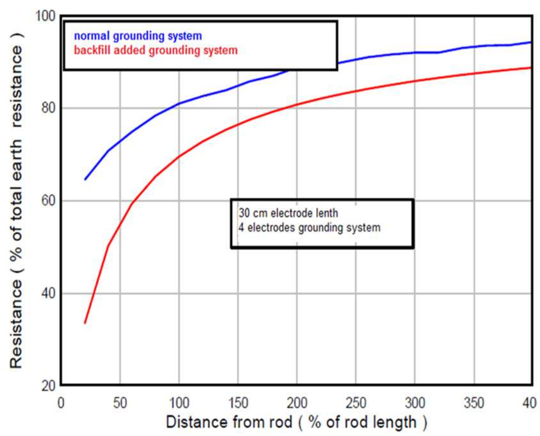

Fig. 7 Normal vs backfill material grounding

implemented has 41% lower values than the normal implemented one.

From these measurements it can be concluded that the bigger the amount of backfill material used in grounding system the better the results are. This proves the utility of the iron waste in developing safe and within the norms grounding systems.

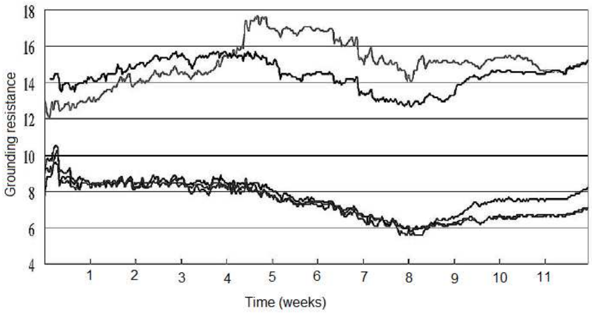

Fig. 8 Measured resistance over time period

In the above figure it is presented the measured result over 11 weeks. The above graph represents the normal grounding system, the second one is the 10 centimeter backfill hole for electrodes and the third and fourth are the 20 centimeters and 30 centimeters respectively. It can be observed that the grounding system presents stable values over time. The fluctuations of the graphs are due to the different humidity values on the different time the measurement was conducted. The backfill material was measured to have a resistivity of 28 ohms*m and in wet conditions only 8 ohms*m.

CONCLUSIONS

In areas where the ground has high values for resistivity or the space for implementing the grounding system is limited, designing the safety system is very difficult. This paper has proven that using the slag, which is a waste from metalurgy industry, as a backfill material is a great way of reducing the overall resistance of the grounding system. The measurements show that these backfill materials almost reach the level of performance for commercially available substitute materials after several months. It was also stated that the level of corrosion of slag backfill on grounding electrodes is less than 1% after more than two years in contact.

8. REFERENCES

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Reducerea rezistivitatii solului in implementarea prizelor de pamant folosind deseul de zgura din metalurgie

Rezumat: Aceasta lucrare prezinta rezultate experimentale ce demonstreaza imbunatatirea performantelor prizelor de pamant in zonele unde solul are valoarea rezistivitatii mare, folosind deseul de zgura din industria metalurgica drep ballast. Se demonstreaza ca folosind acest material ieftin proprietatile prizelor de pamant se imbunatatesc si totodata se recicleaza si zgura.

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