Research Article

Experimentation with Solid Steel Fibre Waste from Lathe as Backfill Material Affecting Earth Resistance

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Abstract: Safety is the major aspect of power systems. Earthing is a bypass mechanism which offers low resistance to protect personnel and equipment. The technology and industry growth in all over world witness benefits and lots of challenges posing serious environmental issues. Solid waste generated by lathe machines need to be disposed well or utilised. This paper details experimentations with steel waste fibresobtained of lathes used as a backfill material for earthing. Primary factors affecting earth resistance are earth electrode, soil resistivity and contact resistance between electrode and soil. The scrap lowered the earth resistance by 90% in wet condition when used with bentonite. Its effect is more profound in presence on bentonite.

Keywords: Earthing, bentonite, steel waste fibre

1. Introduction

Earthing is an important aspect of electrical systems. Personnel and equipment safety is achieved through earthing. Generation, transmission, and utilization sectors of power systems have reformed due to the technology development. With increased urbanization, changing lifestyles, and increased consumerism, solid waste management is a mammoth task [1-3]. Urbanization leadsto negative impacts such as health hazards due to improper waste management and urban environment degradation. The natural and manmade changes have impact on earthing design. Soil has changed due to seasonal variations, concretization of places. Due to all these changes, there is need to search for alternatives of common practices of earthing. Earthing design focus in mainly on reducing earth resistance. Earth resistance is dependent on earth electrode, the soil in which electrode is placed and contact resistance between soil and electrode [4-5]. The electrodes of various shapes like plate, pipe, mesh is used in common practice. They are of steel or Galvanized iron or copper materials. Their burial depth, parallel connection also alters earth resistance. [6-8] The resistivity of soil around electrode is the major contributing in earth resistance. The soil types, moisture contents, chemical compositions are sub factors which are studied and reported in literature extensively. High resistivity soil is artificially treated to reduce the earth resistance. Common salt mixed with charcoal is commonly practice of soil treatment. Some other salts like Copper sulphate ($CuSO_4$), calcium chloride ($CaCl_2$), sodium carbonate (Na_2 CO_3)is also used to reduce earth resistivity. Salt's solution even corrodes electrodes. Natural materials are used to substitute salts are bentonite, flash, even paddy dust, palm kernel oil mixed with soil [9-12]. The natural clay bentonite is mixed with metal burr and its results are presented in this paper.

In this paper, second section details information about backfill materials and its properties affecting earth resistance. Effect on earth resistance by performing scale down experiments is explained in third section. Results obtained from experiments are proposed in fourth session. The fifth section details conclusion followed by acknowledgment and references.

2. Backfill materials

Steel solid waste

Great quantities of steel waste fibers are generated from industrial lathes per year especially when lathes are existing in a large numbers sited in industrial zones . This really represent an environmental problem since that steel waste fibers are difficult in biodegradation and need a large area if it will store. A good management of such a solid waste is to find the way to make use of it in addition to dispose it.

In industrial settings, there are a significant number of lathe devices. Steel waste fibres are generated in large amounts by industrial lathes. These are not biodegradable, so they are a hazard for the ecosystem, and they are also difficult to store [13]. This is something that needs to be tackled. The best way to handle this waste is to bring it to good use rather than dispose of it. Lathe machines are most used machines in machining industry for finishing various machines parts. During this machining process steel scraps are produced. These wastes even require large area for storage. Steel scrap from lathe machines has similar physical properties. Lathe waste is generally in the form of crimped fibre. Lathe waste material for this work is collected from college workshop and local industrial workshops.

Bentonite properties

Bentonite is a clay that formed many years ago because of volcanic ash alteration. It is suitable as a natural backfill material to reduce earth resistance due to its ability to retain moisture. It reduces contact resistance while increasing the effective surface area of the electrode. It's a montmorillonite clay that's off-white in colour. It has a sheet-silicate structure. The swelling effect is caused by additional water molecule embedding into these thin layers.

The physical properties of bentonite are used to deduce its mineralogical composition. The chemical and mineral composition of bentonite influences its properties. There are two kinds of bentonite: swelling bentonite, also known as sodium bentonite and the non-swelling type is Calcium Bentonite.

In moist conditions, bentonite has a low resistivity of about 2.5-ohm m. It is non-corrosive and inert [14]. When bentonite constituents, primarily Na2O (soda), K2O (potash), CaO (lime), MgO (magnesia), and other mineral salts, are mixed with water, they form a strong electrolyte solution that is extremely hygroscopic. Its pH ranges from 7-9. When exposed to enough water, it swells to 13 times its dry volume by absorbing water from its surroundings and almost binds to nearly any surface.

Charcoal & salt mix

Sodium chloride (salt) and magnesium chloride are the chemicals that were traditionally recommended and used. they are wrapped around the electrodes. The salts are dissolved by adding water. Charcoal is made up of carbon, hydrogen, oxygen, and nitrogen in varying proportions depending on the type of wood used. Carbon is main element generally 80% of its mass. Carbon atoms are arranged in layers of hexagonal rings, with interstitial spaces between them in the form of pores. Because charcoal is porous, it increases the Cation Exchange Capacity of the soil, thereby increasing conductivity. Aside from the fact that carbon has pores in the soil that retain water to increase conductivity, when carbon is mixed with sodium chloride in the soil, a series of reactions occur, resulting in hygroscopic NaNO3. As a result, earth resistance is reduced [15].

3. Experimental setup

The study is carried out by scale model of actual earthing. Five Vertical earth electrodes of 30cm lengths and 14mm diameter were buried in soil as shown in fig.1.

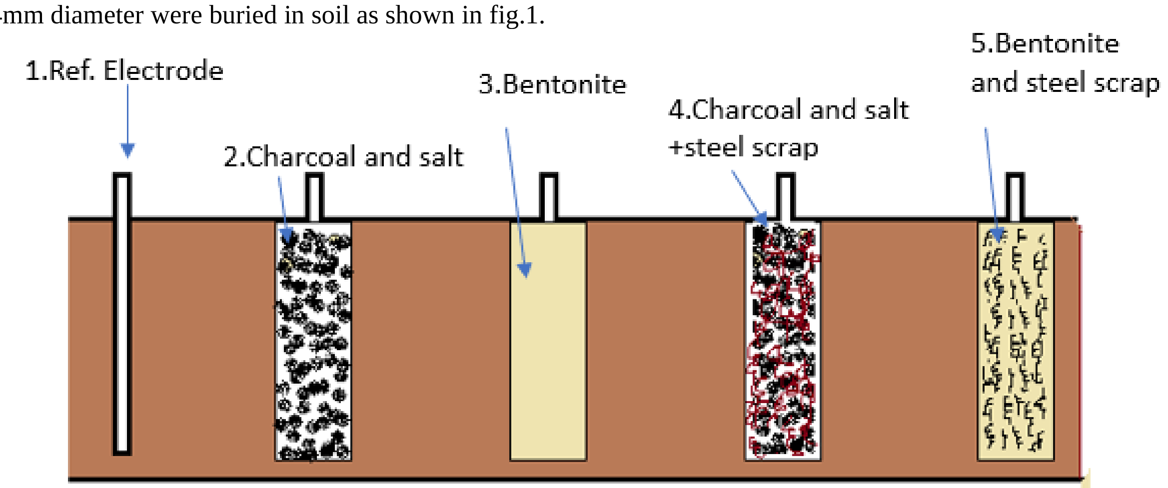

Figure 1.Experimental setup

The various combinations of backfill are tried out as described in Table 1. The pits are excavated and filled with materials. The distance between two electrodes is almost 3 meters. The 30cm diameter area around electrode is filled with backfill material. The earth resistance is measured using fall of potential method.

Table 1.Trial backfills combinations

Test Pit	Backfill material
1	Reference soil
2	Salt & charcoal
3	Bentonite
4	Salt, charcoal+ steel scrap
5	Bentonite +steel scrap

4. Results

The measurement of earth resistance is carried out over a period allowing settling of backfill materials. The earth resistance is measured over a period prior watering. Results in dry conditions are as shown in fig.2. The pits are watered. The resistance is measured again to observe effect of materials on earth resistance in wet condition. The obtained results are as shown in fig3.

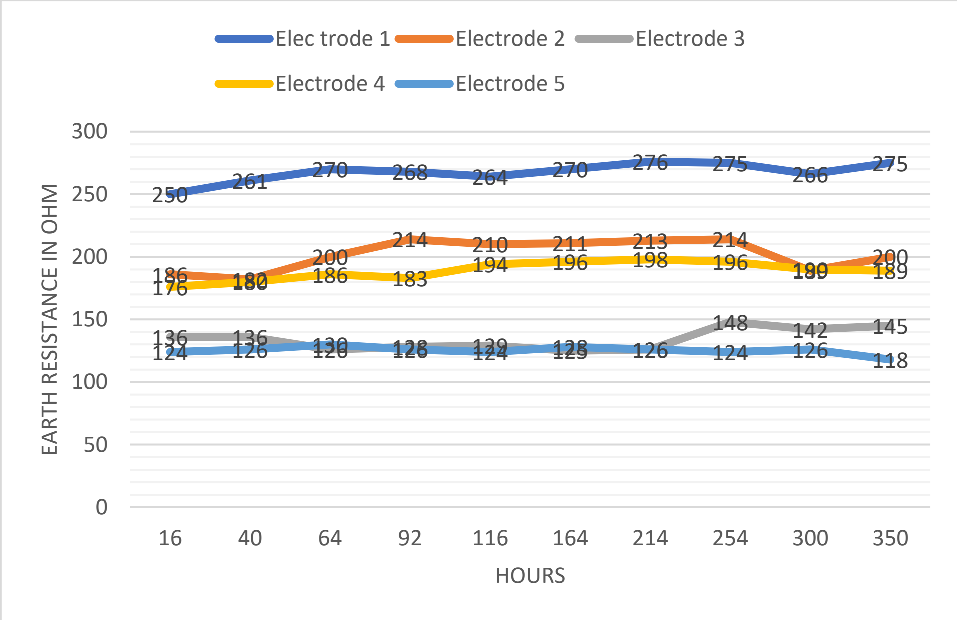

Figure 2.Earth resistance variation over a period with different backfill materials in dry soil

Bentonite at third electrode has lowered resistance as compared to charcoal mix as it absorbs water from surrounding. The effect is slightly more when scarp is added around 70% of reference electrode.

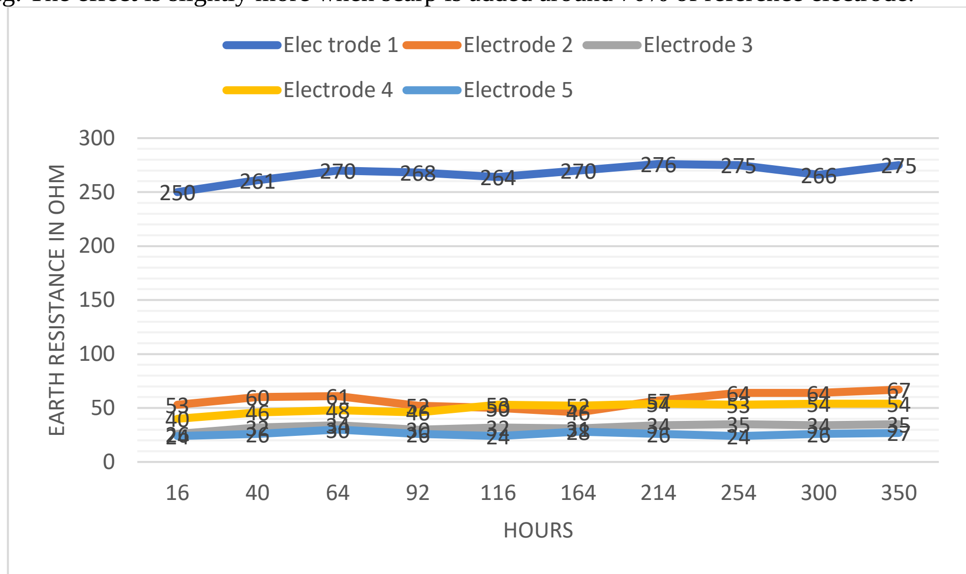

Figure 3.Earth resistance variation over a period with different backfill materials in wetsoil.

It was observed that significant percentage reduction in earth resistance is noticeable due to backfill. Wet condition drastically reduced earth resistance. When water is added to pits electrolytic reaction takes place in charcoal salt mix. Bentonite is more effective in wet condition strong electrolyte is formed due to its constituents resulting almost 85% of reduction in earth resistance As shown in Fig.4, up to about 90% reduction was obtained on the 5th electrode in wet condition.

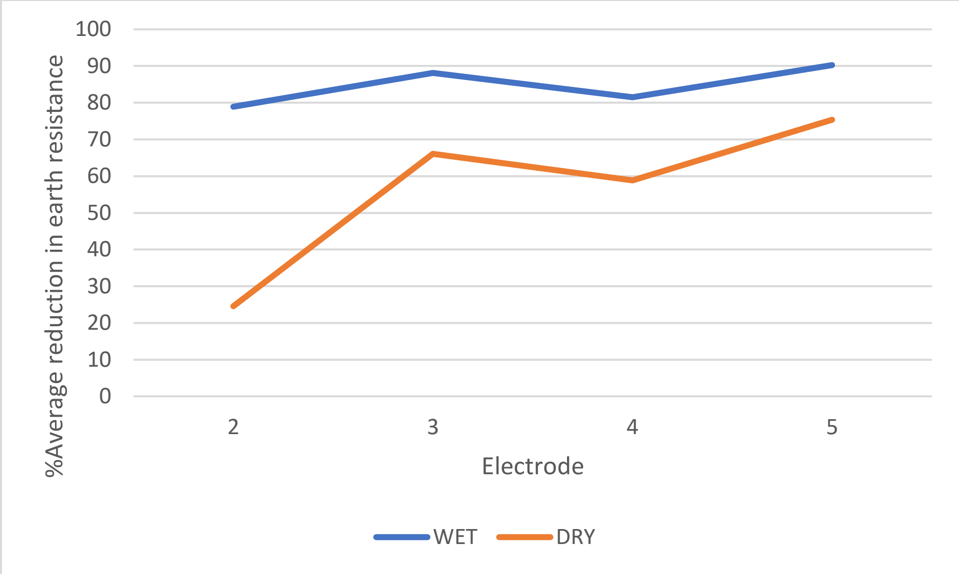

Figure 4.Average % reduction in earth resistance in wet and dry condition

Conclusion

The result from experiments shows that backfill reduces earth resistance. Charcoal and salt combination has least reduction amongst all combinations while metal scrap in bentonite has maximum reduction almost 90% in wet condition. Wet condition helps in reducing earth resistance. Charcoal, salt, and steel scrap reduction in earth resistance was less, dry condition even worsens the results. Bentonite in wet condition reduced almost 85% earth resistance while steel scrap inclusion reduced earth resistance further. Different metal scrap needs to be investigated further. Corrosion effect of dissimilar materials also will be investigated in near future. Solid steel waste can be thus utilized in nearby industrial area for earthing purpose. Transport and disposal of solid waste lathe fiber issue can be addressed if used in earthing.

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