A Guideline on Designing a Safe and Appropriate Grounding System: A Review of Selected Papers

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Liliana [1] & Setiawan David [2]

[1]UIN Suska Riau Pekanbaru
Email : liliana@uin-suska.ac.id
[2]Universitas Lancang Kuning, Pekanbaru, 28265, Indonesia
Email : dsetia@unilak.ac.id

Abstract: This study to review scientific articles from some of the international journal, published from 2005 to 2017. This study focused on articles that discuss how reduce grounding resistance. The article is discussed systematically, criticized, and analyzed. To secure the system from the disorder, we need to design a system. This system was later known with the grounding system. The criteria used in the review journal is focused in terms of: how reduce grounding resistance with electrode be planted a single or parallel, giving conductive material/reducing material, including some of the methods used in reduce grounding resistance specific to regions with high soil resistivity, and the obstacles faced. The discussion on the above issue is a major problem in the article. The article that reviewed published in language of United Kingdom from 2005 to 2017. The analysis of reviewing 20 journal produces two staples of the discussion is existing problems in the grounding system and optimal way in reduce grounding resistance. The reduction of resistance on the location of the grounding that have very high soil resistivity needs to be done, some way is offered in several articles that are discussed so that it could be a guideline the planners in designing a grounding system that is safe and appropriate for the system to be secured.

Keywords: High Soil Resistivity, Grounding Resistance, Grounding System

1. Introductions

Grounding system has not been used when power system still has the size of a small capacity (until 1910). This may be due at the time when there is a disturbance to the soil on the system and magnitude of the current disorder is equal to or less than 5 ampere [21]. In this conditions the fire arc will extinguish. Along with the development of the electric load is increased, causing power system continued to develop both long or voltage, so that the current fault is flowing to the ground will be larger. The arc of fire that appears not to be extinguished itself. This could give rise to more transient voltage is very high, so it is very dangerous for the system. Therefore, it is very necessary that the draft of a system which can cope with the disorder. The system then known as grounding system. One of the grounding system is carried out by means of grounding electrode plant that serves to minimize grounding resistance who meet the standards of safe it is possible to anticipate the disorder. Grounding resistance have value as small as possible in order to flow fault current into the ground well. Grounding resistance with electrode is very dependent upon the type, condition, size and how the placement of the electrodes [1]–[4].

To obtain soil resistivity lower primarily for soil with high soil resistivity, often tried by changing the chemical composition of the soil [4]–[8]. In This research the purpose of the literature review was to identify research related to the grounding system of the more devoted to identify literature that lays out how the reduction of the value of grounding resistance on the soil type who have high soil resistivity.

2. Theory: The review

Research on structure of homogeneous and notof soil for two types condition of soil layers with a single rod elektoda, parallel rod electrode with a certain distance, obtained custody for one rod grounding electrode will be getting smaller when the electrodes were planted further and further from the surface of the ground. Grounding resistance getting smaller if more electrodes, either on the ground homogeneous or not [22].

Grounding resistance electrode depends on the type and condition the land as well as on the size and composition of the electrode. The magnitude of the value of grounding resistance electrodes at soil around the power source or the transformer and on the network of 200 meters, the last of any branches, shall not exceed 10 Ω. For areas with high value grounding resistance, shall not exceed 20 Ω [23]. Type of ground electrode used for grounding electrode is an electrode rods, ribbons, and electrode plate [23]. The electrode rod is required must have a minimum size of 15 mm in diameter with steel coated copper as thick as 250 µm. To get resistivity of soil types, often tried by changing the chemical composition of the soil with chemicals on the ground near the ground electrode. This way is only good for a while because the process of grant of salt should be performed periodically, at least 6 (six) months[22].

3. Research Methods

The step in literature search, the first, researchers to determine the main topic. Topics examined include grounding system and how the reduction of the value of grounding resistance. Second, the major topics have been set to be a basis in the search for literature. In this paper, the researchers using electronic search from multiple sources such as IEEE and Elsevier. Third, in the search for related literature, researchers using a few key words (grounding systems, reduction grounding resistance conductor backfill and high soil resistivity).

4. Result and discussion

Literature search results amounted to 102 articles in 2005 up to 2017, there are 63 articles that are not related to the field of study, 39 articles remaining. Of the 39 articles are then identified and analyzed again, but there are about 19 article discussion not associated with the main topic, there are 20 articles were chosen as the basic data information about how to reduce grounding resistance.

To reduce grounding resistance has been widely performed. Based on standards that have been recommended by the IEEE Std 142-1982. Reduce the grounding resistance consisting of a number of ways including:

4.1 Addition rod electrodes

Rod electrodes quantities additions intended to get grounding resistance decreased up to 40%. To get the maximum recommended grounding resistance decreased is make parallel rod electrode with a minimum distance between the rods exceeds the length of a rod electrode. The more the number of parallel one grounding rod, the greater the decrease grounding resistance.

Rod electrode parallel proven to reduce grounding resistance, see Figure 1, parallel to 2.3, and 4 electrodes rods decrease grounding resistance reached 70%, but when the rod electrode is 5 parallel, decrease grounding resistance reach the saturation state, conditions the increase is not significant, the results of the experiment showed a decrease grounding resistance optimal when the 4 parallel grounding electrode [4]

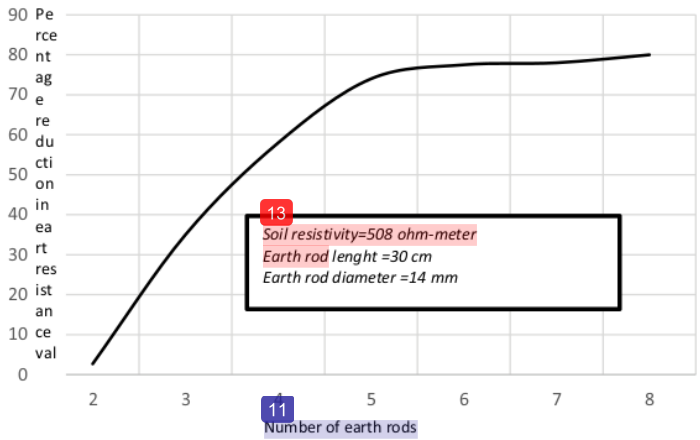

Figure 1. Response Curve of Ground Electrodes Connected in Parallel [4].

4.2 Deepening planting electrodes rod

Rod grounding electrode planting deepen intended to obtain normal water concentrations, related to soil moisture and soil resistivity. The deeper the planting the electrode rod the greater the decrease grounding resistance. Grounding rod electrode planting deepening should be tailored to the needs of the soil resistivity type for the purposes of planning a grounding system.

Research with the deepening of the electrode is indeed proven to be lowering the value of grounding resistance, one of the results of the experiment of planting this electrode with a depth of 3 to 5 m, can be seen in Figure 2, the planting of the electrode with a depth of up to 5 m produces a significant decline, but a depth exceeded 5 m drop in the value of grounding resistance running slow [9].

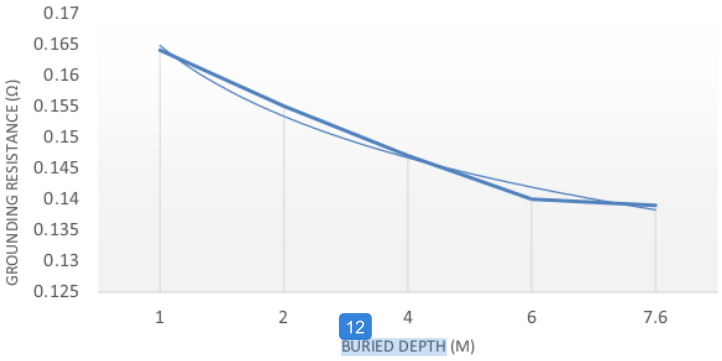

Figure 2. Grounding Resistance Curve after Buried Depth Increases [9]

4.3 Soil treatment

Give treatment of the soil is a method that is quite effective to reduce grounding resistance at high soil resistivity. This method can be done with the giving of chemical elements such as sodium chloride, calcium chloride, magnesium chloride or copper sulfate, bentonite, and which can reduce the value of grounding resistance between 15% to 90%. Research on the treatment of the soil by adding chemical element has indeed been shown to degrade the value of grounding resistance [2], [4]–[10].

Eduful et al., 2009, doing experiments to lower the value of grounding resistance by comparing the several kinds of materials reducing (tyre ashes, wood ashes, the Cocoa shell and palm kernel cake), the results of the research done indicates that tyre ashes that result in the most decrease in the value of grounding resistance (Figure. 3).

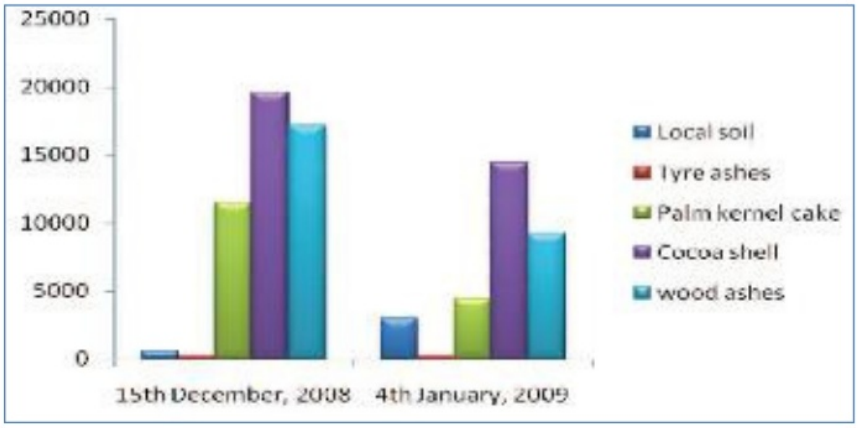

Figure 3. Comparing Efficiencies of Local Materials 2009 [4].

Zhaosheng et al., 2011offers a mechanism for reduce grounding resistance by adding ions electrolyte on grounding system. This research uses a mechanical basis electrolytic ion can be seen on Figure 4 the following.

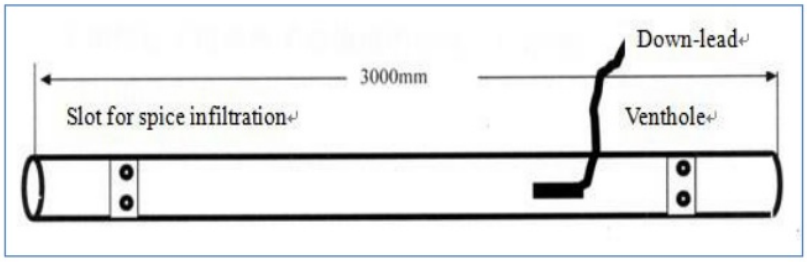

Figure 4. Structure Diagram of Electrolyte Grounding Pole [8]

Ground Pole is a metal tube closed at both ends. On one side is used as the vertical grounded meta, on the other hand is used as a container to produce pharmaceutical chemical ions. Pharmacy in metal tubes to produce large quantities of ions are released into the surrounding soil through a metal wall. The closed metal tube make sure pharmacy is not going with the water, so that chemical reactions can last a long time (30 years). During this period the surrounding soil conductivity can be maintained at a constant value.

This research uses a type of ion electrolytic NJD-2A-type electrolyte grounding rod, made of copper with a diameter of 40 mm, length 2.7 m. Rod electrode planted in vertical and NJD-2B type electrolyte grounding rod, made of steel with a diameter of 40 mm, a length of 3 m. Rod planted in holes with a size of 1 m x 1 m x 1 m in vertical, the result type NJD-2B has better characteristics and tend to a constant value in keeping the desired grounding resistance, compared to type-2A NJD give fluctuations against the value of grounding resistance and have a higher value, certainly the type NJD-2A have unwanted characteristics to reduce grounding resistance. Hu et al., 2012 examines the influence of addition of conductive materials backfill against the value of grounding resistance are given power and lightning impulse frequency. Grounding with conductive backfill resulted a decrease in the value of a better grounding than without backfill while condition or the condition of the power frequency lightning impulse. While Khan et al., 2010.2011 researching new techniques to find the optimal size trench/efficient grounding holes on the power system of high resistivity soil types by adding material that has a low resistivity reducing, the values obtained with the grounding prisoners do optimization of grounding parameters by using the Matlab application.

Research on addition of reducing grounding resistance also conducted by Radakovic et al., 2015., Smohai, 2015, and Zhenghua & Ling, 2011 [10][12][2]. The granting of special materials is made at the location of the dry soil that has a high soil resistivity. On the study of the economic value of the consideration is also taken into account in the design of the grounding system optimal gain. This research resulted in the value of the optimal diameter of 320 mm of backfill material and planting the electrode horizontally is not recommended.

Some of the ways that is done aims to generate the value of the minimum resistance, proper design required to set the value of grounding resistance according to the standard [3], However, in its application to the value of grounding resistance is not always arrest the constant value. In addition to technical factors, grounding resistance is influenced of nature such as the changing of the seasons, humidity, and temperature [13], [14]. Safeguards the value of grounding resistance is very necessary has produced techniques for measuring and controlling the value of it so that remained constant [15]. Measurement and control is done by designing a system that uses moisture sensor, grounding electrodes, and water irrigation system in the ground.

Design of measurement grounding resistance can also be done by the method of Digital Signal Prossesing (DSP) [16], Fall-of-Potential methode [17], and 3D FEM modeling [18]. In addition, the value of grounding resistance was also influenced by frequency [19], [20]. HQ et al examine the characteristics of frequency and the influence of soil resistivity of grounding resistance on type of soil is non uniform that are modeled in the form of 3 layers of the soil, the study said the rise in frequency resulting in a rise in the relatively large grounding resistance Likewise research results Kokorus, Zildzo, Ahmovic, Gacanovic, 2015. States the amplitude effect on the value of grounding resistance.

5. Conclusion

Research of grounding system on special topics reduces the value of grounding resistance has been widely performed, some ways of lowering the value of grounding resistance have been presented in this paper, namely by means of stem planting increased the number of electrodes, electrode rods, planting deepens of rod electrode, and provide materials reducing. In addition to optimizing engineering design of grounding system is indispensable to achieve the desired value for grounding resistance but in applications often encountered obstacles in maintaining value of grounding resistance influences such as changing seasons, temperature and humidity, besides the magnitude of the frequency also affect the value of its. For it in the design should also take into account the proper method to be applied.

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