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TROPICAL CLIMATE EFFECT OF HYDROPHOBICITY AND SURFACE LEAKAGE CURRENT ON ELECTRICAL INSULATION MATERIALS (SILICONE RUBBER AND FLY ASH)

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ABSTRACT

Based on research conducted by I. Kitta, *et al.* (2016), it has been known that the addition of fly ash filler in silicone rubber can increase the dielectric and mechanical strength of the material. In this paper, we are doing a further study about the feasibility of the composite material in terms of use in the tropical climate. The purpose of this study is to investigate the influence of tropical climate and high voltage on changes in the contact angle and leakage current of composite silicone rubber (silicone rubber and fly ash). The results obtained showed that the largest decline in the contact angles occurred in a silicone rubber material that is not given fly ash filler, the smallest decrease in the contact angle occurred in silicone rubber with high levels of fly ash as much as 30%. In observation of surface leakage current similar things happen, namely an increase in leakage current is highest in the silicone rubber material without filler, with increased surface leakage current is lowest at silicone rubber material with a fly ash content of 30%.

Keywords: silicone rubber, fly ash, filler, characteristic material, tropical climate, high voltage.

INTRODUCTION

Electrical insulation materials are essential parts of insulating systems of all electric equipment. Their fundamental purpose is to separate two areas with different electrical potentials, so the electric current cannot pass between them [1]. The addition of fly ash into the rubber silicone can improve endurance electrical and mechanical material silicone rubber [2]. In those researches it is known that the strength of the electrical and mechanical exist with the addition of filler fly ash as much as 20% to 40%, but the data obtained in those studies were conducted under normal conditions without any influence of a tropical climate, while for applications in the real world, especially in tropical region needs to be done further research related electrical and mechanical performance of silicone rubber material with the influence of the working environment, in this case the influence is the tropical climate.

The electrical performance that is the leakage current of the polymer material increases over time in the treatment climate is brought forward [3]. The increasing leakage current is caused by salt fog treatment as artificial rain [4]. Pollution and ultraviolet (UV) radiation increase leakage current on silicone rubber material [5]. The UV rays in the study lowered the decomposition temperature becomes lower and degrade the surface of the polymer material, it is also known that UV C Ray capable of decomposing filler and reduce the ratio of Al / Si.

In addition to factors previously described as, temperature, pollution, and UV.there are other factors that can also affect the hydrophobicity and the leakage current as, moisture environment [6]. Be noted that the surface leakage current of the silicone rubber polymer insulator has a minimum value on the humidity of 40% and a maximum leakage current occurs at 70% humidity.

The leakage current and hydrophobic also increased exponentially with time, the study showed that the increase in leakage current and decrease hydrophobic higher in treatment insulator under pressure from the tropical climate is directly compared with the increase obtained in testing using a cloud chamber salt [4].

A good insulator of course made of material that is resistant to environmental conditions in which the insulator is applied. This study aims to investigate the influence of a tropical climate on the leakage current and the hydrophobic of the silicone rubber material under the influence of a tropical climate. From the research that has been described previously known that factors such as temperature, pollution, UV and moisture, which are components of the tropical climate, have a significant influence on the hydrophobic.The characteristics and leakage current. Based on this it would be monitored in this study how changes in the nature of hydrophobic and leakage current under the influence of a tropical climate.

METHODS

Material

Materials used in this research are a kind of RTV 683 silicone rubber and coal fly ash. Coal fly ash is used as a filler material for silicone rubber insulating material. Fly ash is meant here is the residue from burning coal in the form of smoke or dust coming out through the exhaust pipe and deposited by the electrostatic precipitator.

Contained in the fly ash content of silica and alumina which can improve the quality of the insulation material of siliconerubber, so the selection of waste fly ash, which has high silica content is important so that the results achieved in this study as expected.

Power plants that use coal of this type are known to have two power plants namely Tonasa steam power plant and Barru steam power plant. Tonasa steam power plant has an operating time longer or more frequently used than the PLN, so it will be easier to get the fly ash that is

new or has not contaminated air humidity and other substances in the air. Waste fly ash used in this study was taken directly from the silo of Tonasa steam power plant [2].

In this study the steps to create the test substances carried by vulcanization method room temperature (RTV), where silicone rubber and fly ash adjusted the desired percentage, then mix the two into one, and then put the mixture in a vacuum until the conditions does not have voids, then enter all of the mixtures into the mold. And finally, after drying, the test material was added to an oven with a temperature of 80 °C until the mass of the test material saturation

Based on research that has been done before by I. Kitta, *et al.* (2016), note that the increased electrical and mechanical parameters of the silicone rubber material with a fly ash content of between 20-40%.Therefore, in this test will be made two types of silicone rubber composition variation and fly ash. The variation of the composition can be seen in Table-1 below:

Table-1. Variations mixture of silicone rubber and fly ash to be tested.

Code of test material	Silicone rubber	Fly ash
FAT0-T	100%	0%
FAT30-T	70%	30%

Furthermore, the drying is done, and then the voltage applied to the natural tropical climate conditions as shown in Figure-1.

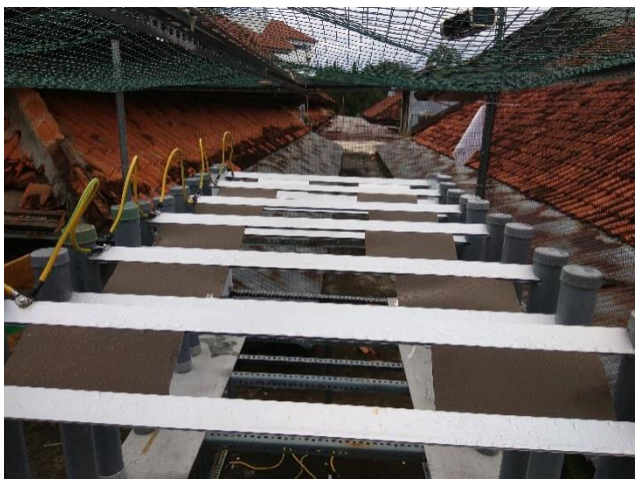

Figure-1. Configuration testing.

Results manufacture of the test material was tested for their performance over 40 days conducted in the open air on the campus of Engineering Department of Hasanuddin University 3rd floor study only counts data contact angle and surface material leakage current while other factors ignored.

Hydrophobic measurement

Contact angle measurements performed by taking pictures of water droplets on 3 locations a trickle of water in four different samples for each type of composition. The image is then processed using ImageJ software, then left and right contact angle of water droplets searched each image value using the tool angle meter on ImageJ software. The contact angle of water droplets for each image is the number 2 of the contact angle of water droplets measured (left and right) divided by 2.

Testing the hydrophobic nature of the material by measuring the contact angle of the silicone rubber material 0%. Tests conducted over 40 days of full data collection every day at the same hour is at 4:00 pm.

Surface leakage current measurement

Surface leakage current testing done in an open space where the test material is FAT0-T and FAT30-T directly affected by weather climate in Makassar especially at Hasanuddin University.

Isolation has a very important role in the power system. Isolation is necessary to separate two or more electrically conductive the voltage so that the conductor does not skip a spark of electricity or, for that it needs good insulating material. With the drain current path, then the heat insulator surface will arise that it will dry up pollutants on the surface of the insulator. In this test, the test material of silicone rubber material given a voltage of 20 KV, using a transformer that is placed on the third floor in the High Voltage Laboratory of the Hasanuddin University. Broadly speaking, a leakage current testing of the surface seen from the figure below.

This testing is done in real time, where the flow measuring instrument is tuned in micro-amperes are connected directly to a PC via a USB cable, then the measuring instrument readings will be read directly by PC by providing some data in a few seconds. From this data will be saved with the file later notepad. Then we will get the average value of its through Excel.

This data will be showing a large influx of unused or waste electrical currents which would be an important parameter of the quality of insulating material used. In this study voltage 20 kV applied to the test material and then placed in the open space, will be able to make us see firsthand the large surface current flowing on the surface of the material. With this, we can get a surface resistivity of the material directly, in which the material is influenced by the tropical climate.

RESULTS AND DISCUSSIONS

The result of the hydrophobicity

Behavioral tests are the hydrophobic surface of silicone rubber materials under exposure to tropical climate over time is assessed using the amount of surface contact angle of the liquid material based on direct observation through the camera scene are then stored on the computer and the image is instantly analyzed. In accordance with the procedure outlined in trial methodology section contact angle measurements, the

obtained results of the contact angle measurements and calculations to test materials silicone rubber with coal fly ash filler percentage of 0% and 30%.

Figure-3 shows the curve pattern changes in the value of the test material surface contact angle FAT0-T and FAT30-T. On the first day before aging up to the 13th day, the value of the contact angle FAT0-T amounted to 92.14° and FAT30-T amounted to 92.04° visible decline in value by 90.91° to FAT0-T and 91.80° to FAT30 -T. And starting on day 14th, the value of the contact angle of test materials had increased up to 40 days in the amount of 93.43° to FAT0-T and 95.59° for FAT30-T.

Contact angle on day 14th to day 40th fluctuated up and down. The increase in contact angle indicates no homogeneous distribution of sediment pollution particles on the surface of the test material [7]. Similarly, a decrease in the contact angle is indicated not homogeneous particle pollution, washed away by the rain.

The pattern of increases and decreases in the value of the contact angle shown in Figure-2 is a phenomenon of transfer and recovery of hydrophobic by the relatively low mass from the bulk to the surface of the silicone rubber and pollution. Surface roughness increasing with increasing sediment pollution has also contributed to the increase in the contact angle.

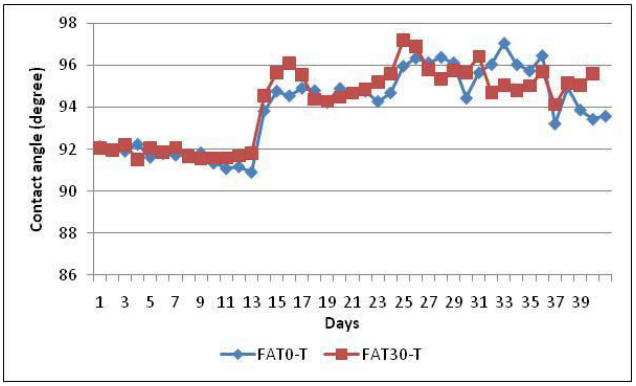

Figure-2. Graph of the contact angle.

The filler is added to the silicone rubber is to improve their resistance to cracking and erosion caused by atmospheric environmental pressures and the possibility of high thermal loading due ribbon bows dry if applied as a high voltage insulator material in outdoor. Figure-2 shows the value of the contact angle as a function of time at a test at a dose of filler material were varied as much as two types of exposure under a tropical climate. From the figure, it is seen that the contact angle of the surface of the test material which has not undergone aging (virgin) are not the same, depending on the number of doses given file. The FAT0-T test material has no filler generates a contact angle of 92.14° compared doses FAT30-T with the value of the contact angle of 92.04°.

The contact angle of silicone rubber without filler and filler that has seen similar behavior against climate change daily. Effect of filler to the hydrophobic nature of each test substance measured were differences in the ability to transfer to the hydrophobic nature of the layer of pollution and the recovery of hydrophobic properties after aging due to climate change. This can be seen until the 40th day, the test material FAT30-T has a tendency to transfer hydrophobic high.

Test materials silicone rubber with the filler, giving FAT30-T still exhibits hydrophobic properties remain high during the 40 days of aging (contact angle > 90°). The high value of this contact angle indicates that the surface free energy of silicone rubber than the free energy surface of the water. As a result, seen from a visual observation when rainwater touches the surface of the test material directly shrunken form granules, then partially fell to the ground and the remaining pellets left behind. Thus, not formed a continuous layer of water on its surface.

Curve down the rising value of the contact angle tends to follow the daily climate change. Contact angle on a surface that has not been polluted in wet conditions that lasts a long time tend to decline less than the contact angle in conditioning in natural tropical climates, as happened at the beginning of the study, but only temporarily because by the time dry conditions recovered. While at the moment the inception of the more sediment pollution does not cause a decrease in the contact angle, even increased, this phenomenon is called displacement to the hydrophobic nature of the layer of pollution.

Hydrophobic surface of the silicone rubber tends to change due to the reorientation of the molecules on the surface so that the interaction energy becomes maximum. The main effect is the polarity of water molecules can provide the propulsive force of high interface free energy. Because of the tendency of water-repellent CH_3 group, then the group CH_3 reorientation of the H_2O molecule will cause an imbalance style inter and between molecules on the surface of silicone rubber.

As a result of the reorientation of the group CH_3, molecular force balance changes and causes oxygen molecules to tend to be oriented to form an intramolecular force balance on the surface where the compound CH_3 oriented. Thus the increased surface energy and consequently decreasing the contact angle is smaller than before wet conditions.

When dry conditions, the methyl group being oriented toward the hydrophobic surface, then start low surface energy so that the contact angle gradually increasing again. The hydrophobic relatively fast recovery time of about one hour when the surface is clean. The increase in the contact angle, especially at high temperatures is the result of the high surface roughness test material caused by sediment pollution and more. Work surface adhesion hydrophobic material will decrease if the surface is getting rough, causing the contact angle increases. It has been proved by S. Manjang (2000), found that hydrophobic material (> 90°) after brutalized its surface will be more hydrophobic, whereas the hydrophilic material (90°) becomes more hydrophilic.

Diffusion of the relatively low mass component that causes a layer of hydrophobic pollutants suspected to have strengthened pollution particles stick. In addition to the physical diffusion process, possibly also a chemical

reaction between pollutants with the relatively low mass. Deposition of pollution can reduce the impact of radiation from the sun to the silicone rubber surface.

The result of the surface conductivity

Surface conductivity of the test material is drawn from surface leakage current measurement results. Parameter leakage current is supporting parameter to characterize the test materials aging. Measurements were made during the 40 days of the study. The value shown is the value of leakage current daily average in size micro-amperes (µA).

Figure-3 shows a comparison of leakage current that occurs on the surface of each test substance FAT0-T and FAT30-T. From these images, it appears that almost 40 days of test materials research FAT0-T provide leakage current higher surface of the test material which has a FAT30-T fly ash filler. This is caused by the effects of various environmental factors that hit the surfaces of both the test material. Environmental factors are likely the largest contributor to the increase in conductivity is particle pollution apart from some climatic factors. Various kinds of pollution particles carried by air/wind easily on the second surface of the test material. High concentrations of various elements of sediment pollution on the surface of the test material FAT0-T is more likely that most conductive and easy to absorb water, causing the surface leakage current is greater than FAT30-T.

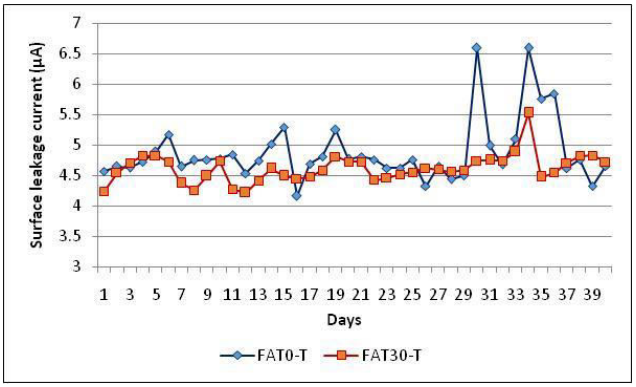

Figure-3. Graph of surface leakage current.

Although with the transfer process by the relatively low mass hydrophobic silicone rubber which makes pollution hydrophobic layer that does not absorb water, but because of particle pollution is more conductive and makes the surface rougher causing the increase in leakage current. However, the increase in leakage current generated is not too large (maximum 6.6 µA for FAT0-T and 5.5 µA for FAT30-T under voltage 20 KV). Impermanent and subject of climate change, especially in temperature and humidity.

On testing for 40 days aging for FAT0-T and FAT30-T obtained fly ash filler influence on FAT30-T causes surface leakage current value of the average is less than the value of surface leakage current FAT0-T (FAT30-T = 4.6 µA and FAT0-T = 4.8 µA).

CONCLUSIONS

From the research that has been done, it can be concluded that in general the addition of fly ash filler in silicone rubber material can improve resistance to surface leakage current and also can maintain the contact angle is better than without the use of fly ash filler treated with a tropical climate.

At the contact angle measurements is known that a decrease in the contact angle was greater in the silicone rubber with no fillers compared with silicone rubber which has a fly ash content of 30%. In the test shown that fluctuations occur when the contact angle measurements were performed. This can occur due to chemical reactions of pollutants or from the effects of UV and temperature that can occur mechanical or chemical process dynamic on the surface of silicone rubber. of regression analyzes also known that UV factor does not have a significant role to decrease the contact angle so that it can be concluded that the temperature and humidity are the main factors influencing changes in the contact angle of the material.

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