RESEARCH ARTICLE

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Effect Composition of Fly Ash Filler on Electrical Characteristics of Silicon Rubber Insulator Material

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This article is an attempt to get the explanation of the insulating material of silicone rubber is cheap. Things done is mixing the silicone rubber with other material in the form filler are cheap and easy to obtain. One source of potential filler material is the coal fly ash because this material has a very fine particle size and its contents are materials that have been and are being investigated as filler silicone rubber insulators. This paper explains the study to determine the characteristics of silicone rubber filled with coal fly ash from different sources, namely from the Tonasa coal-fired power plant and the Barru coal-fired power plant. The parameters measured in this study are the parameters of electrical characteristics such as contact angle, relative permittivity, dielectric strength, volume resistivity, and surface resistivity. The results of this study indicate that coal fly ash from the Tonasa coal-fired power plant more feasible for use as a filler material of silicone rubber compared to coal fly ash from the Barru coal-fired power plant for its ability to increase the contact angle of hydrophobic, dielectric strength, volume resistivity and surface resistivity.

Keywords: Silicone rubber, Fly ash, Filler, Electrical characteristic, Insulator material.

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1. INTRODUCTION

Until now, high voltage electrical insulator such as insulators porcelain and glass insulators are still widely used in the power system in Indonesia. The use of this type of insulators do not advantage because they requires large mass of insulator that they require electrical transmission tower construction more robust and higher, thus requiring greater investment costs. Porcelain insulators and glass insulators require special handling because it is easily broken, especially in the transport and installation process [1].

Currently, silicone rubber material is being developed as an alternative to change porcelain and glass material. The advantages of silicone rubber insulators ie, dielectric properties, volume resistivity, thermal properties, mechanical strength and light weight [2,3,4,5]. The weight ratio of the various types of insulators made of polymer is 36.7% - 93% lighter than porcelain insulators [1].

Despite the various advantages possessed by silicone rubber insulators, until now the use of silicone rubber insulators in some countries such as Indonesia is still limited because of the high cost of production of silicone rubber insulators, so many researchers who conducted the search of material that can be mixed with silicone rubber.

One source of filler material is coal fly ash containing chemical elements, among others, SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, TiO_2, Na_2O, K_2O, SO_3, P_2O_5 and carbon [6]. Thus allowing the coal fly ash can be used as an alternative filling material in the silicone rubber insulators.

In Indonesia, production of coal fly ash waste from the coal-fired power plant is expected 2 million tons in 2006, and increased to 3.3 million tons in 2009. The increase in coal consumption driven by Presidential Decree No. 5 of 2006 on National Energy Policy which it has a target of coal usage from 15.34% to 33% in 2025 so that it requires a management that does not cause environmental problems because of coal fly ash classified as a hazardous waste.

Therefore, to determine whether the coal fly ash can be used as a filler material of material high voltage insulator, has been tested on the material of silicone rubber filled with fly ash coal from two sources, namely from the Barru coal-fired power plant and the Tonasa coal-fired power plant. The parameters measured were hydrophobic contact angle, relative permittivity, dielectric strength, volume resistivity and surface resistivity.

2. EXPERIMENTAL PROCEDURE

This test follows the procedure as shown in flowchart in Figure 1.

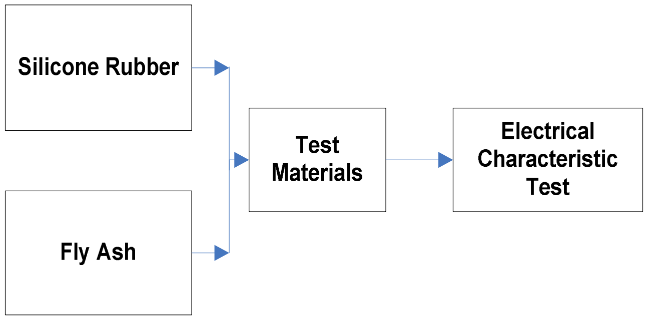

Fig.1. Experimental procedure flowchart

Material

The material used in this study were 683 RTV silicone rubber [7,8,9] and coal fly ash.

Fly ash characteristic

Fly ash used had been examined their chemical content value by using the XRF results are shown in Table 1. The chemicals most widely percentage is SiO_2, Al_2O_3 and Fe_2O_3. Coal Fly ash from come from two locations coal-fired power plant in Indonesia, namely the Barru coal-fired power plant (PLTU Barru) and the Tonasa coal-fired power plant (PLTU Tonasa).

Table.1. Typical chemical compound content of fly ash

Chemical Compound	Percentage (%)	
	PLTU Barru	PLTU Tonasa
Al_2O_3	4.79	19.48
SiO_2	28.45	40.16
K_2O	0.47	1.75
CaO	13.64	8.35
TiO_2	0.73	1.30
MnO	0.92	0.29
Fe_2O_3	50.08	20.22
SrO	0.37	0.12
ZrO_2	0.09	0.06
BaO	0.28	0.19

Making of test materials

Before the test material is made, The first is weighing silicon rubber material and fly ash. Silicone rubber is mixed with fly ash in a container by using a blending technique that uses manual mixing equipment. Subsequently, the mixture is put into a vacuum chamber to reduce air bubbles trapped. The mixture is poured into molds that have a size of 5 mm thick. In the process of maintenance, test materials were placed in a room with a temperature of 80 for 24 hours. Test materials (a mixture of silicon rubber and fly ash) are made with 3 composition (Table 2).

Table.2. Type of test materials Silicone rubber based filler concentrations of fly ash

Code	About
No-FA	No Filler fly ash
Barru	30% Filler FA-Barru
Tonasa	30% Filler FA-Tonasa

Measurements of contact angle

Contact angle measurements were performed measurements of static contact angle, in this case the surface of the test materials are cleaned of pollutants such as dust particles and other impurities, by keeping the temperature and air pressure at constant conditions. The standards used in this study is ASTM C813. The test equipment used is shown in Figure 2.

Fig.2. Contact angle measuring equipment

Measurements of relative permittivity

Measurement of relative permittivity was using capacitance measuring instrument. The test equipment is shown in Figure 3. The standard used in this study is ASTM D150.

Fig.3. Capacitance measuring instrument

Measurements of dielectric strength

Dielectric strength measurement is based on ASTM D149. Testing is done by comparing some of the test material. The electrodes used are needle electrodes and plate electrodes. Equipment used as a test equipment shown in Figure 4.

Fig.4. Dielectric strength test equipment

Measurements of DC resistivity

The volume resistivity (Rv) is the ratio between voltage and current distributed on the volume of the test material. And surface resistivity (Rs) is the ratio of potential gradient parallel with current of the test material to the current density. The standard used in this test was ASTM D257. The equipment is used as a test equipment shown in Figure 5.

Fig.5. DC resistivity test equipment

3. RESULT AND DISCUSSION

Contact Angle

The magnitude of the contact angle of the surface of test material to liquid droplets obtained by direct observation through the camera scene and processed using software applications on the computer. It can be seen that all test materials have contact angle ranges from 103.8° - 97.8° which value is greater than 90° so classified are Hydrophobic [10]. The addition of filler resulted in the increase in value of the contact angle, which the largest contact angle is test material Tonasa at 103.8°, and the smallest is the test material No-FA at 97.8° as shown in Figure 6.

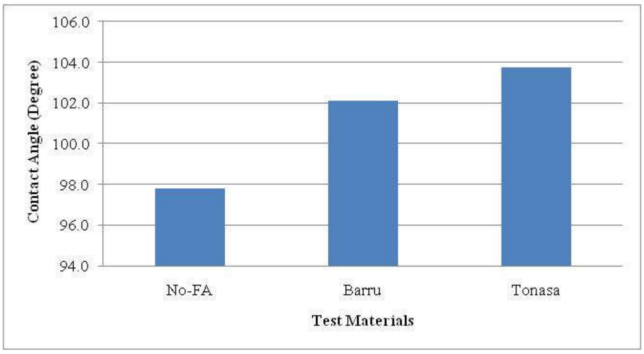

Fig.6. Graph contact angle value of the test materials

Relative permittivity

The relative permittivity of the test material had been studied and shown in Figure 7, where the figures show a graph the relative permittivity of the test material is increased, whereby the Barru test material has a relative permittivity value the most. Values relative permittivity of the Barru test material 3.32, the No-FA test material at 2.4, and the Tonasa test material at 3.06. Comparison between the Barru test material with the No-FA test material of 1.4. And a comparison of the Tonasa test material with the No-FA test materials of 1.3.

Fly ash is made of silicone rubber have increased permittivity value that would cause the dielectric loss and dissipation material will increase as well. Many factors can affect relative permittivity enhance on the test material, including elements of Alumina (Al_2O_3) in the fly ash has a high permittivity [11].

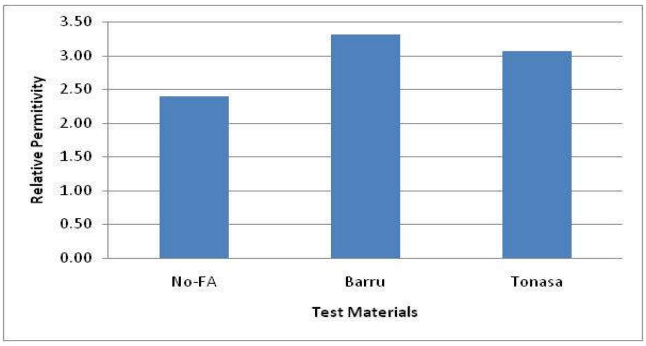

Fig.7. Effect of fly ash content on relative permittivity of silicone rubber composite

Dielectric strength

Measurements of dielectric strength done with test of voltage breakdown, where the results can be seen in Figure 8. The figure see dielectric strength of silicone rubber that is filled by fly ash from the Barru coal-fired power plant (Barru) decreased compared to the dielectric strength of Tonasa test materials are becoming more bigger than of the No-FA test material. Value breakdown voltage of No-FA test material is 12 kV/mm, Barru test material is 10 kV / mm, and Tonasa test material is 13 kV/mm.

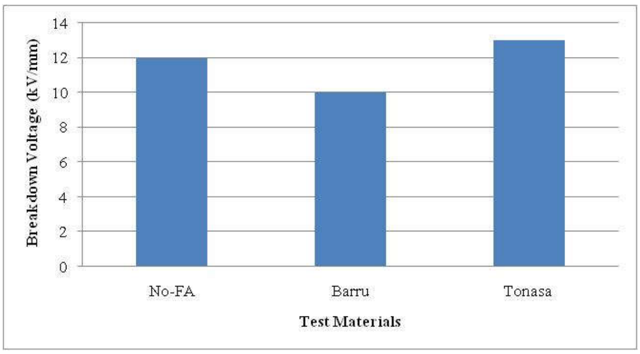

Fig.8. Effect of fly ash content on dielectric strength of fly ash filled silicone rubber

Breakdown voltage of test material can be influenced by the nature of intrinsic and extrinsic properties of the test material as the type of applied voltage. The presence of air bubbles in the test materials can be one intrinsic factor that causes decrease in the dielectric strength of test material. Another factor that can affect the dielectric strength of the test material is a volume resistance. If the volume resistance is low, the electric current in the test material will increase, which at a certain level will trigger the mechanism of destruction of the materials [12].

Volume resistivity

Volume resistivity of test material was measured with a measuring value is shown in Figure 9.

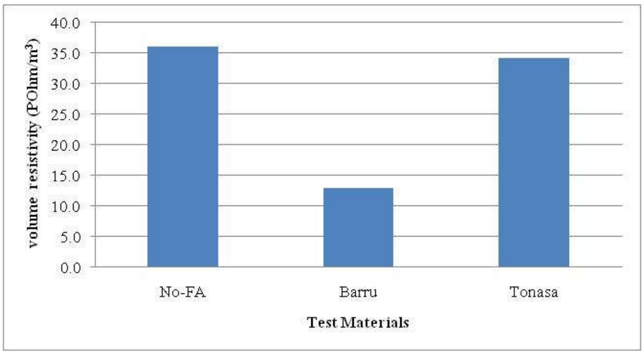

Fig.9. Effect of fly ash content on volume resistivity of fly ash filled silicone rubber

From Figure 9, it can be seen that the volume resistivity of the No-FA test material at 36.0 POhm/m^3, Barru at 12 POhm/m^3, and Tonasa at 34.3 POhm/m^3. Filler from fly ash of the Barru coal-fired power plant is causing value the volume resisttivity of slicne rubber decreasing. While filler from fly ash of Tonasa coal-fire power plant is not affecting the volume resistivity values of silicone rubber.

Surface resistivity

Figure 10 shows a graph that use fly ash causing surface resistivity of test material becomes higher. Surface resistivity value in the Tonasa test material increases of 175% of the test material without fillers (No-FA). Barru test materials at 139%. Thickness measurement accuracy is determined by the test material. The surface resistance is also influenced by the recovery of the surface.

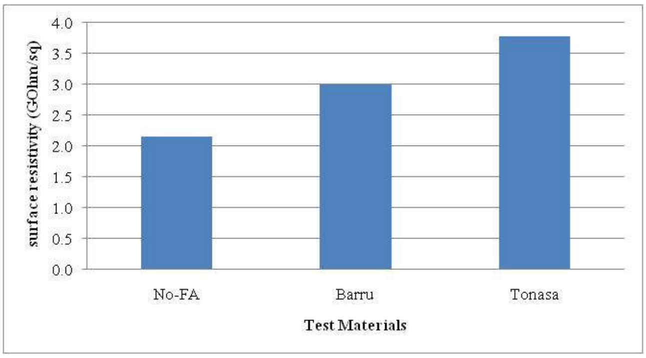

Fig.10. Effect of fly ash content on surface resistivity of fly ash filled silicone rubber

4. CONCLUSION

Coal fly ash as filler affects the electrical properties of silicone rubber insulating material. This is evidenced in the studies that have been conducted, in which the measured parameters are contact angle, relative permittivity, dielectric strength, volume resistivity, and surface resistivity. The test materials are made in three types, namely: No-FA (silicone rubber without fly ash), Barru (silicone rubber + fly ash of the Barru coal-fired power plant), and Tonasa (silicone rubber + fly ash of the Tonasa coal-fired power plant). Results from the study showed that the hydrophobic contact angle increases with the addition of filler, where Barru test material and Tonasa test material have values greater than the No-FA test material. Neither the relative permittivity values, where of Tonasa test material, value relative permittivity of silicon rubber increases. And the surface resistance of silicon rubber increased after adding fly ash from the Barru coal-fired power plant and the Tonasa coal-fired power plant. But of testing on dielectric strength and volume resistivity, Barru test material has the smallest value compared with the No-FA test materials and the Tonasa test materials.

The results of this study indicate that coal fly ash from the Tonasa coal-fired power plant feasible to used as a filler in silicone rubber material because of its ability to increase the value of the contact angle of a hydrophobic, dielectric strength value, volume resistivity value, and surface resistivity value.

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