Effect Of Fly Ash Filler To Dielectric Properties Of The Insulator Material Of Silicone Rubber And Epoxy Resin

Ikhlas Kitta, Salama Manjang, Wihardi Tjaronge, Rita Irmawaty

Abstract: Currently, many operated the coal fired power plant to meet the energy needs of the world's electricity. But the coal fired power plant produces waste that can pollute the environment, such as fly ash and bottom ash, so requires management to not cause environmental problems, because coal fly ash classified as a hazardous waste. Fly ash has a particle size that is very smooth, and of some literature research done previously, fly ash coal containing silica (SiO_2), alumina (Al_2O_3), titanium dioxide (TiO_2), magnesium oxide (MgO) and zinc oxide (ZnO) are potentially as filler that are likely to be used as a mixture of silicone rubber and epoxy resin for electrical insulators. So this research theme was engineering insulation materials by utilizing waste coal fly ash. The purpose of this study was to obtain performance characteristics of waste coal fly ash as filler in silicon rubber and epoxy resin. To achieve these objectives, the activities that have been done is examined the effects of the use of fly ash as filler in silicone rubber material and epoxy resin. Parameters measured were dielectric strength and relative permittivity. The result of this research is the dielectric strength of silicone rubber rose with increasing quantity of fly ash. Conversely in epoxy resin, dielectric strength decreases with increasing quantity of fly ash. Furthermore, the measurement results relative permittivity, where the value of the relative permittivity of silicon rubber swell if it is filled with fly ash, as well as epoxy resin which has a value of permittivity relative to the concentration of fly ash filler material is linear.

Index Terms: Silicone rubber, Epoxy resin, Fly ash, Filler, Dielectric properties, Insulation material.

1 INTRODUCTION

Coal ash is a part of the combustion of coal in the form of fine particles and ash are amorphous inorganic material formed from mineral material changes due to the combustion process. From the coal combustion process in a steam generating unit (boiler) will form two types of ash is fly ash and bottom ash. The composition of the coal ash produced is composed of 10-20% bottom ash, while the remaining approximately 80-90% in the form of fly ash captured by the electric precipitator before being discharged into the air through the chimney. Coal fly ash derived from coal combustion in a simple production, with gas funnel and spread into the atmosphere. This is causing environmental and health problems, because of coal fly ash is results from the burning of coal discarded as a heap [1]. The coal fired power plant is currently the main support overcome the electricity crisis in Indonesia. But also coal as a fuel will cause effects in the form of pollutant emissions. The increasing use of coal for power plants, the environmental burden will also be more severe and should be anticipated with the use of clean coal technology and optimal utilization of coal waste (fly ash).

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Event waste utilization of coal fly ash is done by giving priority to the protection of human health and safety and environmental protection by applying the precautionary principle. Munir [2] explains that Fly ash contains chemical elements, among others, silica (SiO_2), alumina (Al_2O_3), ferrous oxide (Fe_2O_3) and calcium oxide (CaO), also contains elements of other enhancements that magnesium oxide (MgO), titanium oxide (TiO_2), alkaline (Na_2O and K_2O), sulfur trioxide (SO_3), phosphorus oxide (P_2O_5) and carbon. Forms handling of the environment that has been applied in the use of waste fly ash is, among others, for the purpose of ceramic raw materials [3], adsorbents [4], filler in asphalt [5], as well as replacement and cement raw materials [6]. Power plant was built to obtain electrical energy which is one of the infrastructure concerning lives of many people. Electric energy demand continues to increase with increasing electrical energy needs for development, especially transport infrastructure, and the building to support the process of industrialization and community cooperation. Electrical energy is channeled through a network of transmission and distribution of electricity. For the transmission of electrical energy by a considerable distance required high working voltages so that power losses can be reduced. Currently on the transmission voltage is applied in Indonesia is 70 kV and 150 kV for the Overhead High Voltage, as well as for the Overhead Extra High Voltage 275 kV and 500 kV, while the distribution voltage of 20 kV. High voltage electricity transmission requires insulation material particularly high insulation reliability as a separation device voltage parts with no voltage as well as retaining and supporting wire channel [7], [8]. Until now, insulators are ceramic and glass still widely used in the power system in Indonesia. The use of this type of insulators on the transmission network the higher the voltage is less profitable because it takes a large mass of insulator so require construction of transmission towers are more robust and higher, thus requiring greater investment costs. In addition ceramic and glass insulators require special handling because it is easily broken, especially in the transportation and installation [9]. Since the last few years polymer material has emerged gradually and was developed as an alternative to ceramic materials and glass. Advantages of polymeric materials in this case of silicon rubber and epoxy resin are dielectric properties, volume resistivity, thermal properties, mechanical strength and lightweight [10], [11], [12], [13]. Because light, installation and maintenance easier than ceramic materials and glass. The weight ratio of the various types of insulators made of polymer is 36.7% - 93% lighter than insulators porcelain / ceramic [9]. Despite the various advantages of polymer material but the material is synthetic materials are generally vulnerable to climate (intensity of ultraviolet radiation (UV), temperature, humidity or rain), pollution and exposure to high electric field, which can result in degradation and subsequent resulting in aging. Aging of polymeric material outside mainly due to the energy of photons produced by the UV radiation from the sun. When the photon energy is higher than the bond energy between chains or between molecules will lead to the termination of the chain or the formation of cross linking is characterized by mechanical changes such as the polymer becomes hard and brittle [14], [15]. Efforts to improve the stability of polymeric materials against degradation due to aging being conducted by several researchers, the results suggest that a filler were added to the polymer material with a specific composition can change its properties. Until now, the use of silicone rubber and epoxy resin for the power company is still limited because of the high price of insulator made of silicone rubber and epoxy resin, so many researchers who conducted the optimization of material that can be mixed with silicone rubber and epoxy resin, especially in terms of filler material that is concentrated in silica and alumina. So from the description presented on the material content of coal fly ash which has silica and alumina [16] may be used as an alternative of filler in silicone rubber polymer and epoxy resin as the material of high voltage insulators. So this study was to assess the effect of coal fly ash as filler material to the dielectric properties of the silicone rubber and epoxy resin as an effort to address environmental problems. Research have been carried out in the form of testing dielectric strength and relative permittivity.

2 Experimental Procedure

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

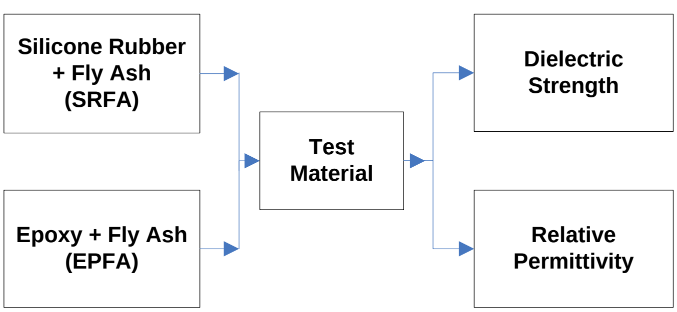

Fig. 1 *Experimental procedure flowchart*

2.1 Materials

The material used in this study is the type RTV silicone rubber 683 [17], epoxy resins, and coal fly ash.

2.2 Characteristic of Fly ash

Fly ash has been examined the value of the chemical constituents using XRF (X-ray fluorescence), which results are shown in Table 1. Percentage of chemical most widely is SiO2 and Al2O3. Fly ash comes from coal fired power plant in South Sulawesi (Indonesia) with type F (ASTM).

TABLE 1
TYPICAL CHEMICAL COMPOUND CONTENT OF FLY ASH[18]

Chemical Compound	Percentage (%)
Na_2O	2.4
MgO	3.8
Al_2O_3	19.48
SiO_2	40.16
P_2O_5	0.15
SO_3	1.33
K_2O	1.75
CaO	8.35
TiO_2	1.3
Cr_2O_3	0.05
MnO	0.29
Fe_2O_3	20.22
CoO	0.06
SrO	0.12
ZrO_2	0.06
BaO	0.19
Pr_6O_{11}	0.05
Nd_2O_3	0.08

2.3 Making of the test Materials

Before the test material is made, the first to be done is to weigh silicone rubber, epoxy resin and fly ash. Silicone rubber is mixed with fly ash in a container using manual mixing technique that uses mixer equipment. Likewise the epoxy resin is mixed with fly ash. Subsequently the mixture is inserted into a vacuum chamber to reduce air bubbles trapped. The mixture is poured into a mold having a depth of 2 mm thick size as shown in Fig. 2. In the process of maintenance, test materials were placed in a room with a humidity of 80%, which runs for 24 hours.

Fig. 2 *The test materials*

Test material (a mixture of silicon rubber and fly ash) is made with six compositions, as well as the test material derived from a mixture of epoxy resin with fly ash (Table 2 and Table 3).

TABLE 2
TYPE OF TEST MATERIAL OF SILICONE RUBBER BASED FILLER CONCENTRATIONS OF FLY ASH

Code	Notes
SRFA0	Non Filler fly ash
SRFA10	10% Filler fly ash
SRFA20	20% Filler fly ash
SRFA30	30% Filler fly ash
SRFA40	40% Filler fly ash
SRFA50	50% Filler fly ash

TABLE 3
TYPE OF TEST MATERIAL OF EPOXY RESIN BASED FILLER CONCENTRATIONS OF FLY ASH

Code	Notes
EPFA0	Non Filler fly ash
EPFA10	10% Filler fly ash
EPFA20	20% Filler fly ash
EPFA30	30% Filler fly ash
EPFA40	40% Filler fly ash
EPFA50	50% Filler fly ash

In this study measures the manufacture of test specimens was conducted using a room temperature vulcanizing (RTV).

2.4 Measurement of Dielectric Strength
Dielectric strength test was conducted in accordance with ASTM D 149 standards. Electrodes used in the measurement is the needle electrodes on the top plate and the electrode at the bottom. Voltage frequency of 50 Hz is used in this test. Damage to the material is determined when there is a high increase in electric current in the secondary side of the transformer or the occurrence of flash in the insulator. Tests were carried out under room temperature of 27° C and 80% humidity. Tests carried out at the High Voltage Laboratory at the University of Hasanuddin, as shown in Fig. 3.

Fig. 3 *Dielectric strength testing Model*

2.5 Measurement of relative permittivity
Measurement of relative permittivity of the test material aims to determine the dielectric constant of the polymer insulator. Relative permittivity is obtained by measuring material capacitance with a capacitance meter as shown in Fig. 4. The material is placed between the parallel circular plate and measurements were performed with a frequency of 800 Hz. Capacitance measurements performed below room temperature 26 °C and humidity around 85%. The capacitance value obtained is then converted into the relative permittivity.

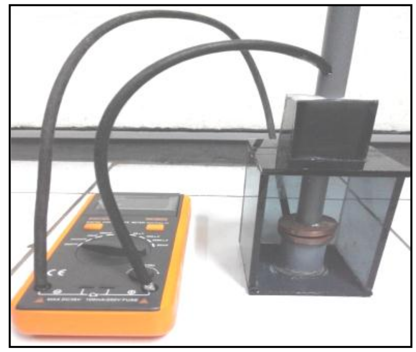

Fig. 4 *Model of capacitance measurement*

3 Results and Discussion
The following shows the results of testing of the test material.

TABLE 4
TEST RESULTS OF THE TEST MATERIAL

Fly ash content	0%	10%	20%	30%	40%	50%
SILICONE RUBBER						
Breakdown Voltage (kV/mm)	9.8	10.2	14.9	16.1	16.8	14.1
Realtive Permittivity	2.7	3.0	3.8	3.7	3.7	3.8
EPOXY RESIN						
Breakdown Voltage (kV/mm)	22.0	20.5	17.0	14.5	12.5	11.5
Realtive Permittivity	4.5	5.4	6.6	6.7	7.2	7.0

The explanation of the test result table in Table 4 will be described in the next section.

3.1 Discussion of Dielectric Strength (Breakdown Voltage)
Measurement of dielectric strength (breakdown voltage tests) have been done and the results can be seen in Fig. 5, where the graph show the dielectric strength of silicon rubber and epoxy resin. Silicon rubber that is used has a values of dielectric strength (breakingdown voltage) is smaller than the value of the dielectric strength of the epoxy resin is used, which is to SRFA of 9.8 kV/mm and EPFA0 of 22.0 kV/mm. This is consistent with the values of the dielectric strength of the silicon rubber and the epoxy resin contained in the book "High Voltage Engineering" [19]. Silicone rubber filled with fly ash (SRFA10, SRFA20, SRFA30, SRFA40, and SRFA50) has a value greater dielectric strength than silicon rubber without fly ash (SRFA0). In Fig. 5 looks graph value dielectric strength increases with increasing amount of fly ash in silicon rubber. The maximum dielectric strength is achieved in 40% fly ash content in the silicone rubber (SRFA40) of 16.8 kV/mm, an increase of 71% compared with silicone rubber without fly ash (SRFA0). Fig. 5 also shows a graph of dielectric strength (breakdown voltage) for epoxy resin (EPFA0, EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50). EPFA0 (epoxy resin without filler) have value dielectric strength of 22.0 kV/mm, where the value is greater than epoxy resin that filled

fly ash (EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50). Dielectric strength values decreased with increasing amount of fly ash in the epoxy resin. The minimum dielectric strength is achieved in 50% fly ash content in the epoxy resin (EPFA50) of 11.5 kV/mm or decreased 48% compared with epoxy resin without fly ash (EPFA0). Breakdown voltage or dielectric strength of the test material can be influenced by the intrinsic properties of the material and extrinsic properties such as the type of the applied voltage. The presence of air bubbles in the material being tested can be one of the many intrinsic factors that lead to a decrease in the dielectric strength of the material.

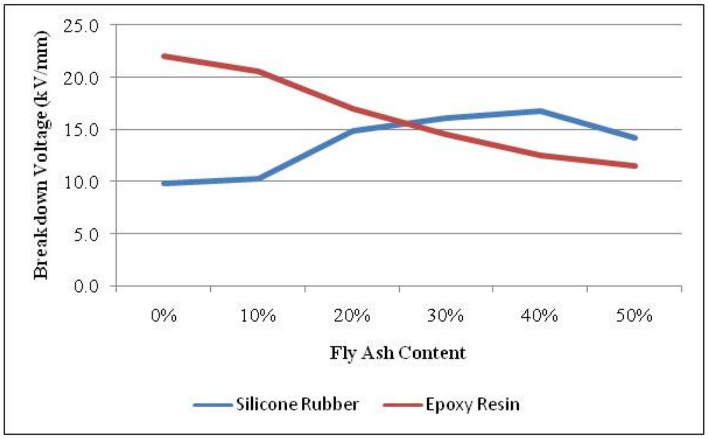

Fig. 5 *Effect of fly ash content on dielectric strength of fly ash filled silicone rubber and epoxy resin*

3.2 Discussion of Relative Permittivity

The relative permittivity of the material with a variety of content fly ash have been investigated and shown in Fig. 7, where the figures show a graph the relative permittivity of the test material SRFA0, SRFA10, SRFA20, SRFA30, SRFA40, SRFA50, EPFA0, EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50.

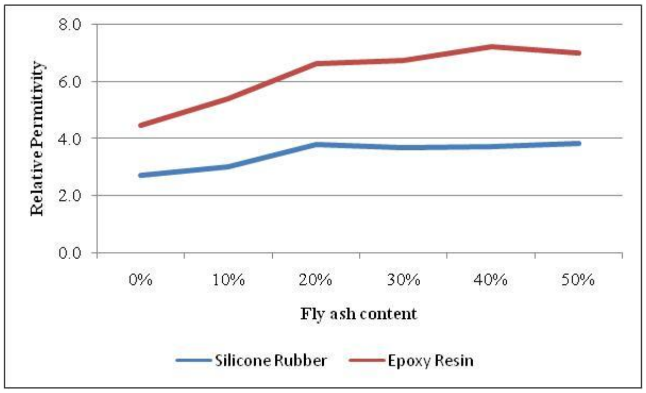

Fig. 6 *Effect of fly ash content on relative permittivity of silicone rubber composite*

Values relative permittivity of silicon rubber material without excipients (SRFA0) of 2.7, where this value is less than the relative permittivity of epoxy resin without filler (EPFA0) which is worth 4.5. SRFA0 relative permittivity smaller than SRFA10, SRFA20, SRFA30, SRFA40 and SRFA50 (fly ash filled epoxy resin). Value of the relative permittivity most is SRFA50 which increase to 3.8, where the value has increased 42%. Fly ash has made silicone rubber have increased permittivity value, causing losses or dissipation dielectric material will also rise. Many factors can affect the increase in the permittivity of the test material, including elements of Alumina (Al_2O_3) in the fly ash that has a high permittivity. Further to the epoxy resin material. From fig. 6 show the value of an epoxy resin filled with filler fly ash (EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50) had a relative permittivity greater than the epoxy resin without filler (EPFA0) of 4.5. From the graph of the relative permittivity values for epoxy resin can be seen the relationship between the value of permittivity relative to the concentration of fly ash filler material is linear. This is demonstrated by test material that have the lowest relative permittivity value of 4.5 is EPFA0 and the test materials with the highest value of relative permittivity 7.2 is EPFA40 an increase of 62%. This is possible due to the concentration of the test material effect on the increase in bandwidth interfaces and increased polarization interface of filler materials with polymers resulting material becomes more easily absorb water, in addition to the increasing concentration of filler also resulted in the emergence of cracks and small holes (micro void) in the process manufacture of test material. These phenomena will provide opportunities water molecules accumulates more in.

4 CONCLUSION

In this study, the test materials are made from a mixture of silicone rubber and fly ash (EPFA0, EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50), and a mixture of epoxy resin and fly ash (EPFA10, EPFA20, EPFA30, EPFA40, and EPFA50). The parameters that have been tested are the dielectric properties (dielectric strength and relative permittivity). The results showed that the dielectric strength of the test material in the form of silicone rubber of breakdown voltage increases with the addition of fly ash filler. Maximum of The dielectric strength is SRFA40 with filler composition of 40% with an increase of 71% compared with the test materials without fillers (SRFA0). As for the epoxy resin, the dielectric strength values decreased with increasing the amount of fly ash in the epoxy resin. The minimum dielectric strength is achieved in 50% fly ash content in the epoxy resin (EPFA50) decreased 48% compared with epoxy resin without fly ash (EPFA0). To test the relative permittivity, value of the relative permittivity of silicon rubber will swell if it were filled with fly ash, value of the relative permittivity of maximum is SRFA40 of 3.8, where the value has increased 42% from SRFA0. The relationship between the value of permittivity relative to the concentration of fly ash filler material is linear. This is also shown by the epoxy resin which has a lowest relative permittivity for EPFA0 of 4.5 and the highest was 7.2 to EPFA40 or increase of 62%.

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