Electrical Performance of Composite Material Insulators

Nawfal Al-Araji, Luay Tareq Aal Dhabi, Wissam T. Alshammari

Abstract: - In this paper, the results of tests on sixteen different composites materials insulators samples were presented. The results shows, that the grain size of composite materials affected the loss factor (Tan δ) of the insulators, (Tan δ) decreased with the decreasing in grain size and increased as the applied voltage increased. The capacitance C [F] of insulators decreased as the frequency increased and it's increased as the insulator length increased. Also the results show that the high percentages of raisin and Portland cement in composite insulators decreased (Tan δ).

Keywords: High voltage, Transmission lines, Loss factor

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1. INTRODUCTION

High voltage insulators have developed rapidly since early for more than 35 years, beginning with simple porcelain insulators [1]. Composite insulators recognized as excellent substrates for traditional glass and porcelain insulators [2]. They are light weight, better contamination performance, resistance to damage, and allow compact line designs [3]. In present time modern polymeric insulators are used, as well as the earlier materials. A classification of the main types of insulators is shown in figure (1).

Cylindrical shape or long – rod composite insulator typically is composed of a glass – fiber core rod, weather sheds, protective housing and end fitting. It is important to understand the factors contributing to insulator degradation in order to identify approaching end of life of insulator populations [4]. . A number of parameters affect the working life of insulators such as pollution deposition; Insulators exposed to the environment collect pollutants from various sources. Pollutants become conducting when moistened are of particular concern [5].

Two major sources one considered

1. Costal pollution, the salt spray from the sea or wind – driven salt laden solid materials such as sand collects on the insulator surface. These layers become conducting during periods of high humidity and fog.
2. Industrial pollution, substations and power lines near industrial complexes are subject to the stack emissions from nearby plants. These internals are usually dry when deposited; they may then become conducting when wetted. The materials will absorb moisture to different degree, and apart from salts, acids are also deposited on the insulator.

- Nawfal Al-Araji[1] Professor Dr. in Mechanical Engineering, Tribology.
- Luay Tareq Aal Dhaheb[2] M.Sc in Electronic and Communication Engineering. Luay_tarq@yahoo.com
- Wissam T. Alshammari[3], MEE Telecommunication Systems. wissam.talib@gmail.com

[1,2,3]Al-Hussain University College, Karbala-Iraq

Weather affect the life of insulators, wind is instrumented in the deposition process. High humidity, fag or light rain cause wetting of the pollution layers, Heavy rain removes the pollution layer especially in the upper of the sheds [5].

Line insulators are designed to ensure electrical insulation and mechanical support for the power transmission conductors. Composite insulators have been widely used in high voltage transmission lines due to their hydrophobic properties, low weight and maintenance casts, and high mechanical strength. However, the special shape and the low conductivity of silicon make the electric field and potential distribution of composite insulators more an even when compared to ceramic ones [6].

It allow-core composite insulators are in use for more than thirty years. For line insulation the time period during which plastic materials are used as an alternative to ceramic rods or glass chains is even longer. However, due to the different fields of application of instrument insulators and line insulators the requirements and thus the demand on the quality is largely different. The polymeric insulators were developed and its improvement in design and manufacturing, in the recent years the insulators are more attractive to utilities [7]. Different polymers were used in the manufacture of composite polymeric insulators. Virtually all non-ceramic insulators consist of three main components: fiberglass reinforced resin rod system, metal end fittings, and polymeric weather sheds [7].

The weather shed is intended to protect the fiber glass rod from the environment and electrical surface discharges. Weather sheds are usually polymeric materials[7].

The aim of this paper is to study the electrical performance of an organic calasium composite insulator under the effects of different voltages.

2. EXPERIMENTAL PROCEDURES

2.1. Materials, Mixing and Molding

Mechanical grinder machine used for preparation of the organic calasium powders. Powders of organic calasium in four grades 300μ m, 250μ m, 200μ m, and 150μ m were prepared by using saving mechanism. Four types of composite mixtures of organic calasium with different amounts of pure resins and Portland cement were mixed as show in table (1).

The components were mixed for about 2 min, the mixture and cast in a plastic mold 10 mm diameter 20 mm high under vibration conduction for 15 mins to extract air bubbles figure (2)which represent the samples used. The cast samples have therefore about three hours, after which it was removed from the molds.

2.2. Electrical Tests

In order to determine the withstand voltage of the insulators specimens under service conditions, alternate 60 HZ sinusoidal voltage were applied simultaneously on the specimens as shown in figure (3) These voltage were increased at uniform rate, from (0) volts up to the breakdown of one of the insulators or even of the air .

During these test the temperature and relative humidity were kept at 24c° and 45%, respectively. It should be noted that all the electrical tests were conducted on specimens by the electric circuit shown in fig (4). Voltage applied range from 30 volts to 240 volts, the results of testing shown in figures (5)-(8).

2.3. Dielectric measurements

Measurement of dielectric constant (E) in static and alternating field's dielectric loss specific electrical conductivity in constant electrical field and electric strength for solid dielectric, determination of the capacitance [C] of plane electrical capacitor with test dielectric placed between its plats figure (3). The dielectric constant (E) is determined from the formula :

$$E= [kd/s] C = 0.2 \qquad \ldots\ldots\ldots (1)$$

Where
d = Thickness of the dielectric specimen
s = Area of its lateral face
k = A proportionality factor = 0.22
C = Capacitance [F]

Measuring capacitance in a constant field and low frequency (tenth of Hz) , the capacitance is determined by measuring the change or discharge current of the capacitor with a ballistic galvanometer , in the frequency range from tenths of Hz to 107 Hz .it's important to measure , In addition to [C] , the dielectric loss, which can be expressed by the tangent of the dielectric loss, angle (tan δ) figure (5) and figure (6),the quantities (c) and (tan δ) are measured by means of bridge circuits particularly the - Schering bridge. The capacitance of insulator over the frequency at difference garn size of organic calcium as shown figure (7) .the dielectric length affected the capacitance the result show in figure (8).

3. Discussion

The electrical test results reveal that under the same test condition, composite insulators with a fine organic calcium grain have a lower (tan δ) as compared with other types of composites insulators, as a function of applied voltage figure (5), this due to the increased in grain boundary networks, which resist the flow of electrical current Portland cement percentage in composite affected the insulators properties as its increased. This due to the high percentages of (cao) in Portland cement figure (6).

Figure (7) show the relation between the capacitance C [F] of different grain size of composite insulator specimens and the frequency f (Hz), decreases in C [F] as the frequency increased. It can be seen from figure (7) that sample No (1) shows a lower value of C [F] as compared with the other samples. The value of C [F] increased for samples No (2-3-4) as the grain size of composited increased

The dielectric of insulators affected by the types, size dimensions and other parameters such as length

Figure (8) shows the relation between the capacitance C [F] and the length of four samples. It can be seen that C [F] increased as the length of sample increased.

4. Conclusions

i. Loss factor (tan δ) increased as the applied voltage increased.
ii. Loss factor (tan δ) affected by the grain boundary network of the microstructure of composite insulators.
iii. Organic Calasium materials act as good dielectric materials.
iv. High percentage of Portland cement affect the loss factor (tan δ).
v. The performance of insulator affected by the types and dimension of insulator.

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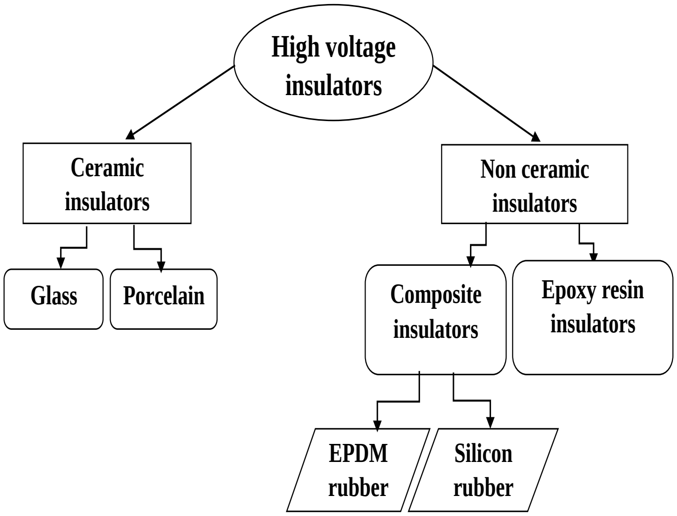

Figure 1: Classification of Insulator materials

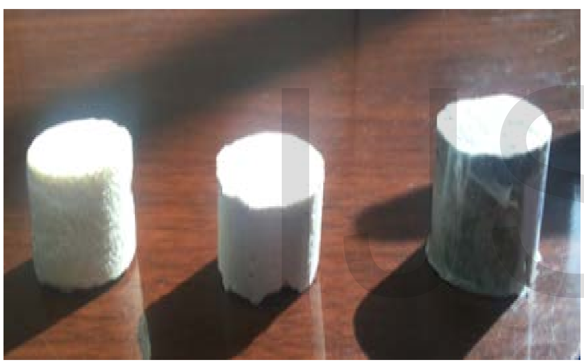

Figure 2: Insulators samples

Figure3 : Insulators specimen under test

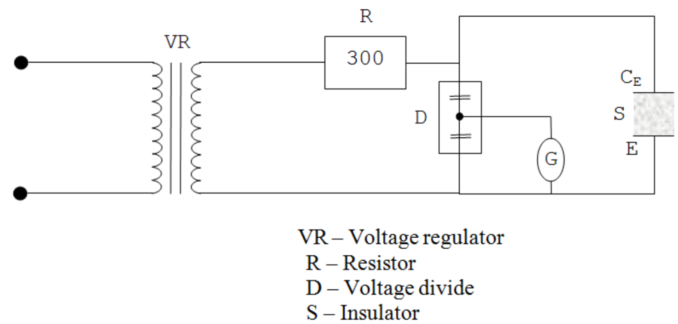

Figure 4: Test Circuit

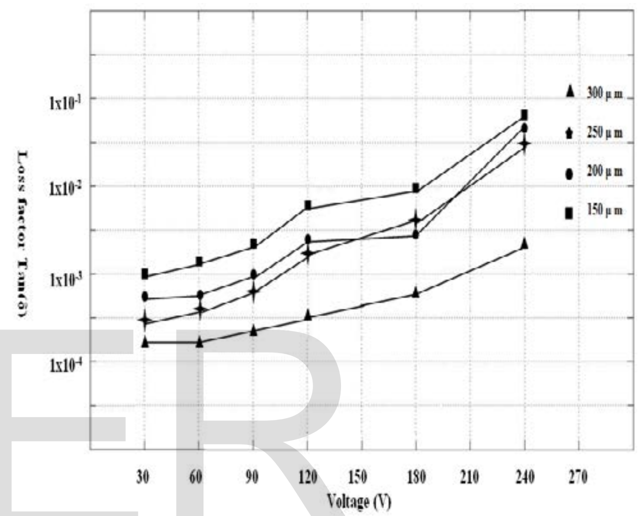

Figure 5: Relation between applied voltage and tan δ at different gran size

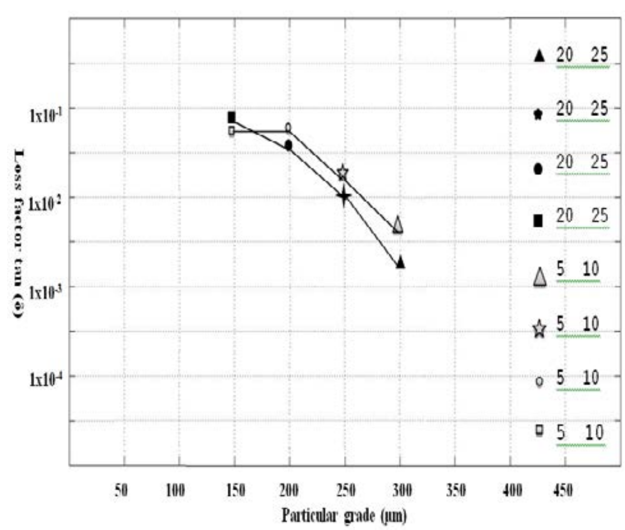

Figure 6: Relation between particles grade and tan δ at constant percent of cement and resin at: 270 volte, 50 Hz, Portland – cement 20%, Resin 25%

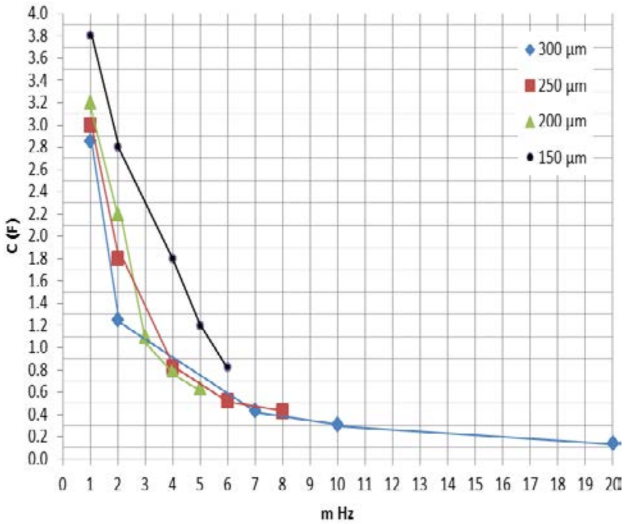

Figure 7 : Capacitance of insulator over the frequency

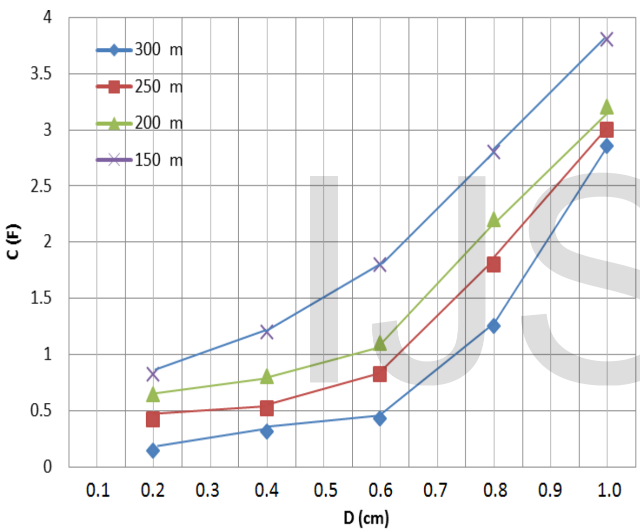

Figure 8: Capacitance of insulator over the length of insulator

Table1 : Composition of Insulators

Specimen no.	Practical size	Resin % (by weight)	Portland % current (by weight)
A	150µ m	10	5
B	150µ m	15	10
C	150µ m	20	15
D	150µ m	25	20
E	200µ m	10	5
F	200µ m	15	10
G	200µ m	20	15
H	200µ m	25	20
I	250µ m	10	5
J	250µ m	15	10
K	250µ m	20	15
L	250µ m	25	20
M	300µ m	10	5
N	300µ m	15	10
O	300µ m	20	15
P	300µ m	25	20