Dielectric strength and insulating property on surface of spacer for particle contamination under dry air gas

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Abstract*- Sulfur hexafluoride is the most commonly used insulation gas in electrical systems. Gas insulated systems are widely used in the electric power industry for transmission and distribution of electrical energy. When SF6 was first discovered, the potential application was only considered for insulation because of good dielectric properties. But the widespread use of SF6 gas by electric power and other industries has led to increased concentrations of SF6 gas in the atmosphere. This causes concern as to possible effects on global warming because SF6 is a potent greenhouse gas. Due to this reason, first we studied uniform and non-uniform field property by dry air gas. This paper presents the dielectric strength and insulating property on the surface of spacer for particle contamination under dry air. We performed tests for the length and shape of particle. Test gas pressure is from 0.2 to 0.7 MPa. Particle position on surface of spacer is divided into nine parts and review. The results of analysis on the central conductor 31mm concave point has been identified as critical point. We anticipated that the breakdown voltage through analysis and testing were conducted. To find the 50% Breakdown voltage, the number of breakdown was performed 10 times and all test results were applied to analyze the normal distribution. The study was conducted to develop environment-friendly insulating material for GIS that can reduce SF6 gas and make a design Criteria for dry

I. INTRODUCTION

Sulfur hexafluoride(SF6) is widely used in the electrical equipment such as gas insulated switchgear(GIS) and gas circuit breaker(GCB), due to its excellent insulation and arc extinguishing characteristics and thermal stability. Despite its important advantages, SF6 gas became the focus of environmental influence, because SF6 gas causes the serious green-house effect by its emission in the atmosphere. Due to this problem, SF6 gas was classified as regulated gas on Kyoto Protocol(1997) and many countries are studying it for reduction of SF6 gas.

Reduction of using SF6 gas in electrical equipment has been going in various methods.

A study of insulation materials which have isolation and arc extinguishing capability is used in variety of medium voltage class commercial products, however, the basic research that can substitute for SF6 in high voltage class is not in advanced level yet. So we were conducted to develop environment-friendly insulating material for GIS that can reduce SF6 gas and make design criteria under dry air gas.

This paper presents the dielectric strength and insulating property on the surface of spacer for particle contamination under dry air gas

II. EXPERIMENTAL SETUP AND PROCEDURES

A. Test chamber

A lightning impulse voltage with a waveform of 1.2/50 μs was applied to the surface of spacer with particle. All tests were carried out in a pressure vessel. The chamber was designed for the maximum pressure of 1.0Mpa. The high-voltage connection to the vessel was through a composite bushing.

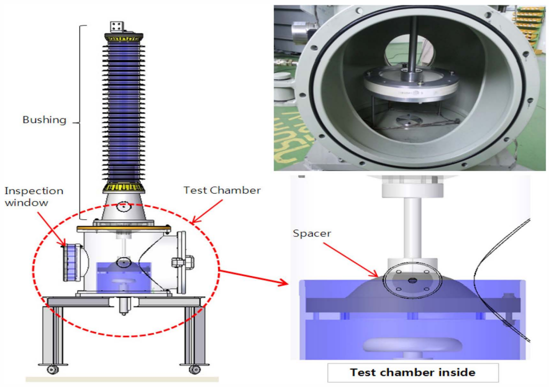

Fig. 1. Test chamber Layout

Figure 1 is the test chamber layout. The upper conduct and spacer's central conductor was assembled. The outer surface of the spacer applied flanges in order to implement the same conditions for GIS.[1]

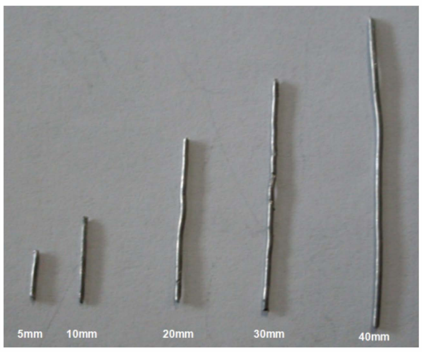

Fig. 2. Particle shape

Figure 2 presents particle's shape. Each length is from 5mm to 40mm

TABLE 1 Test information

	Test Information	
Particle	Material type	AL
	Length[mm]	5,10,20,30,40
	Thickness	0.2,0.3,0.4
	Attaching Position	Spacer (maximum field)
Test condition	Test Method	LI/AC
	Pressure[Mpa]	0.2, 0.3,0.5,0.7
	Gas	Dry Air

Table 1 presents the test information. Particles were used to create a material after processing tanks in the factory.

B. Anaysis

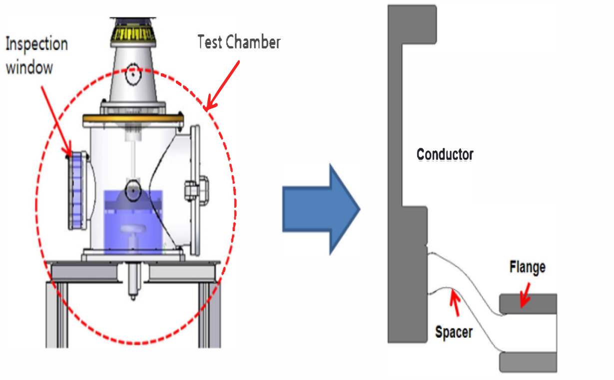

Fig. 3. Analysis Model

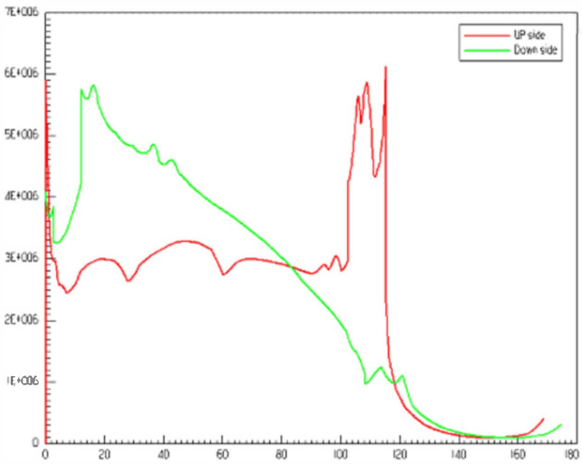

Fig. 4. Analysis result without particles

Figure 3 shows the test chamber is a 2D shape model for analysis using the Maxwell program. Firstly the analysis was conducted on insulator without particle. Figure 4 is the result of insulation surface from the central conductor to flanges. The Convex and concave surface were almost identical to the value of the maximum electric field without particle. But the convex surface maximum electric field location was close to the central conductor and the triple point of the concave surface maximum electric field was located.

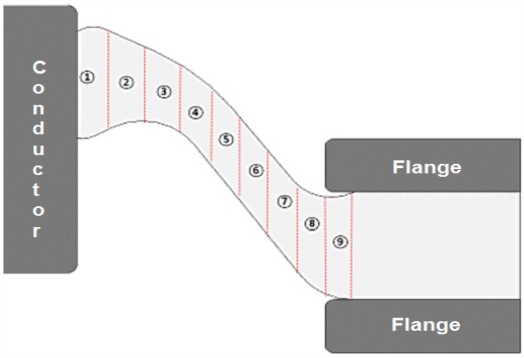

Fig. 5. Spacer's surface attachment site for a particle

Figure 5 is the spacer's surface attachment site for a particle. A particle position on the surface of spacer is divided into nine parts and reviewed. Analysis results by each location of a particle are shown in the figure 6 graph. The distance between conductor and flange of the spacer's surface.

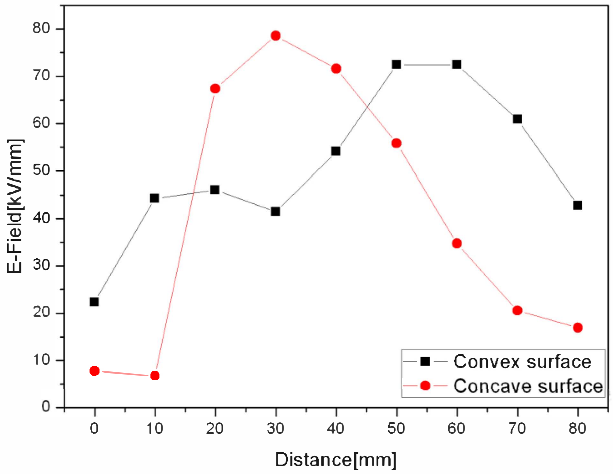

Fig. 6. Analysis result for attachment site of spacer' surface for a particle(particle length 10mm)

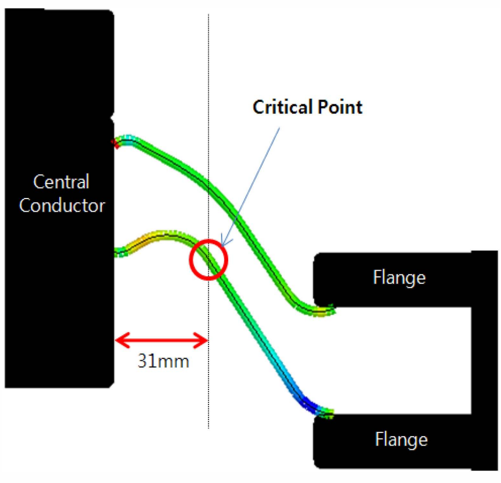

Fig. 7. Analysis result for critical point of a particle

In the initial attachment site, we conducted the analysis for spacer on the surface with the particle's length to 10~50mm in 10mm gap. As particle's length becomes longer, the maximum E-filed increase and the breakdown voltage can be expected to become lower. The results of analysis on the central conductor 31mm concave point has been identified as critical point. That is shown in Figure 7.

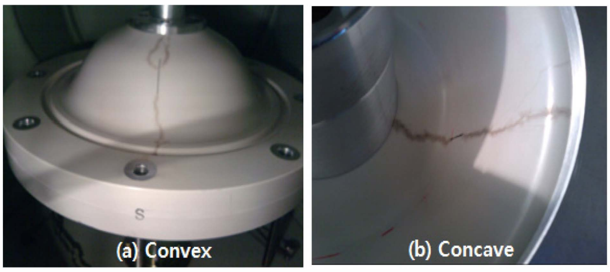

Fig. 8. Breakdown picture of spacer for initial Tests

(a) convex of spacer, (b) concave of spacer

Based on these results, the initial tests(LI) were conducted. According to the position of spacer's the convex and concave surface, the dielectric break down test was carried out.

C. Test and Results

The test results based on the particle's length was estimated according to the breakdown voltage. During the test, the voltage increased by 5kV until the breakdown were performed. To find the 50% Breakdown voltage, the breakdown was performed 10 times and all test results were applied to analyze the normal distribution. [3]

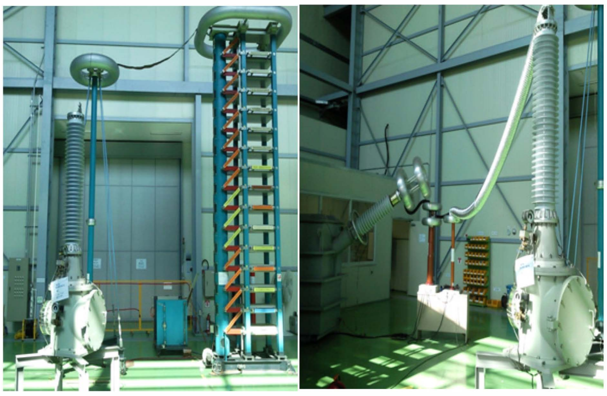

Fig. 9. LI and AC Test layout

Figure 10 shows the results in the breakdown of the gas pressure for dry air gas. With increasing gas pressure in same conditions, small change was shown in the breakdown voltage. Figure 11 shows the results in breakdown of the diameter of particle. Figure 12 shows the results for particle length in dry air gas.

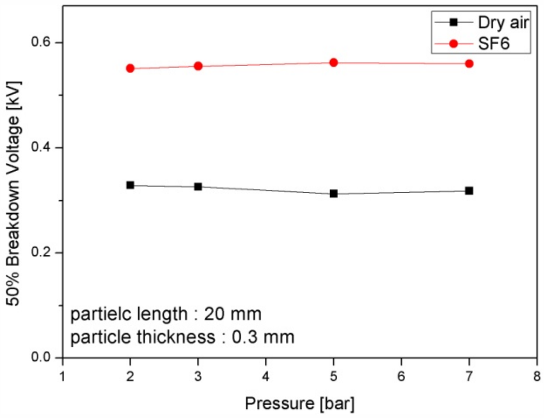

Fig. 10. LI Test result for Pressure in gas

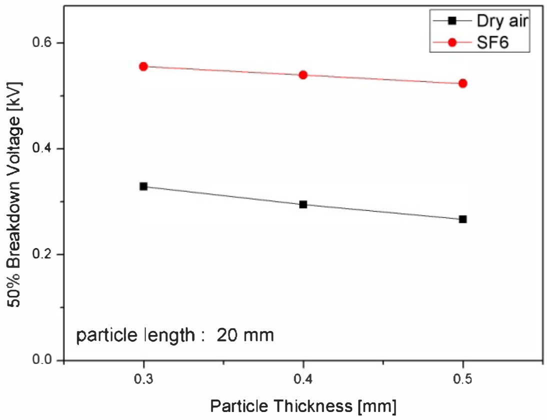

Fig. 11. LI Test result for Particle Diameter in gas

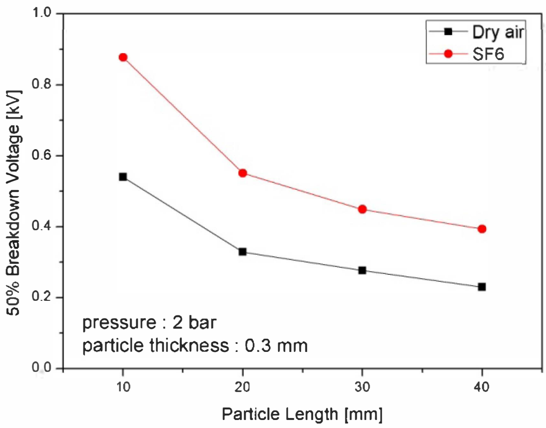

Fig. 12. LI Test result for Particle length in gas

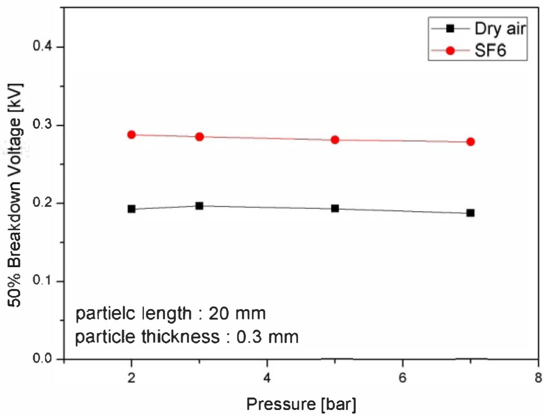

Fig. 13. AC Test result for Pressure in gas

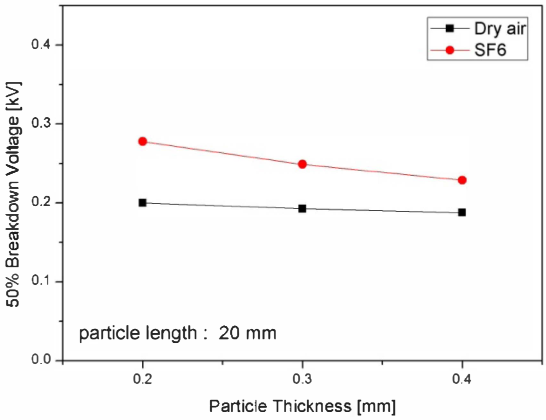

Fig. 14. AC Test result for Particle Diameter in gas

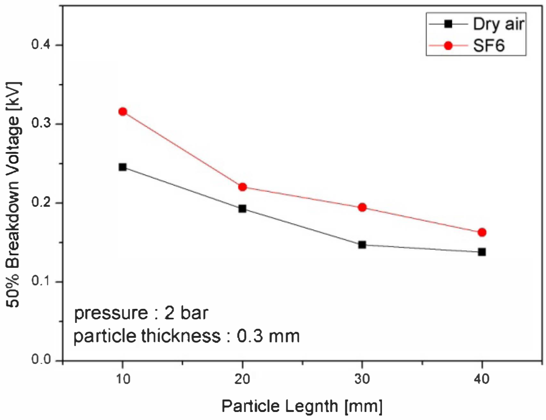

Fig. 15. LI Test result for Particle length in gas

Figure 13 shows result of AC Test for gas pressures. Figure 14 shows the AC test result for particle diameter in gas. Figure 15 shows the LI test result for particle length in gas.

III. CONCLUSION

This study is performed to make the insulation design criteria about the surface of spacer for particle contamination under dry air gas, as the fundamental step to develop the environmental friendly product of HV class level.

1. The dielectric strength of SF6 gas is about 60% higher than dry air gas under particle contamination.
2. The metal particle on Spacer's surface by the attractive force is easy to attach
3. Particle's breakdown is determined by the electric field strength of spacer's surface direction
4. Under the same particle, there is small change in breakdown voltage by the gas pressure
5. The larger the diameter of particle breakdown the voltage decreases
6. Smaller the length of particle, the breakdown voltage is increased

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Through this study, we established the process about the insulation design criteria in the surface of spacer for particle contamination using test chamber. And we also performed the electric test about uniform and non-uniform field and the temperature rising test for the application of products using this design criteria. Now, we are reviewing the results. Finally, we think the results will be used as the basic data of dry air gas to develop the environmental friendly power equipment.

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