

PARTIAL DISCHARGE MEASUREMENT SYSTEM AND FAULT ANALYSIS OF 25.8KV SF₆ GAS INSULATED SWITCHGEAR IN KOREA

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ABSTRACT

KEPCO(Korea Electric Power Corporation) has analyzed abnormality and breakdown phenomenon of MV gas insulated switchgear(GIS) for 5 years, and recently discovered decrease in troubles and improvement in power quality. As a result, main breakdown causes were from poor quality of epoxy insulator, miss-operation by lubricant hardening, broken shaft, etc.

KEPCO has applied partial discharge(PD) diagnosis technology for maintenance of distribution facility. In this paper, we sorted aging type of 25.8[kV]-class GIS and analyzed discharge characteristic of each aging type. We presented suitable PD measurement system to GIS.

Rated Voltage	I/S	G/S	P/S	P/E	etc.	total
6.6kV	0	60	0	0	142	397
22.9kV	2,849	76,029	25,347	5,375	3,564	113,164
Number	2,849	76,089	25,347	5,375	3,706	113,366
%	2.5	67.1	22.4	4.7	3.3	100

- * I/S : Interrupter Switch
- * G/S : Overhead Gas Insulated Switchgear
- * P/S : Pad Mounted Gas Insulated Switchgear
- * P/E : Protective Equipment(Recloser, Sectionalizer)
- * etc : ASS, ALTS, FAS, A/S, O/S
 - ASS : Automatic Section Switch
 - ALTS : Auto Load Transfer Switch

INTRODUCTION

It has been widely accepted that GIS has proven to be reliable and to have high availability. However, a lot of defects in GIS can reduce the voltage withstand level of the system.

In MV GIS installation certain types of defects can occur, e.g.:

- internal defects in dielectrics
- protrusion on conductor or enclosure
- defects in cable terminations
- bus insulation with moist or dirty surface
- defects correlated to the surface of dielectric

The most practical method employed on the non-intrusive detection of partial discharge activity in MV GIS is through use of both electromagnetic and ultrasonic detector[1].

In this paper, the ultra high frequency(UHF) technique has been used to detect partial discharge activity within the equipment.

OVERVIEW OF MV GIS IN KOREA

Present condition of MV GIS

Korea has up to 113,366 GIS. Switchgears that pole mounted equipments are about 80,000 and pad mounted equipments are about 30,000. Typically SF₆ gas insulated type switches are used in approximately 89.5 percent of the total number of switchgears.

Faults Status of GIS

The list below shows the result of KEPRI's survey on the causes of faults on 25.8kV SF₆ gas insulated type switches over the past 5 years.

- mis-operation : grease hardening , corrosion of switchgear, broken shaft
- insulating materials : contact badness of electrodes, transient over voltage, tracking phenomena of the polymeric insulation material.
- damage of bushing : defect in voltage screen
- breakdown of elbow connector : surface damage, loose contact of connector
- others : moisture absorption, trouble of control circuits

Fig. 1 shows the perception of a survey on the causes of GIS breakdown

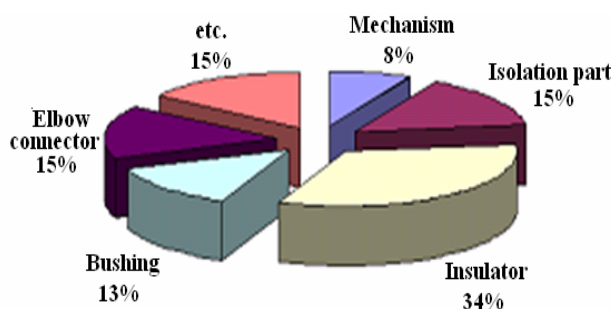


Fig. 1 Faults perception

UHF PD MEASUREMENT SYSTEM

Fig. 2 shows a UHF PD measurement system of GIS. It consists of three parts; an internal/external UHF PD sensor which can detect electromagnetic wave by occurring PD signal of inside defects, a DAU which can process a sensor signal, and a Human Machine Interface(HMI) that is capable of saving, analyzing and controlling measured signals.

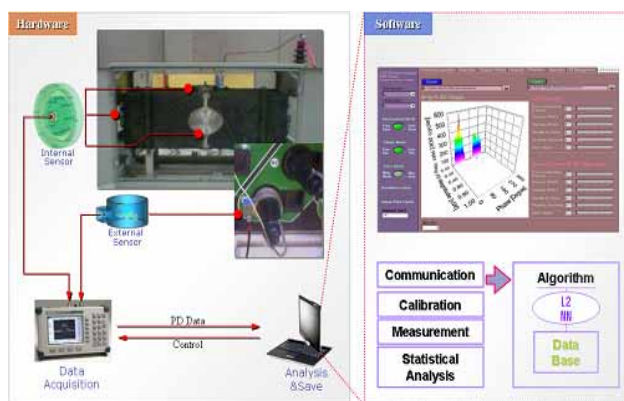


Fig. 2 UHF PD measurement system

UHF PD SENSOR

Internal UHF PD Sensor

The internal UHF PD sensor, which detects PD signal inside of GIS, was designed by using the principle of broadband frequency characteristic of Archimedean spiral antenna[2-3].



Fig. 3 Internal UHF sensor(proto-type)

External UHF PD Sensor

The external UHF PD sensor, which is set up outside of GIS and detects PD signal of inside GIS, was designed by using the principle of narrow band frequency characteristic of log-periodic antenna.

The sensor can be installed at GIS bushing while the GIS operate. And it has a shield structure to minimize outside noise.



Fig. 4 External UHF PD sensor(proto-type)

A sensitivity measurement of UHF PD sensor

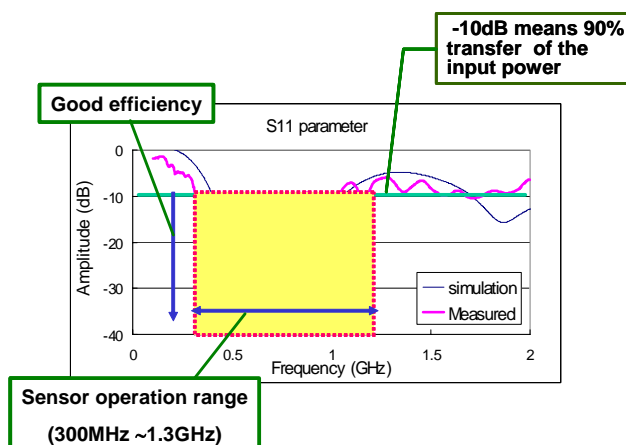


Fig. 5 The comparison of results between test and simulation

To get the performance of internal UHF sensor, we measured S_{11} parameters. A network analyzer was used to testify the internal UHF sensor in free space, work place, and GIS. Fig. 5 illustrates the comparison between simulation results and tests, and it shows difference result. The reason of the difference result is out of accord with the condition of test. The result shows that the sensor has excellent value under 10dB in 300[MHz] ~ 1300[MHz] band.

To compare total band of frequency, internal sensor has 5~10[dB] of characteristic transmission value that is higher than the external sensor. However, sensibility of the external sensor was highly performed at its resonance frequency area, which is between 300[MHz] and 1,200[MHz].

Interconnection experiment with the network
Experiments were carried out in the Go Chang Power Testing Center on weaknesses, which are protrusion, free moving particles, and damage in installed insulation of two ad mounted switchgears.

Manufacture of artificially defective product

With the demonstration of field test, three different types of variables were artificially manufactured, such as protrusion, free moving particle, and set up on the damaged insulation ; “A” company’s switch was used as a damaged insulation, and “B” company’s switch was used with protrusion and free moving particle in this experiment.

Protrusion

Protrusion was made by using 2[mm] copper wires, cutting its edge sharp, and was put into the third circuit of B Company’s switch as shown in Fig. 6. To simulate under severe conditions, the experiment was carried out within a 15[mm] gap between ground stirrup and power unit.

Free moving particle

To make shortage of the free moving particle, which was made as an electrode type, the free moving particle was installed into the first circuit of “A” company’s switch, as shown in Fig. 7.

The space between upside and downside electrode was controlled to 12.5[mm] in diameters while the ball type aluminum to produce PD signal was 1[mm] in diameter.

Surface discharge of dielectrics

Fig. 8 illustrates the artificially damaged insulation installed into the inside of “A” company’s switch to identify the shortage of insulation. To get surface of insulation aging with the actual level of the network voltage, aluminum tape was put into the upside surface of insulation.



Fig. 6 Protrusion



Fig. 7 Free moving particle

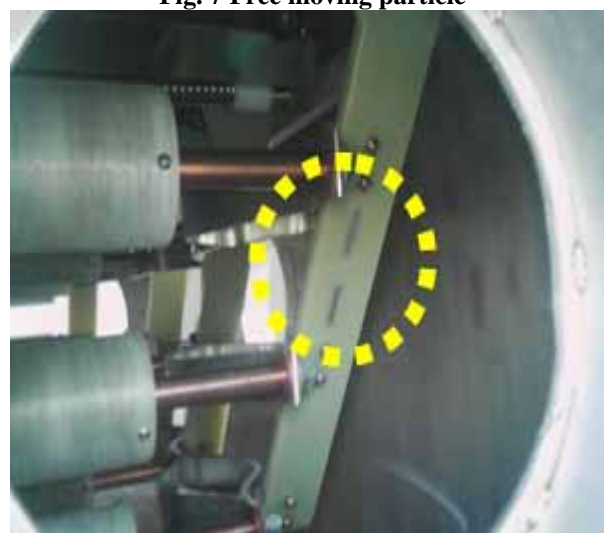


Fig. 8 Surface discharge of dielectrics

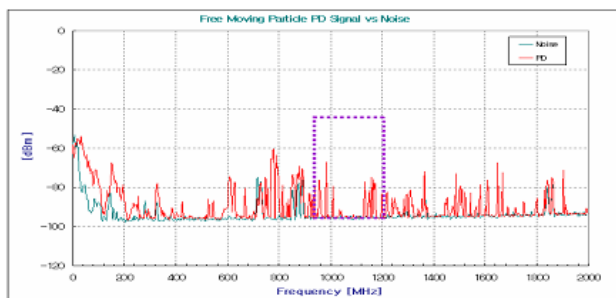
Measurement of each type of defects

Protrusion

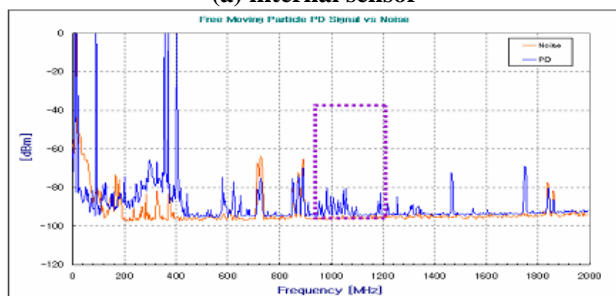
While the several tens of PD signals were generally not damaging the system, however if the transient voltage occurs to the system, they can cause misoperation or faults. The PD signal was found in both the internal sensor and external sensor between the 900 ~ 1200[MHz] bandwidth.

Free Moving Particle

The PD signal was found in nearly all frequency bandwidth with the PD signal at about 5[pc]. And it was found in both the internal sensor and the external sensor with the main target area of 900~1200[MHz]. This type of the defect classifies serious damage on the system. It may not happen by the aging phenomena, but by mechanism. Fig. 9 shows the signal of PD on free moving particle.



(a) internal sensor



(b) external sensor

Fig. 9 The signal of PD on free moving particle

Surface discharge of dielectrics

The minute signal was detected in the internal sensor, however, not in the external signal. It can be referred from the result that the surface is the beginning level of aging, and it may cause less PD signal than the expected level. There is still predictive assessment required by measuring the aging by periods to determine the impact of the events.

CONCLUSIONS

This paper developed a UHF PD measurement system that can examine and measure the insulation conditions of an operating MV switch.

Invent the internal/external UHF sensor in MV GIS.

Development Measurement the PD signal and the analysis algorithm

result provide a means to examine the performance characteristics which will be applied to the actual level of network voltage.

For accurate diagnosis, analysis on the characteristics of the field noise is needed.

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