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Frequency Spectrum Analysis of Corona Discharge Source Measured by Ultrasound Detector

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초음파 감지기로 측정한 코로나 방전 소스의 주파수 스펙트럼 분석

조현섭

Abstract This paper addressed the spectrum of ultrasonic waves produced by arc and/or coronal discharge inside the switchboard. Portable ultrasound sensors are useful for detecting discharge phenomena, such as coronal means in electrical systems. However, a typical handheld ultrasound detector has a disadvantage of determining the type of problem by listening to the sound characteristics and predicting the results, as a result of the determination of whether a discharge is present. Therefore, a new method of analysis is required to distinguish ultrasonic characteristics. In this paper, we published an ultrasound analysis case study to visualize the sound of ultrasonic waves measured with ultrasonic sensors. From the results of the experiment, it was possible to detect coronal discharge and serial arc discharge without interference by the ultrasonic detection system.

요 약 본 논문에서는 수배전반 내 코로나 및 직렬아크 발생 시 나타나는 초음파 신호의 측정 및 분석에 대해 기술하였다. 휴대용 초음파 감지기는 전기 시스템에서 발생하는 코로나와 같은 방전 현상 감지에 유용하다. 그러나 일반적인 휴대용 초음파 감지기는 방전 여부에 대한 판단 결과가 사용자의 주관적 반응에 영향을 미치며, 음향 특성을 듣고 결과를 예측함으로써 문제 유형을 판별하는 것이 어렵다는 단점을 가지고 있다. 따라서 초음파 특성을 구별하는 새로운 분석 방법이 필요하다. 본 논문에서는 초음파 감지기로 측정 한 초음파 음향을 시각화하기 위한 초음파 분석 사례를 연구하였다. 실험 결과 초음파탐지계통은 외부소음의 영향을 받지 않고 배전반에서 코로나 및 직렬 아크 방전을 검출할 수 있었다.

Key Words : Ultrasound, Interference, Electric Power, Series-arc, Frequency spectrum

1. Introduction

As electric power demand increases, the use and capacity of electric power facilities are rapidly increasing. If power outage or breakdown occurs, it will cause not only damage to people but also enormous economic loss [1]. According to the fire statistics of the National Emergency Management Agency of Korea in 2010, there are electrical factors as the causes of fire accidents, insulation deterioration, contact failure, and tracking, and the electric arc or short circuit accounted for 59.3% . Corona and series arcs are small in magnitude of current and discharge charge at the early stage of generation, but they do not have a large effect on the insulator, but if they continue, insulation performance degrades and leads to parallel arc or short circuit [3, 4]. In this paper, the method of diagnosis of the switchboard by detecting ultrasonic waves generated by corona and series

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arc is described. In order to prevent discharge phenomena such as corona, partial discharge, flashover, etc. occurring in a high voltage situation, various kinds of insulators are used in the installation devices inside the switchgear. However, such insulation may cause gaps such as voids or delaminations during cooling and heating during operation for some reason or during operation. However, such a gap generates a partial electric discharge every time a high electric field is applied, and if such partial discharge is repeated, the insulation is slowly eroded and the dielectric strength is reduced, resulting in serious dielectric breakdown. In order to solve this problem, it is desirable to remove the gap in the insulating material in advance to reduce the occurrence of partial discharge, but it is difficult to completely remove the gap in consideration of various reasons. In addition, the insulation characteristics of the insulator must be sufficiently inspected from the time of manufacture. Such inspections are effective for inspection of initial manufacturing defects, but insulative deterioration over time occurs during the operation of the switchboard, so that it is difficult to conduct practical inspections. Therefore, in the past, the time interval between inspections increases, and it is impossible to accurately grasp the insulation characteristic at all times, resulting in an unexpected serious accident. In addition, the deterioration can be monitored by measuring the partial discharge.

Ultrasonic detectors have been used as one of the early diagnostic methods for electrical equipment such as transformers, cables and isolators because they are very simple. Portable ultrasound detectors typically provide information to the meter through headphones for audio signals and to display readings of light in decibels in general. So, operator must decide whether there is corona or not by listening through headphones and observing a decibel meter.

These methods have problems that interpretation and analysis on measurement results are difficult and can be changed by auditory response, experience and skill of operator. Therefore, due to the long measurement distance, low noise and the driver's ability to adjust the sensitivity of the device and the diversity of electrical equipment, only operators with extensive measurement experience can determine the type of problem accurately. In addition, if the casing of electrical and mechanical equipment is used in an ultrasonic scanning location, it is very difficult to create ultrasonic waves and electrical discharges due to faulty mechanical equipment such as bearings, valve leaks and gears. Therefore, the diagnosis of the audio analysis of the measured ultrasonic emission is not accurate.

This paper presented a case study to develop an ultrasonic wave analysis program and to visualize the ultrasonic sound effects measured with an ultrasonic wave detector. The developed program not only provides a spectrum of sounds and a time series view of sounds, but also allows sounds to be heard. Diagnostic results, including details such as the specific equipment, inspection conditions, and recommendations inspected, can be reported by the program. By using these spectra or time series, you can easily understand and diagnose faults in electrical equipment.

2. Ultrasound Detector

Sound levels exceeding the normal hearing range of 20 Hz to 20 kHz are generally considered ultrasonic. Typically, the frequency range from 20 kHz to 40 kHz includes all ultrasound applications, such as discharge and leak detection. This is generated by friction, shock, turbulence and electric discharge.

In order to simulate corona and series arc discharge in the switchgear and detect ultrasonic signals, the experimental system was constructed as shown in Fig. 1. These instruments provide information via headphone for audio signal and on a meter to display intensity readings, usually in decibels. The directional nature of ultrasound emission makes it possible to confirm the location of the ultrasound source.

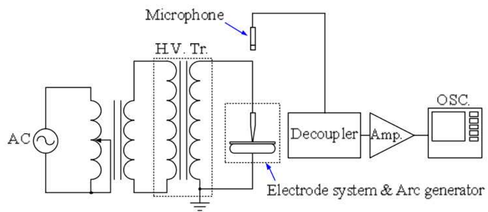

Fig. 1. Configuration of the experimental set-up

Typically, the frequency of ultrasonic waves caused by electrical partial discharge inside the equipment is between 20 kHz and 30 kHz. For coronal, arches, and traces, the ultrasonic wave frequency is approximately 40 kHz [5]. So most ultrasonic detectors have a direction for the special frequency band.

The user of the ultrasonic detector scans the electrical equipment. Corona, tracking and arcing problems with electrical equipment sound hard. It has a distinct sound quality that can be heard and spoken, but it's very difficult to tell what type of problem you're hearing through your headphones.

Therefore, it is difficult to determine the type of problem by listening to the sound characteristics and estimating the results, as a result of the determination of whether or not a discharge is present [6,7]. If casing of electrical and mechanical equipment is used in ultrasonic scanning locations, it is also very difficult to generate ultrasonic waves and electric discharge due to faulty mechanical equipment such as bearings, valve leaks and gears. Therefore, the diagnosis of the audio analysis of the measured ultrasonic emission is not accurate.

3. Development of Analyzing Program

An example of measured ultrasonic signals and current pulse waveforms during corona discharge are shown in Fig. Respectively. Ultrasonic waves of 20 kHz ~ 100 kHz band were observed in the corona discharge. Especially, 30 kHz ~ 50 kHz component was 8 mV ~ 10 mV. This work developed an ultrasonic analysis program using the Nashoreal Instruments Work bench in the Nashore Instruments as shown in Figure 2. Sound measured by an ultrasonic detector can be downloaded to the PC via an MP3 recorder or a quality cassette recorder and viewed as a spectrum (amplitude - versus - frequency) known as a frequency domain or a time series.

The developed program also provides a spectrum of sounds and a time series view of sounds, as well as sounds. Diagnostic results, including details such as the specific equipment, inspection conditions, and recommendations inspected, You can view it in a program. By using these spectra or time series, you can easily understand and diagnose faults in electrical equipment.

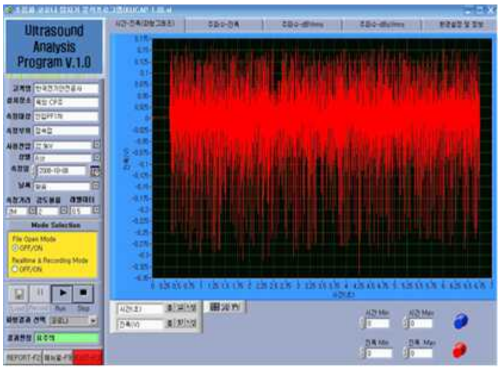

Fig. 2. The developed program

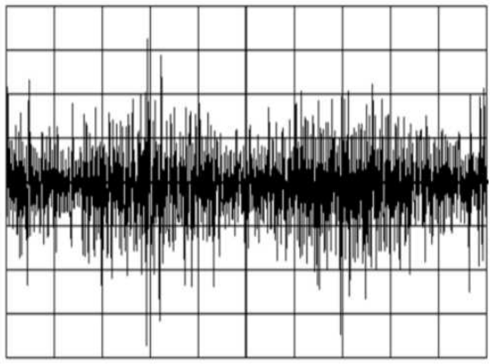

Fig. 3. View of the corona sound as seen in the frequency-domain analysis. Ultrasonic signal [100 mV/div, 10 ms/div]

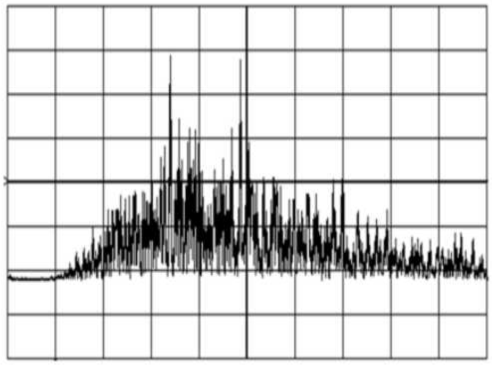

Fig. 4. View of the corona sound as seen in the time-domain analysis. Frequency spectrum [2.0 mV/div, 10 kHz/div]

4. Analysis Method and Case Study

A microphone with a frequency band of 4 Hz to 100 kHz was installed on the ceiling of the switchgear and the discharge was simulated below 1 m. An inverse coupling circuit was connected to the microphone, and a low noise amplifier was installed to amplify the minute signal. In order to analyze the optimal detection frequency band, the active bandpass filter was used to measure the signal while varying the frequency band. In order to confirm that the generated ultrasonic signal is due to discharge, discharge current was measured using a high frequency current transformer.

The electric coronal maintains a steady 60 Hz harmonic. As shown in Figure 3, an ultrasonic signal [100mV / div, 10ms / div] occurs between spikes containing a large number of the spikes. Fewer 60Hz harmonics are present between 60Hz peaks and indicate harmonics other than 60Hz[4, 6]. For coronal time - domain graphs have a uniform band of signal frequency spectra of [2.0mV / div, 10kHz / div] with peaks above the average band as shown in Figure 4.

Figures 5 and 6 show the results of the spectral and time domain analyses, respectively, using developed programs. The results of the spectrum analysis show the harmonics of electrical radiation. In time domain analysis, a uniform signal band with a peak higher than the average hand was found. So we decided that CT was defective.

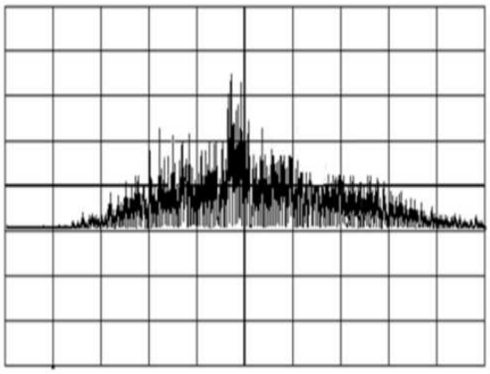

Fig. 5. View of the arching sound as seen in frequency-domain analysis in the scanned CT. Frequency spectrum [2.0 mV/div, 10 kHz/div]

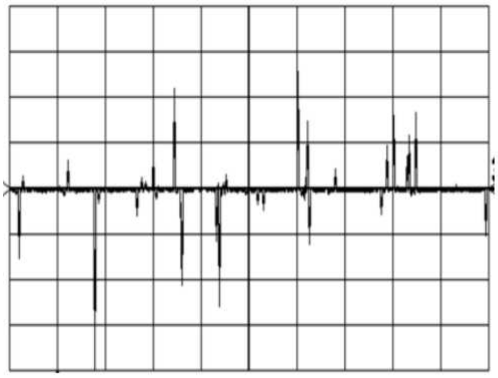

Fig. 6. View of the arching sound as seen in the time-domain analysis in the scanned CT. Current signal [2.0 V/div, 10 ms/div]

5. Conclusions

In this paper, the technology of diagnosis of power equipment in the switchboard by ultrasonic signal detection is described. Corona and series arc discharge phenomena occurring in the switchboard are simulated and it is found that the optimum detection band of the ultrasonic signal generated at this time is 30 kHz to 60 kHz. Measure results. Spectrum and time domain analysis of sound measured by an ultrasonic detector can be a useful tool for determining the type of problem with electrical equipment.

REFERENCES

[1] S. Tenbohlen, D. Uhde, and J. Poittevin (2000) Enhanced Diagnosis of Power Transformers using On- and Off-line Methods: Results, Examples and Future Trends, CIGRE Paris, No. 12-204.

[2] National Emergency Management Agency (2010) A Statistical Analysis on the Electric Accident.

[3] Wen-Jun Li, Yuan-Chun Li (2005) Arc Fault Detection Based on Wavelet Packet, Proc. of 2005 4th International Conference on Machine Learning and Cybernetics, Vol. 3, pp.1783-1788.

[4] Gyung-Suk Kil, Hong-Keun Ji, Dae-Won Park, Il-Kwon Kim, et

[5] Mark Goodman, Using Sound Imaging to Enhance Your Diagnosis, UE Systems (2011)

[6] James Brady, Corona and Tracking Conditions in Metal-clad Switchgear Case Studies, Brady Infrared Inspections (2006)

[7] Mark Goodman, Methods of Inspection to Determine the Presence of Potential Arc-Flash Incidents, NETA WORLD (2007).

[8] C. Li, F. Dawson, H. Kojori, C. Meyers, et al. (2003) SAE Technical Papers 2003-01-3037, 591.

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〈Research Interests〉 Electric and Electronics Application, Automatic Control