Partial Discharge Monitoring System on High Voltage Equipments Using Electroacoustic Technique

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***Abstract*—Partial discharge (PD) monitoring system is considered as one of the most promising solutions for monitoring and detecting possible faults. PD is able to diagnose faults within the system in the most fundamental and simplest way. PD monitoring and measurement of high voltage equipment substations panel and power transformers have not gained the same attention in the electrical community as compared to those of rotating machines. PD tests are conducted on-site to verify the insulation of bushings, termination box and windings. The cost of an unexpected outage may be considerably more significant for a high voltage substation panel and power transformers system than just for a single motor failure. In this research, the electroacoustic PD monitoring technique is used, which is a combination of internal PD detection and ultrasound or surface PD detection was used. The testing equipment which will be used in this research is UltraTEV Plus+ equipment from EA Technology. Result shows the transient earth voltage (TEV) PD magnitude fluctuates with time. Significant high value of PD magnitude (> 19 dB) was detected and recorded at several switchgear panel and transformer. However, for the ultrasound or surface PD, from the monitoring and measurement record, no detection of PD signal was recorded at the UltraTEV Plus+ testing equipment.Keywords—**

1. INTRODUCTION

In modern society, electricity is regarded as the most important energy medium enabling many electric facilities to operate. In order to maintain and sustain these facilities, the quality of power from the grid should be as stable as possible to meet the requirements of electric equipment. Nowadays there are many factories and buildings that rely on constant power supply to operate, in which supply failure means additional costs or loss. Even though there has been growing concern about this issue, power systems reliability levels have remained fairly dormant for the last several decades. This has led to catastrophic cascading blackouts occurring several times all over the world in the recent years. These events illustrate the importance of protecting and monitoring power systems which are the most intricate system humans have ever made in history [1].

Compared to many protection methods in power system, Partial Discharge (PD) is considered as one of the most promising solutions for monitoring and detecting possible faults in the system before they occur. Thanks to the development of other engineering areas such as radio communication, computer science and signal processing, protection systems are becoming cheaper and more robust, also high sensitivity. PD is able to find possible symptoms of faults in the system in the most fundamental and simplest way [1]. Investigation of PD phenomena and its analysis method have been conducted in our previous research for laboratory test [2-3].

With IEC 60270 and other standards regarding PD monitoring, PD measurement techniques and calibration had been established with detailed explanations for monitoring purposes. Since direct detection of PD is not possible, conventionally technicians have been using so-called "apparent change" detection. Whilst traditional methods are detected after failure or discrete periodic interval monitoring, modem techniques are largely dependent on the relative changes of important parameters in time or frequency domain. As a result, Condition Based Maintenance (CBM) has been considered a powerful tool for real-time monitoring on power system components. In order to conduct on-line PD monitoring, the noise to signal ratio is the key variable to determine whether there is PD activity or not. That is the reason unconventional methods for detecting electromagnet PD phenomena using High Frequency (HF), Very high Frequency (VHF), or Ultra High Frequency (UHF) detection and Acoustic Emission (AE) detection have been developed for on-site and on-line PD monitoring being supported by IEC 62478 in near future [1].

Nevertheless, whilst the theory behind PD monitoring system is similar for different components, the application on power system apparatus such as transformer, switchgear, cable, or rotating machines differ from each other. Thus, intensive literature survey of PD monitoring of power system components will be presented as a big picture in the field of on-line monitoring [1]. The on-line partial discharge condition assessment of in-service MV and HV plant are reported by many researchers [4-6].

PD is also defined by IEC 60270 as a localized electrical discharge that only partially bridges the insulation between conductors and which may or may not occur adjacent to a conductor. A lot of measuring methods for PD signals from switchgears were proposed in the past and some were proven to be useful. But most switchgear is still needed to be tested off-line to measure the insulation condition. As their main disadvantages are the high capital cost of the test equipment and the complexity of the testing procedure, the new TEV PD detection method used on-line can solve the problem effectively. When a partial discharge occurs, a transient earth voltage (TEV) is impressed on the inner surface of earthed metal cladding. This local voltage elevation spreads out in all directions travelling on the surface of the metalwork. It then emerges on the outer surface of the switchgear through joints, seams or gaskets. TEV signals vary widely in amplitude from millivolts to volts. The signals are extremely fast, with typical rise time of a few nanoseconds [7].

In this research, the electroacoustic PD monitoring technique is used, which is a combination of internal PD detection and ultrasound or surface PD detection was used. This monitoring activity was started from January 2011 to July 2013 at Lotte Chemical Titan Plant, Johor, Malaysia.

2. METHODS

In this research, the latest PD monitoring equipment and technology provided in the market is used. The PD monitoring equipment in the market and suitable to used is UltraTEV Plus+ which has the ability to measure the PD at the surface and internal discharge. This UltraTEV Plus+ is design to detect PD sources in high voltage equipment in the electrical substation and in also in the plant. This equipment can be used to detect any PD sources without interruption to the equipment operation. If no discharge detected, this does not necessarily imply that an item of high voltage equipment in the plant is discharge free. But the discharge site often has dormant periods and insulation structures can fail through causes other than those attributable to partial discharges [8].

The UltraTEV Plus+ is the ultimate hand held instrument for the detection and measurement of PD in high voltage or medium voltage equipment. Both transient earth voltage (TEV) and surface discharges can be detected and are displayed as numerical values on a colour screen.

The instrument also has the ability to display the number of PD pulses per cycle, severity levels, maximum levels for internal discharges, and a numerical value for ultrasonic emissions, which can be heard with the supplied headphones. The equipments chosen for the measurements are UltraTEV Plus+ with their accessories which are humidity meter, temperature meter, portable sensor or flexible sensor, headphone and ultrasonic contact probe. The flowchart of PD testing application is shown in Fig. 1.

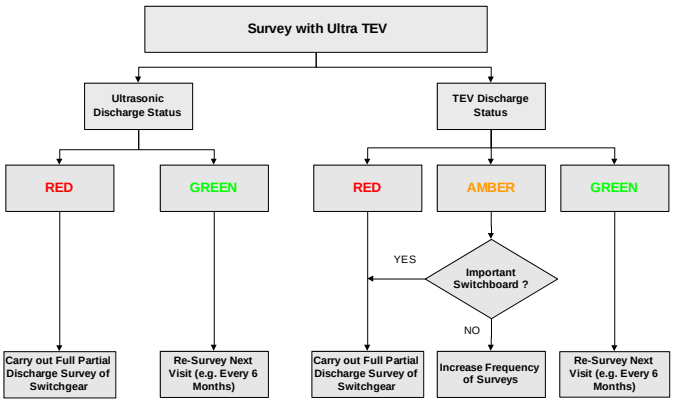

Fig. 1. Flowchart of PD testing procedure.

3. Results and Discussion

Based on the trend charts that are obtained, an investigation, evaluation and analysis process were conducted to see and compare the result with previous measurements. Then, the result which is obtained from this process, the PD pattern and characteristic at high voltage equipment are known and the prevention action or rectification plan can be made, accordingly.

In this section, it shows the compilation of PD measurement and monitoring data, as mentioned in the earlier section. These data are collected using electro acoustic technique which is transient earth voltage (TEV) for internal PD detection and the other is via ultrasound method which is designed for surface discharge detection on HV equipment such as main substation, transformer, switchgear, and switchgear & transformer.

Fig. 2 shows PD magnitudes are within the safe region. But there are show a pick up PD activity at TPP Outgoing Feeder, Busbar Earthing and Busbar Chamber at 132/22kV substation. The PD magnitude is within safe limit which is at below 20 dB but already reached at the border line limit. The border line limit is at less or equal than 19 dB. Since this panel is very critical and essential to the plant and cannot stop, the recommendation is to install PD locator or monitor for at least ONE-week monitoring time to pin point the actual PD source.

Fig. 3 and Fig. 4 show normal PD magnitude, namely belo 20 dB and no activity of partial discharge was detected for transformer and switchgear. Based on the Fig. 5, the PD magnitude at step-up Transformer (11/22kV), 22 BAT 10 Primary Transformer shows significant high values of PD activity, which is in between 26 dB to 27 dB of magnitude. However, the PD magnitude reduces to 6 dB to 7 dB after high tension (HT) cable raychem replacement at transformer primary cable, which is at 11kV side. But during the visual inspection at the surface of the cable and at the cable termination area, no abnormalities or partial discharge sign were found. Other than that, the PD activity also detected at Dry Transformer with step-down transformer with capacity of 11/0.415 kV.

This 21 BFT10 and 22 BFT10 dry transformer was captured with PD magnitude of 24 dB to 27 dB. Further investigation was conducted and base on analysis found the entire nearer panel gives high value of PD reading. Finally, found that the real PD signal is not coming from the dry transformer panel but it is coming from external signal from 440 VDC rectifier panel. This rectifier panel gives the PD result is 38 dB. Technically, it is normal for rectifier unit to have high switching signal but it is very important to thoroughly check the physical condition of the internal component in the panel.

Fig. 6 shows the gas turbine generator 2 or Cogen 2 PD monitoring data. It is found a significant high PD activity at zero equipment switchgear panel which is more than 20 dB of PD magnitude. The root cause of this high PD magnitude is still unknown because it is required for further assessment at this equipment to find the real root cause of the high PD reading and it is required for equipment isolation or stop from operation.

Furthermore, it also shows that there have significant drop of PD magnitude at the high voltage equipment panel which is shared common 11kV feeder. This is happened after the previous gas turbine generator high tension yellow cable fault on February 15, 2013. During the investigation of the cable faulty, found there have sign of PD activity inside the cable insulation and the carbonization was released from the point of electrical discharge and flow through up to the grounding wire mesh and this caused direct shorted to the ground.

Based on the overall PD measurements result above, shows the TEV PD magnitude was fluctuating. The TEV PD magnitudes for high voltage motor and switchgear panel is in normal range which is below than 19 dB.

However, for the Ultrasound or surface partial discharge, from the monitoring and measurement record, no any single detection of PD signals were recorded at the UltraTEV Plus+ testing equipment. All the measurement gives negative PD magnitude result, which is overall the result is less than 0 dB. Besides, no abnormal sound recorded and no tracking and hissing signal are detected.

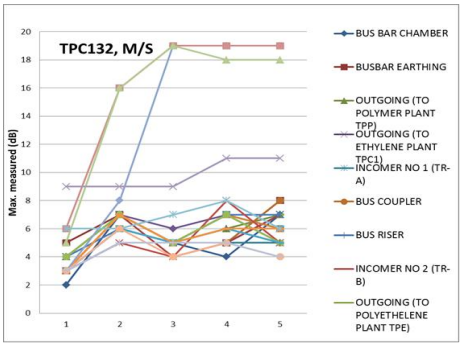

Fig. 2. TPC 132kV Main Substation

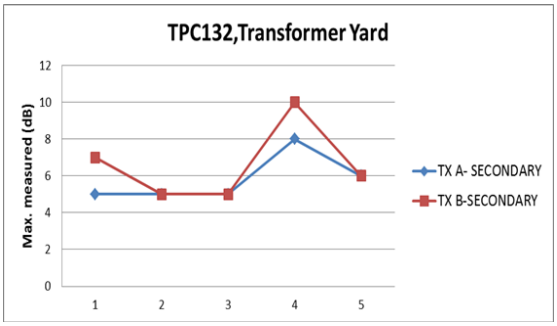

Fig. 3. TPC 132 kV Transformer

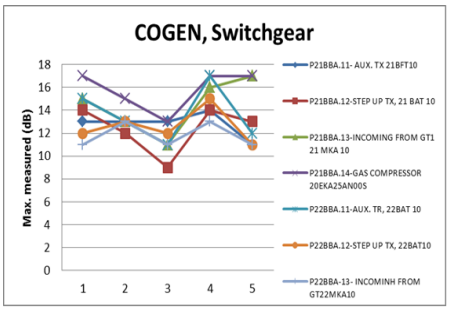

Fig. 4. COGEN 1 Switchgear

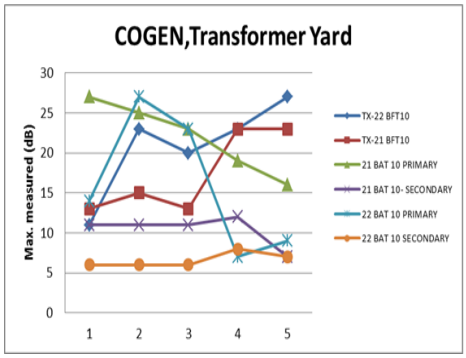

Fig. 5. COGEN 1 Transformer

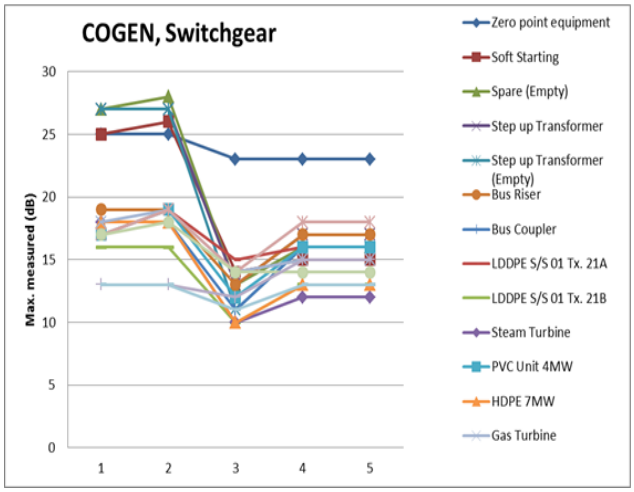

Fig. 6. COGEN 2 Switchgear & Transformer

4. CONCLUSION

A condition-based monitoring which is partial discharge (PD) monitoring system is implemented in this study. The output from this monitoring system and the system performance were identified accordingly and any abnormalities from the PD pattern will be notified earlier for immediate rectification and preventive action works. From the PD monitoring and measurement results, it can be clearly seen that the research is achieved and meet the required objective. The PD monitoring and measurement at high voltage equipment has been performed successfully.

PD monitoring system results has been investigated and evaluated. Based on the results, shows the TEV PD magnitude was fluctuated. The TEV PD magnitude for high voltage motor and switchgear panel is in normal range which is below than 19 dB. However, significant high value of PD magnitude detected and recorded at 132/22kV substation switchgear panel at 19 dB which is already nearly reach to border safe limit line. It is recommended to install PD monitor and locator to pin-point the exact PD source and location. This is easy for shutdown planning and rectification work. This will eliminate production loss when equipment required shutdown for PD source investigation without knowing the actual PD source.

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