Inspiration and Interactive Factors of Partial Discharge Detection: Insulating Gases in High Voltage Gas Insulated Transmission Systems

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Abstract—**Partial discharge in gas insulated switchgear is a well-known phenomenon that can be an indicator of insulation ageing and degradation. It is vital to analyse and post-process these signals under different humidity, pressure, dielectric gaseous media, contamination, pressure, temperature and voltage waveforms in order to understand the severity of the underlying defect in a practical system. In this paper, an initial prototype including coupling device and external measurement system with phase-resolved partial discharge data processing methods is introduced to study the effects of the aforementioned parameters, which may lead to greater insights into defect type and severity in eco-friendly alternative insulating gases.**

Background & Experimental Setup

In the current decade, some verified cutting-edge factory assembled Gas Insulated Switchgear (GIS) will be poised to construct complementary elements such as transmission lines and Offshore Substation Platforms (OSP) [1], thereby taking advantage of synergies in HVDC/HVAC design, to achieve the integration with new HVDC transmission systems. [2] Vitally, the industry needs to pay attention to insulation degradation in critical infrastructure such as offshore wind farms and HVDC interconnections, particularly since repair and replacement costs in such harsh environments can be greatly elevated.

Additionally, GIS development from manufacturers also requires insulating gas replacement in anticipation of increasing regulatory restrictions and eventual banning of SF_6 due to its high Global Warming Potential (GWP) [3]. In this study, CO_2 was chosen an alternative insulating gas and partial discharge (PD) was measured under various pressure and voltage conditions. HFCTs were chosen as a coupling device to measure apparent charge and a custom data acquisition and post-processing system was used to reveal the Phase Resolved Partial Discharge (PRPD) pattern under diversified pressure levels and gaseous containment under HVDC conditions. Thereafter, we demonstrate the principle of the coupling device in series with the test object driven by an HV amplifier, which can generate the superimposition of harmonics and HVDC converter ripple. A wideband oscilloscope (Lecroy HDO6104 1 GHz , 2.5 GS/s) was used as the measuring instrument to capture the high frequency signals. The system will become the primary prototype for future work on the modernisation of the Ultra High Frequency (UHF) measurement techniques or more advanced sensor and coupling systems. As shown in Fig. 1, test cells representing typical defect topologies were utilised for PD measurement. Defects such as point-plane and free particle samples can indicate the heterogeneity in PD inception voltage and PD signal distribution.

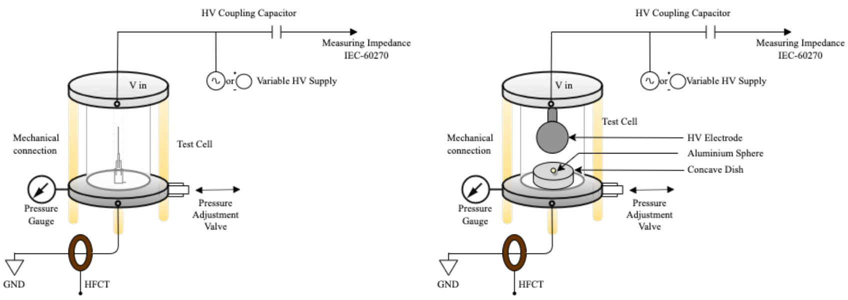

Figure. 1 Point-plane (left) and Free particle test cell containing pressurised CO_2

Conclusions and Future Research

With over 12kV HVDC input, what can be observed is that partial discharge will be produced in these two cells and the PRPD signal processing approach can demonstrate unique features of respective defect topologies using the AC phase or the dominant HVDC harmonic as reference. Future testing will utilise gas handling facilities to mix and test SF_6 alternatives with inert gases such as CO_2, N_2 or technical air to simulate practical GIS gaseous replacement. These experiments with multiple influencing elements from the PD will practically facilitate the commercial application of assembled HVDC offshore substations and evolve the usage of more eco-friendly insulating gases contented in HVDC GIS.

References

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