Investigation of Space Charge Dynamics at the Interface between Oil and Impregnated Paper/Pressboard

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Introduction

Oil - paper insulation has been widely used in HVDC convertor transformers as the main insulation system. Compared with conventional power transformers, the dielectrics in the HVDC convertor transformer should withstand not only normal AC stress, lightning impulse and switching surge, but also DC stress and polarity reversal. The easy accumulation of the space charge is one of the major issues associated with HVDC. Moreover, it has been demonstrated that the interface between dielectrics as well as electrode/dielectric behaves as a barrier, resulting in significant charge accumulation. It is, therefore, necessary to investigate space charge dynamics at the interface between oil and impregnated paper/pressboard, especially, under combined AC and DC voltages and polarity reversal.

In the present work, a purposed-built pulsed electroacoustic (PEA) system is established to measure space charge not only within the impregnated paper/pressboard bulk, but also at the interface between impregnated paper/pressboard and oil.

System setup

The new PEA system is used for:

- Measuring space charge not only within the impregnated paper/pressboard bulk, but also at the interface between impregnated paper/pressboard and oil.
- Measuring space charge in thick samples (>500μm)
- Measuring space charge under different stress conditions, e.g. polarity reversal.

Requirements:

- Provide a thin oil gap above or below the impregnated paper/pressboard sample to create the interface between two materials.
- Generate strong enough signal to be detected and evaluated.
- Acquire data fast that can measure space charge under a transient electrical stress.

HV pulse generator

Using high voltage mechanical relay to generate high voltage pulse (300 Hz, 5 ns pulse width, up to -3 kV pulse voltage)

Modified PEA system

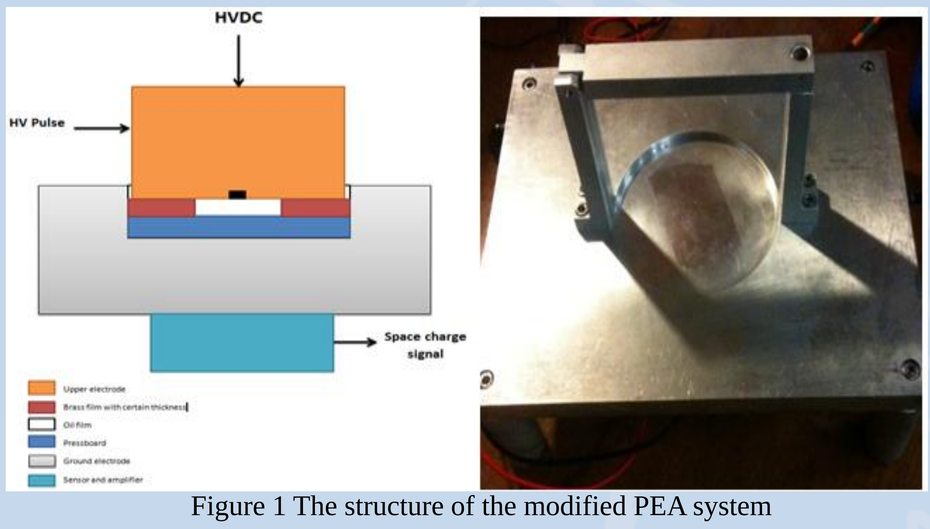


Figure 1 The structure of the modified PEA system

- Sensor and absorber are pressed together under the Al plate within a shielded sensor cell.
- The sensor is made of PVDF with 40 μm in thickness and 0.8 cm^2 in area to generate a stronger signal.
- Considering the thickness of samples, the thickness of the absorber is reasonably larger to proved a longer signal delay.

- A 15mm thick aluminium plate is used as ground electrode and it also acts as oil container with 5mm in depth.
- The first layer of insulation is impregnated pressboard which lies on the ground electrode that can have a good contact with the ground electrode.
- Brass films with different thicknesses are applied to provide a oil gap between the upper electrode and the impregnated paper/pressboard sample.

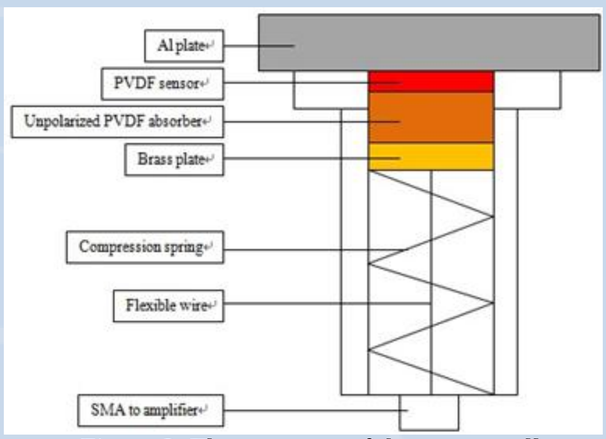


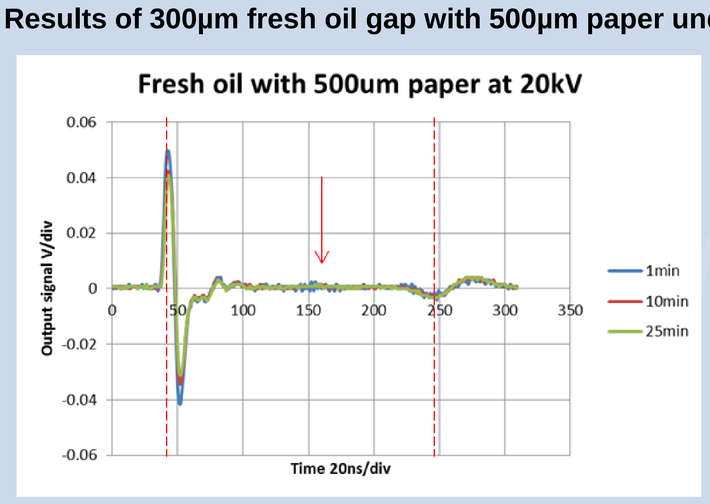
Figure 2 The structure of the sensor cell

Results and Discussions

Test samples:

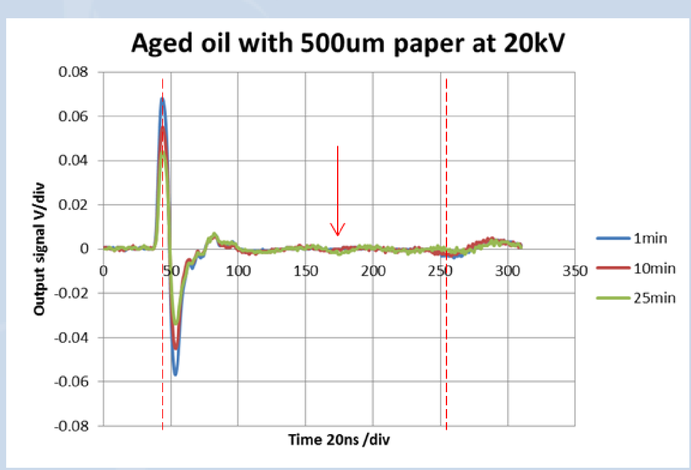
- Oil: Aged breakdown transformer oil and fresh Shell ZX-IG transformer oil.
- Paper: 500μm thickness paper is cut into circle shape with 90mm diameter, dried and then impregnated with the above mentioned two types of oil separately.

Results of 300μm fresh oil gap with 500μm paper under 20kV at 23 ℃



- The red arrow indicate the interface between oil and paper.
- The great difference between anode and cathode is mainly due to the large attenuation.
- The decrease of the cathode indicates homocharge injection occurs at the cathode.
- At the beginning, no interface peak can be observed; with the voltage application, the interface peak occurs and gradually increases.

Results of 300μm aged oil gap with 500μm paper under 20kV at 23 ℃



- The cathode peak decreases faster than fresh oil, indicating the stronger charge injection.
- For applying DC stress 25min, the interface peak grows much larger than fresh oil.

Conclusions

- The modified PEA system can successfully measure space charge accumulated at the interface between oil and impregnated paper and also in the bulk of insulation.
- The results shows that the space charge injected from the electrode and accumulated at the interface between two dielectrics.
- More charges are injected and accumulated at the interface between aged oil and impregnated paper than fresh oil and impregnated paper in 30 minutes.

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