

EXPERIMENTAL RESEARCH ON THE TRANSFORMER WINDING INTER-TURN DISCHARGE CAUSED BY CORROSIVE SULPHUR

Ming Chen^{1*}, Yangchun Cheng¹, Changjin Diao¹

¹High Voltage&EMC Beijing Area Major Laboratory, North China Electric Power University
Beijing, 102206, China

*E-mail: <chenming@ncepu.edu.cn>

Abstract: In order to study transformer winding inter-turn discharge caused by corrosive sulphur, a series of comparative tests were designed. Firstly, a series of accelerated aging tests of transformer oil were completed. All the oil samples were processed by dehydration and degasification, then divided into three groups, one group samples were added with insulation paper wrapped-copper electrodes and sulphur, while the other group samples were added with electrodes but no sulphur, then aged under 130 °C for 14, 24 and 30 days respectively. Next a number of experiments were taken to research the discharge process according to IEC standard methods. The results indicated that the partial discharge inception voltage by corrosive sulfide dropped very significantly compared with the electrodes without sulphur, and it reduced with the aging time, but the breakdown voltage variation was much smaller and during the whole developing process, the discharge capacity was increasing with the time until breakdown on the whole. At the same time, the spark and bubbles could be seen. Those results are valuable for evaluating the transformer condition order of severity corroded by corrosive sulphur and helpful to evaluating the large transformer life and monitoring the condition of large electrical power transformers.

1 INTRODUCTION

In recent years, the transformer accidents caused by corrosive sulphur have occurred several times, and caused great loss to the power grid. As the transformer is of great importance to power grid, people have paid great attention to the problem.

It is generally considered that the source of corrosive sulphur was from the transformer oil and formed Dibenzyl disulfide (DBDS), and it reacted with copper, and resulted in copper-sulfide deposition on the insulation paper, degraded the insulation paper strength and led to transformer accidents finally. [1]. The dissolved oxygen and the content of copper have played an important role in the process of generating cuprous sulfide, and cuprous sulfide resulted from Cu-DBDS, and the existence of oxygen could accelerate the cuprous sulfide deposition. [2-3] and some solutions have been suggested to reduce the corrosive sulphur [4-5]. But rare papers have reported about the characteristic of insulated paper corroded by sulphur.

In order to study this discharge phenomenon, the transformer winding inter-turn model was designed, which was called pigtail model [6]. shown in figure 1, the model consists of two coil windings, each of size is 16cm length, 0.2cm thickness, 1.4cm width. Each coil winding is divided into three portions. the straight portion is 10cm, with a bent portion extending to 3cm, and making

an angle of about 30 ° to the horizontal. and the ends were polished in advance.



Figure 1: Pigtail model

2 EXPERIMENTAL PROCEDURE

2.1 Thermal aging tests

Thermal aging tests are done with 25# Kunlun transformer oil, and each sample with 1500mL and 400mg sulphur to simulate the real environment in 130 °C. The sulphur concentration is 0.3mg/g. Before the thermal aging, the samples were pumping to vacuum under 50 Pa, 105 °C for 24 hours, and then immersed in oil for 24 hours. The aging period is for 14 days, 24 days and 30 days respectively, and take samples to do experiments regularly. The samples are shown in Figure 2 to Figure 4 after thermal tests.



Figure 2 : Aging for 30 days



Figure 3: Aging for 24 days



Figure 4: Aging for 14 days

2.2 Experiment Research

Transformer is used as the electrical source, which the capacity is 10kVA, rated voltage 120kV, and the whole system discharge is under 5pC when the voltage is 60kV, and the equivalent circuit is shown in Figure 5 and 6.

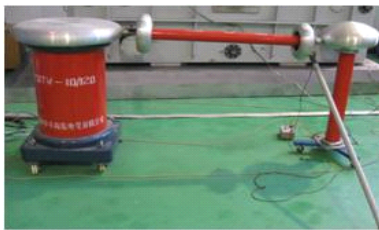


Figure 5: Transformer

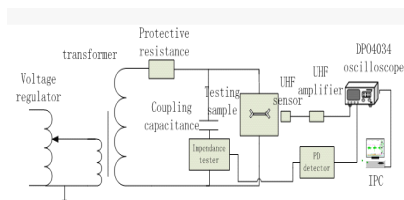


Figure 6: Equivalent circuit

3 EXPERIMENTAL RESULTS

3.1 PDIV and breakdown voltage

Firstly, two samples are selected from different periods to measure the partial discharge inception voltage (PDIV) and breakdown voltage. The results are listed in Table 1.

period	PDIV(kV)		Breakdown(kV)	
	With sulphur	No sulphur	With sulphur	No sulphur
14	25	15	41.6	43.1
24	24.5	27	45	44
30	11.2	39	48.25	46

3.2 THE DISCHARGE PROCESS

Three typical experiments were taken to demonstrate the whole process for aging 14 days, 24 days, and 30 days, and measured the average discharge magnitude, maximum discharge magnitude, pulse numbers.

3.2.1 Samples aging for 14 days with sulphur

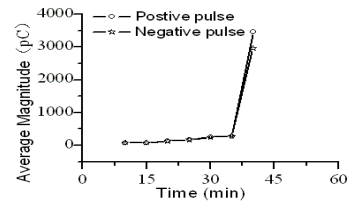


Figure 7: Average magnitude

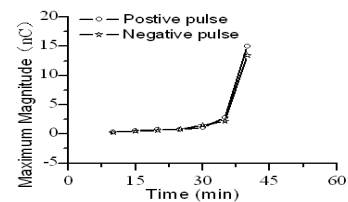


Figure 8: Maximum magnitude

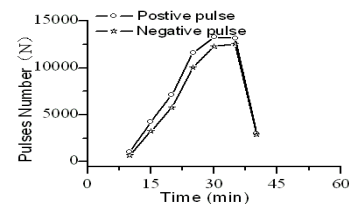


Figure 9: Pulse number

3.2.2 Samples aging for 24 days with sulphur

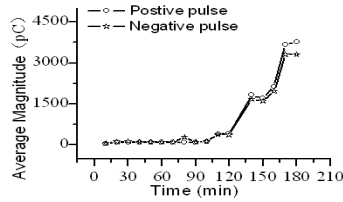


Figure 10: Average magnitude

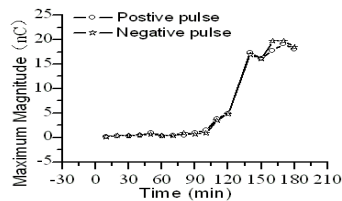


Figure 11: Maximum magnitude

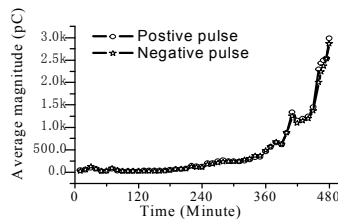


Figure 12: Pulse number

3.2.3 Samples aging for 30 days with sulphur

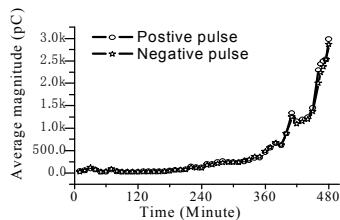


Figure 13: Average magnitude

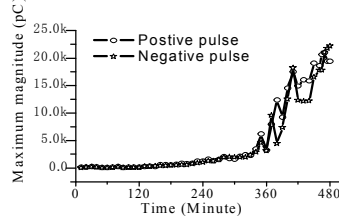


Figure14: Maximum magnitude

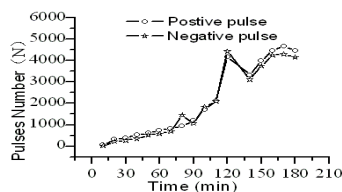


Figure 15: Pulse number

3.2.4 Samples near breakdown

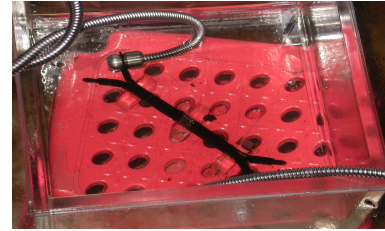


Figure 16: Aging for 30 days

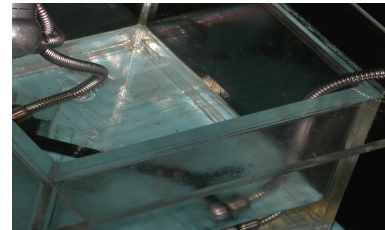


Figure 17: Aging for 24 days



Figure 18: Aging for 14 days

4 CONCLUSION

Three different aging samples have been studied, the experiments have demonstrated that corrosive sulphur has great effect on the transformer winding inter-turn insulation. Some salient features of study are:

- 1) The PDIV variations between different aging periods are obvious, and it dropped very sharply with the aging time. But the breakdown voltage variations are smaller.
- 2) The average magnitude, maximum magnitude are growing in the exponential rule, and the pulse number is growing in the early and middle stage, but reduce very sharply near breakdown.
- 3) At the early and middle stage, the discharge amplitude is stable, but at the late stage, near breakdown, discharge amplitude is growing very fast, and it can be observed spark and bubbles.

5 REFERENCES

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