An Internal Defect of Transformer Discovered by Abnormal Acetylene Content of Insulating Oil

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Abstract. In order to analyze the abnormal problem of acetylene content in a 220kV transformer, field tests and return-plant tests are carried out. Through disintegration and checking the running records, it is considered that the problem of system overvoltage and insulating cardboard are the fundamental reasons. Finally, precautions and suggestions are put forward.

1. Introduction
In January 10, 2018, a routine test of dissolved gas in transformer in a 220kV substation transformer was carried out, and the test results showed that there was 2.93 uL/L acetylene in the insulating oil. In January 11th, the acetylene in the oil was 2.90 uL/L after retesting, the result exceeds the standard value [1, 2]. The operation and maintenance personnel immediately reported to the higher authorities, where the experts decided that the transformer should be in no-load operation. The model of the transformer is SFSZ11-120000/220. The voltage ratio is 230 + 2×2.5%/69/10.5 kV. The serial number of the plant is 201407-27. This transformer was put into operation in November 2015, and the results of routine tests carried out in May 2017 showed no abnormal. The transformer operated well without any short-circuit impact and lightning impulse. In March 15, 2018, the transformer was returned to the manufacturing plant. A total of 15 tests were carried out according to the standard of transformer overhaul. After the test, the dissolved gas in the insulating oil is normal.

2. Disintegration of returning manufacturing plant
In May 28, 2018, the transformer was disintegrated in the manufacturing plant. The situations of disintegration are as follows:

2.1. Discharge of the insulating cardboard
After pulling out B phase winding in the high voltage side, it is found that the inner insulating cardboard of the high voltage winding has obvious dendritic discharge traces. In the first layer of folding screen where the high voltage winding is towards the middle voltage winding, obvious discharge traces are found on three insulating cardboard. As shown in Figure 1. ① represents the first insulating cardboard, ② represents the second insulating cardboard, ③ represents the third insulating cardboard. No abnormality is found in the rest of the insulating cardboard.
2.2. The upper part of B phase high voltage winding
The first section of the high voltage winding of the transformer is in the middle. Each winding is divided into 52 segments, and is paralleled by two electromagnetic lines from the bottom and top. The 14th-15th space and 44th-50th sections of the upper section of the B phase winding is discharged. When the insulating paper is removed from the electromagnetic line, it is found that all the 9 layers insulating paper are breakthrough. As shown in Figure 2.

2.3. Winding and the corresponding pad
Open the high voltage winding corresponding to the standard size of insulating paper in Figure 1. It is found that the second electromagnetic line on the inner side of the tenth sections from the top to down is discharged. All 9 layers of insulating paper have a through discharge and there is a distinct concave point on the surface of the electromagnetic line. As shown in Figure 3.

2.4. Other components
All bushing, voltage regulation winding, A phase and C phase winding, B phase medium and low voltage winding, on load tap changer are in good condition.
3. Analysis of discharge traces

3.1. Discharge traces on insulating cardboard

3.1.1. The situation of the first layer of insulating cardboard. There are many protrusions on the front surface of the first layer of insulating cardboard. The discharge traces are found after cutting the protrusions with the blade. Obvious dendritic discharge traces are found on the back of the first cardboard.

3.1.2. The situation of the second layer of insulating cardboard. The same discharge traces are found on the front of the second layer of insulating cardboard and the back of the first layer of insulating cardboard. Obvious dendritic discharge traces are found on the back of the second layer insulating cardboard.

3.1.3. The situation of the third layer of insulating cardboard. The same dendritic discharge traces are found on front of the third layer of insulating cardboard and on the back of the first layer and the second layer of insulating cardboard respectively. There are no discharge traces found on the back of the third layer insulating board.

3.1.4. The situation of the remaining insulating cardboard. There are not any protrusions on the surface of other insulating cardboard and no discharge traces. The discharge traces of the insulating cardboard is shown in Figure 4.
3.2. Path analysis of discharge traces

3.2.1. First. The starting point of discharge is the 19th-20th void of the second electromagnetic line on the inner side of the tenth sections of the high-pressure B phase. Creepage starts from this point and develops toward low electric potential (Low electric potential is high voltage winding end and medium voltage winding).

3.2.2. Second. The electromagnetic line at the starting point discharges the 43rd pad from the top to the bottom and the insulating cardboard at the corresponding position.

3.2.3. Third. Creepage phenomenon was found on the high voltage winding side of the first insulating cardboard.

3.2.4. Fourth. Breakdown occurs at weak points of insulating cardboard.

3.2.5. Finally. Creepage develops to the end of the high voltage winding. The whole discharge trajectory is shown in Figure 5.

![Figure 5. Schematic diagram of discharge trajectory](image)

4. Analysis of causes

4.1. Possible reasons

4.1.1. Overvoltage. It is possible that the overvoltage of the power system leads to the increase of the voltage at the head of the high voltage side of B phase, which eventually leads to the creepage of the insulating cardboard. By reading the operating records of the transformer, it is found that no lightning overvoltage or switching overvoltage has occurred since the transformer was put into operation. Therefore, the possibility of overvoltage is eliminated [3, 4].

4.1.2. Quality of insulating cardboard. The poor quality of insulation cardboard may be the fundamental reasons. When there are impurities, bubbles and moisture in the insulating cardboard, it can lead to excessive local field strength and creep. By contacting the insulating cardboard manufacturer, it is found that there are some problems in the drying process of the batch of insulating cardboard, which leads to insufficient drying degree of the cardboard and the existence of bubbles. After investigation, the same situation has occurred in other transformers.
4.2. Fundamental reason
In summary, the fundamental reasons of the internal defects of the transformer is the quality problem of the insulating cardboard.

5. Conclusion
The major work and conclusions of present paper are as follows:

5.1. Measure
The existent of acetylene in dissolved gas indicates that the discharge and high temperature overheat occur in the transformer. When it happens, it should be reported in time, and the corresponding measures should be formulated as soon as possible to avoid the defect expanding into an accident [5-7].

5.2. Tip
Up to now, high voltage test is an important mean to detect the internal defects of transformers. However high voltage test may not detect all the internal defects of transformer. With the continuous development of technology, new detection technologies will emerge constantly, which will provide important new methods for detecting transformer internal defects.

5.3. Proposal
In the future work, it is necessary to strengthen the supervision of transformer factory, and the quality control of various processes and links, in order to reduce the probability of defective transformer operation.

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