Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Analysis and Treatment of Abnormal Defects in Transformer Oil Chromatography

To cite this article: Rui Li *et al* 2022 *J. Phys.: Conf. Ser.* **2310** 012053

Analysis and Treatment of Abnormal Defects in Transformer Oil Chromatography

Rui Li[a*], Lei Zhang[b], LiangYuan Chen[c], DaJian Li[d]

Guangxi Key Laboratory of Intelligent Control and Maintenance of Power Equipment, Electric Power Research Institute of Guangxi Power Grid Co., Ltd, Nanning 530023, China

[a*]1193736858@qq.com, [b]438902132@qq.com, [c]4902874198@qq.com, [d]2907531978@qq.com

Abstract—This article analyzes the cause of an abnormal defect in the oil chromatogram of a transformer, and puts forward control measures and suggestions. It is analyzed that the cause of the abnormal oil chromatogram of phase A and B of the main transformer is the poor contact o f the dynamic and static contacts of the unloaded tap changer, high temperature and overheatin g, and the development of contact ablation, resulting in abnormal oil chromatogram. The cause of the ablation of the dynamic and static contacts of the no-load tap-changer may be due to the installation and transportation (or electrodynamic shock or U-switch design and other factors), the contacts are not in close contact, the larger contact resistan ce causes the contacts to overheat, and high temperature conditions Sulfur corrosion occurs on the surface of the lower contact, and the corrosion product gradually deposits on the surface of the contact, which further aggravates the poor contact. Although passivation agent is added in t he later period, the protection effect of the passivation agent at high temperature is limited, and it can no longer protect the contact. Under the action of current, the dynamic and static contacts that cause poor contact are gradually ablated.

1. Introduction

With the rapid development of my country's economic construction and the gradual improvement of people's lives, the safety and reliability of power grid operation are getting higher and higher. As the core equipment of the power grid, the operation state of the power transformer will directly affect the stable operation of the power grid. Oil-paper composite insulation is a commonly used insulation structure for large transformers, mainly composed of insulating oil, insulating cardboard and other solid insulating materials. Oil-paper insulation is designed to meet the requirements of relevant electrical strength and mechanical properties, but during production, transportation, storage, installation and operation, some accidental factors may cause defects in the re-insulation system, which may further develop into equipment failures. Oil chromatography analysis will help to grasp its insulation state and provide strong support for the formulation of maintenance and operation strategies.

2. Main transformer oil chromatography

2.1 Offline Oil Chromatography of Phase A Main Transformer

The long-term discovery of offline oil chromatography data shows that the total hydrocarbon content of the main transformation of phase A exceeded the attention value in December 2019, and the data has been relatively stable since February 2020. It is inferred that there is a high temperature and overheating fault inside, and the nature of the fault has not changed; The total variable hydrocarbon content exceeded the attention value in May 2020, and the overall trend was increasing, and there was a high temperature and overheating fault inside; no abnormality was found in the C-phase main transformation. The specific analysis is as follows:

(1) A-phase situation

1)Detection data: The detection data of the main transformer phase A off-line oil chromatography found that the total hydrocarbon content in the oil remained at a low level before 2013, and there was a relatively obvious increase from 2013 to 2016 (the equipment was replaced in September 2016 The capsule was replaced and oil filter maintenance); in March 2019, trace amounts of acetylene (less than 0.1 μL/L) were detected in phase A oil for the first time. On December 19, 2019, the offline test results showed a sudden change, and the acetylene content had reached 0.8 μL/L. L, close to the attention value, the total hydrocarbon content is 245 μL/L, which has exceeded the attention value (the attention value is 150 μL/L)). After that, by controlling the load, the total hydrocarbon and acetylene content remained stable without abnormal increase.

2)Gas production rate: The absolute gas production rates of total hydrocarbons, hydrogen, and acetylene in the period from September to December in 2019 all exceeded the noted values. Entering 2020, except for the period from March to April and from May to June Except for the carbon dioxide production rate exceeding the standard, the absolute gas production rate of dissolved gas in other oils is lower than the attention value. Recently, the overall stability of the A-phase main transformation data is stable, and there is no growth trend. The carbon dioxide content was detected at 2817.46 μL/L on July 27.

(2) B-phase situation

1) Detection data: The detection data of the main transformer phase B off-line oil chromatography found that the total hydrocarbon content in the oil remained at a low level before December 2019, and the total hydrocarbon content detected a sudden increase on December 19, 2019 67.55μL/L increased to 110.9μL/L, followed by an increase, and the total hydrocarbon content reached 199.45μL/L on June 30, 2020. In December 2018, trace amounts of acetylene were detected in phase B oil for the first time. From December 19, 2019 to March 25, 2020, the acetylene content fluctuated in the range of 0.2-0.3 μL/L, and then increased. Detection (July 27, 2020) acetylene content was 0.64 μL/L, and total hydrocarbons were 193.82 μL/L.

2) Gas production rate: From September to December 2019, the gas production rate of total hydrocarbons exceeded the standard, and the absolute gas production rates of other gas components were all lower than the noted values. From February to June 2020, its total hydrocarbons and acetylene showed an increasing trend, the gas production rate exceeded the attention value, and the failures tended to aggravate.

(3) C-phase situation The total hydrocarbons, hydrogen content and absolute gas production rate of phase C were all low, and no acetylene was detected. Based on the above analysis, the oil chromatography data of the main transformer phase A has changed abruptly since December 2019, the total hydrocarbons exceeded the standard, and the total hydrocarbon and acetylene contents remained stable until July 2020. The possibility of solid insulation is small; the main transformation of phase B has changed since the sudden change of oil chromatography data in December 2019. Until March 2020, total hydrocarbons and acetylene were relatively stable. Hydrocarbons and acetylenes showed an overall increasing trend. The faults were high-temperature overheating faults, and the possibility of the faults involving solid insulation was small. No abnormality was found in the main transformation of C-phase.

2.2 Offline Oil Chromatography of Phase A Main Transformer

The total hydrocarbon content of the main transformation phase A main transformation online monitoring data exceeds the attention value and contains acetylene, and the recent data has remained stable with no obvious growth trend. The total hydrocarbons in the online monitoring data of the main transformation of phase B showed a continuous growth trend. The phases A and B had abrupt changes since November 2019, and the online monitoring data of the main transformation of phase C showed no abnormality. The change trend of online monitoring data is more consistent with the change of offline data.

3. Main transformer maintenance

3.1 Offline Oil Chromatography of Phase A Main Transformer

(1) No-load test situation

Tab.1 No-load test result of No. 1 main transformer

different	excitation voltage (kV)	no-load current(A)	load loss(kW)	No-load loss nameplate value(kW)	deviation
A	36.27	2.9265	53.91	53.96	-0.09%
B	36.13	2.9978	55.53	53.96	2.91%
C	36.0	3.0744	54.63	53.96	1.24%

In order to verify whether the A and B-phase faults involve the iron core, the no-load test was carried out on the three-phase main transformer before the maintenance. From the analysis of the test results, the deviation between the no-load loss of the three-phase main transformer and the nameplate value is small, which meets the requirements of the regulations, and there is no obvious difference between the three phases. It is inferred that the fault location is less likely to involve the iron core.

（2）Other test situations

DC resistance, insulation resistance, winding dielectric loss, transformation ratio, winding deformation, low voltage impedance, etc. were carried out as required. The situation is as follows:

1) The unbalance rate of the three-phase DC resistance of the low-voltage side winding is 4.67%, which exceeds the specified attention value (2%).

2) No abnormality was found in other test results.

3.2 Maintenance situation

According to the maintenance plan, the main transformer was inspected internally and the GOE casing was replaced. No obvious abnormality was found in the visible parts of the main transformer body, lead wires, iron core clamps, the lower wiring of the GOE casing, and the fuel tank. The main problems found and their solutions are as follows:

(1) Sludge-like black deposits are found under the no-load pressure regulating tap-changer at the bottom of the main fuel tank of A and B phases, and the shape and distribution are highly similar; no black deposits are found at the bottom of the main fuel tank of phase C.

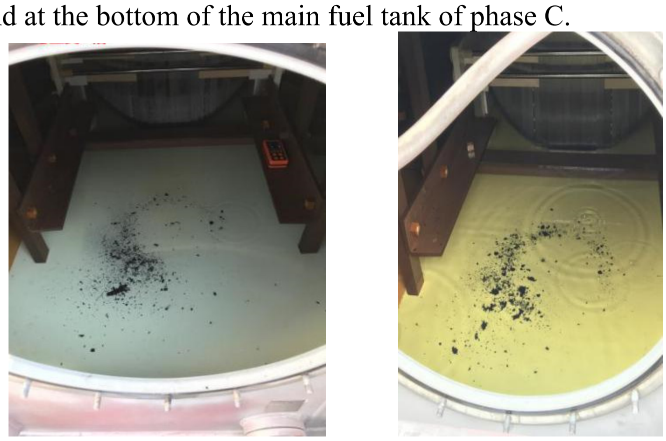

Figure 1 The bottom of the main transformer A and B phase oil tank

(2) There are various degrees of ablation on the moving contacts and the first-grade static contacts of the A and B-phase no-load tap-changer, and the effective conductive contact area is seriously insufficient compared with the normal equipment, and the static contacts at other positions have no obvious abnormality. (The main transformer has been running in the 1st gear for a long time); There is no obvious abnormality in the dynamic and static contacts of the C-phase no-load voltage regulating tap-changer, and there is no bolt loosening in the tap-changer contacts.

Figure 2 Main transformer A and B phase no-load tap changer dynamic and static contacts

Processing of the A-phase and B-phase no-load tap-changer: replace the moving contact of the main transformer A-phase and B-phase no-load tap-changer on site, and replace the 5th-grade static contact of the no-load pressure regulating switch to the 1st gear (running After replacing the dynamic and static contacts, carry out DC resistance and contact resistance tests, and the test data meet the requirements of the regulations; use qualified transformer oil to rinse and clean the contact parts of the No. 1 main transformer no-load switch and the tank wall, etc. respectively. The overhaul of the main transformer and the replacement of the GOE casing have been completed and put into operation on August 15, and it has been running normally since it was put into operation.

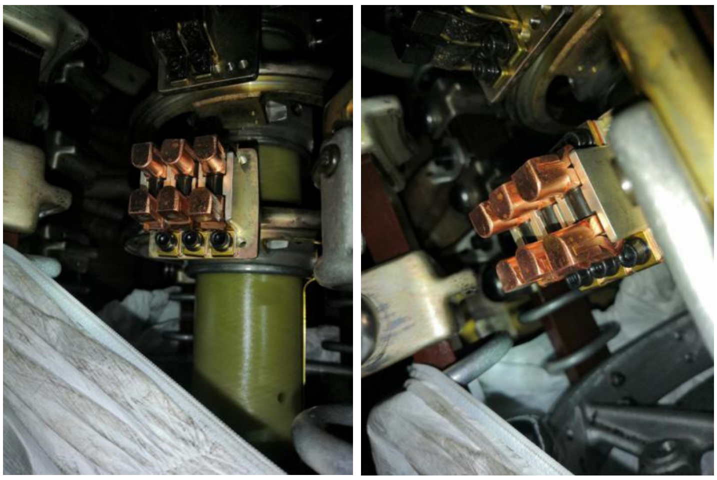

Figure 3 The dynamic and static contacts of the no-load tap-changer after replacement

4. Conclusion

From the above analysis, it can be seen that:

(1) Analysis of main transformer oil chromatographic tracking detection data, A and B phase faults are high temperature overheating faults, and the possibility of the fault location involving solid insulation is small; C phase main transformer has no abnormality.

(2) In November 2019, the main transformer was overloaded, and then the oil chromatograms of phase A and B main transformers were abnormal, and the oil chromatographic data of phase B showed a positive correlation with the load, indicating that the fault location may be related to the conductive circuit.

(3) Corrosive sulfur is contained in the main transformer oil of phase A and B, and no corrosive sulfur is detected in the equipment oil of phase C. In 2010, metal passivators were added to phases A and B. The addition of passivators could not cause the reverse reaction of the formed corrosion products, and the protective effect of metal passivators on metals such as copper and silver increased with the increase of temperature. Gradually decrease, it is inferred that there may be corrosion products on the surface of the moving and static contacts before adding the passivating agent.

(4) The induction withstand voltage and partial discharge tests before and after the overhaul show that there is no abnormality in the insulation between the turns of the A and B phase windings.

(5) There is no abnormality in the no-load test of the three-phase main transformer before the maintenance, indicating that the fault location is less likely to involve the iron core.

(6) There are various degrees of ablation on the moving contacts and the 1st gear static contacts of the A and B-phase no-load tap-changer, and there is no obvious abnormality in the other gears (the equipment has been running in the 1st gear for a long time).

(7) It is also understood that the tap changer found with ablation defects during the power outage maintenance of a main transformer is also a U-shaped tap changer produced by a company (the same model as the main transformer), and the reason for the switch defect is inferred to be insufficient mechanical strength. The installation and tightening are not in place. Based on the above facts, it is believed that the reason for the abnormal oil chromatogram of the main transformer A and B phases is that the dynamic and static contacts of the no-load tap-changer have poor contact and high temperature overheating, which developed into contact ablation, resulting in abnormal oil chromatogram. The reason for the ablation of the dynamic and static contacts of the no-load tap-changer may be that the contacts are not in close contact due to installation and transportation (or factors such as electric power shock or U-type switch design), and the large contact resistance causes the contacts to overheat and high temperature conditions. Sulfur corrosion occurs on the surface of the lower contact, and the corrosion products are gradually deposited on the surface of the contact, which further aggravates the poor contact. Although passivation agents are added later, the protective effect of the passivation agent at high temperature is limited and cannot protect the contacts. Under the action of the current, the dynamic and static contacts with poor contact are gradually ablated.

Acknowledgments
Thanks to the project for the research and application of overload capacity evaluation technology of 110kV and above power transformers (Project 1 and Project 2)

References

[1] Wu Guoqiang, Yao Jianfeng, Guan Minyuan, Zhu Xuesong, Wu Kai, Li Haoyan, Song Shanshan. Power Transformer Fault Diagnosis Based on DBSCAN [J]. Journal of Wuhan University (Engineering Edition), 2021, 54(12): 1172-1179.
[2] Ma Xiaojuan, Wang Haitao, Liu Ying. Comparison of anomaly analysis of offline and online chromatographic data[J]. Electric World, 2021, 62(12): 7-12.
[3] Yang Xiang, Zong Hegang, Cai Hongmeng. Application of oil chromatography in transformer oil quality supervision [J]. Yunnan Hydropower, 2021, 37(11): 194-196.
[4] Tong Fuxiang. Fault analysis of rectifier transformer based on gas chromatographic analysis in oil[J]. Shanxi Metallurgy, 2021,44(05):221-222+279.
[5] Du Xiuming, Xie Jia, Wu Jie, Ding Guocheng, Yan Song, Wu Xingwang. Analysis and troubles

hooting of a 500kV transformer oil chromatogram abnormality caused by a field installation defect[J]. Transformer, 2021, 58(10): 70-72 .
[6] Li Lin, Liao Wenlong, Deng Yong. Analysis of a 110kV main transformer bushing caused by d amp failure[J]. Sichuan Electric Power Technology, 2021, 44(05): 91-94..
[7] Zheng Weiqin, He Shenghong, Xu Pengjiang, Jin Xiangchao, Zhang Yong, Zhong Wei. Cause a nalysis and treatment of a 220kV main transformer light gas protection action [J]. Electrical Engineering, 2021(10): 35-38+43.
[8] Xu Shan, Zhang Zihan, Yang Shuai, Zuo Wenzhi. 35 kV transformer fault gas chromatography analysis [J]. Electrical Engineering Technology, 2021(18): 112-113+115.
[9] Geng Shan. Analysis of laboratory technology for power transformer oil [J]. Modern Industrial Economy and Information Technology, 2021, 11(08): 179-180+183.