Typical fault analysis and preventive measures of 110kV XLPE cable fully prefabricated dry terminal

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Abstract. With XLPE cables are widely put into operation in the city underground power system, it is more and more important of the stability of 110kV cable lines. The prefabricated dry terminal due to lack of firmly fixed and other shortcomings, Cable breakdown faults are easy. In recent years, several terminal breakdown prefabricated dry cable typical case in shandong power network, a comprehensive analysis of the breakdown faults reason, combined with the operation experience, put forward the new 110kV cable line prefabricated dry terminal platform installed in the transport line, the new 110kV cable line prefabricated dry terminal comprehensive inspection, strengthen the infrared temperature measurement of charged detection, transformation timely preventive measures. Through the development of 110kV cable line full prefabricated dry terminal breakdown prevention measures, it can effectively reduce the probability of the faults and improve the reliability of high voltage cable line operation.

1. Introduction

In recent years, due to the sustained and rapid development of China's economy, the power supply is very tight, triggering a new round of power investment construction climax. With the rapid expansion of power grid scale and the continuous improvement of voltage level, the security problem of power operation is becoming increasingly prominent. In particular, XLPE cables are widely used in urban underground power grids, resulting in new security issues.

Prefabricated dry cable terminal is a contraction of prefabricated cable terminal, has the advantages of reliable operation, convenient installation and maintenance, construction design, the uniform electric field of dielectric loss factor is small, suitable for a variety of advantages such as operating environment, ideal for high voltage XLPE cable accessory, widely used. In recent years, the city of overhead line cable floor renovation project gradually increased, the cable rate continues to increase, along with a significant increase in the number of terminals of flexible cable, as of the end of June 2019, the 110 kV high voltage cable flexible terminal were used more than 1300 groups in Shandong power grid. With the gradual extension of the running time, exposed some problems of high voltage cable terminal flexible design selection and installation process, resulting in continuous flexible cable terminal occurred on the single-phase breakdown, affecting the security and stability of power grid operation[1-6].

This paper introduces the characteristics of 110kV cable lines in common terminal, through the 110kV XLPE high voltage cable prefabricated dry terminal insulation breakdown of typical cases, the breakdown faults reasons are analyzed, and combining with the production operation experience, put
forward to prevent 110kV prefabricated dry terminal breakdown measures, so as to guarantee the safe operation of power grid power cable and improve the reliability of power supply, to reduce economic losses caused by cable fault has laid a good foundation.

2. Overview of 110kV high voltage cable terminal
At present, there are 110 kV cable outdoor terminal, porcelain composite bushing type outdoor terminal and prefabricated dry outdoor terminal, porcelain type cable terminal due to the failure of nearby equipment and personnel easily cause serious danger, its consumption is less and less, the more applications for the composite sleeve type composite terminal and prefabricated dry outdoor terminal, its characteristics and differences are as follows. As shown in figure 1 and figure 2.

2.1. Composite sleeve type outdoor terminal
The advantages of composite sleeve type outdoor terminal are:
(1) It has all the advantages of porcelain bushing terminal, but its outer insulation is changed from porcelain bushing to composite bushing;
(2) Silicone rubber insulation rain skirt composite bushing by a epoxy glass fiber tube outer covering weather resistance, has excellent mechanical properties, can avoid the damage to the surrounding equipment when the explosion occurred, with excellent explosion-proof performance;
(3) The silicone rubber umbrella skirt has excellent stain resistance, UV resistance and good anti-aging properties. In addition, due to the good hydrophobicity of silicone rubber, even if the surface pollution is very serious, it is difficult to cause pollution flashover.

The Disadvantages of composite sleeve type outdoor terminal are: heavy weight, installation cumbersome.

2.2. Fully prefabricated dry outdoor terminal
The advantages of fully prefabricated dry outdoor terminal are:
1) Dry outdoor terminal imported silicone rubber material quality, in the overall molding factory, improve the cable shielding electric field distribution of the cutting place, compared with the composite casing type outdoor terminal structure is greatly simplified, the weight of the product is only 30% sleeve type terminal;
2) The installation is very convenient, and the installation position is flexible;
3) It is a fully flexible dry structure, without any insulation agent, to prevent the oil leakage phenomenon, and has good explosion-proof performance.
The disadvantages of fully prefabricated dry outdoor terminal are: flexible dry outdoor terminal self-sustaining force is insufficient, easy to bend after operation, need to support.

3. Typical fault cases of fully prefabricated dry terminal
The prefabricated dry terminal is widely used in Shandong power network because of its advantages of simple installation and short power interruption time. The dry end of prefabricated dry terminal has insufficient self-sustaining force. If it is not fixed firmly, it will easily swing with the wind, bend, cause the stress cone position displacement, and then lead to the terminal insulation breakdown. In 2008 and 2009, a single phase breakdown fault occurred in four 110KV cable lines of a company. In 2014 -2019 years, 110 kV prefabricated dry terminal caused by insulation failure caused by a fixed failure occurred 8 times in Shandong power network. The typical cases are as follows:

3.1. Case 1
2014 in November 110kV, a cable trip, inspection found that the cable terminal head has obvious burn traces. The scene picture of the fault cable terminal is shown in figure 3.

![Figure 3. Field diagram of flexible terminal fault.](image)

The fault cable terminal is dissected, and it is found that the punch hole is located below the terminal stress cone, and the insulation shield is peeled and cut off. The insulation shield is not neatly cut, the surface is uneven and the treatment is uneven.

3.2. Case 2
2014 November, A 110kV cable failure, cable terminal stress cone at the bottom has obvious burn marks. The scene picture of the fault cable terminal is shown in figure 4. The fault cable terminal and the cable connection crack, the cable has an area of about 12 square centimeter round punch hole, can see the cable copper core line.

![Figure 4. Field diagram of flexible terminal fault.](image)

As shown in figure 5, the fault cable terminal is dissected, and it is found that the punch hole is located below the terminal stress cone, and the insulation shield is peeled and cut off. The insulation shield is not neatly cut and cut.
3.3. Case 3  
2016 in May, a 110kV cable fault, cable terminal insulation breakdown, terminal insulator surface ablation serious, about 10 cm² of the hole. The scene picture of the fault cable terminal is shown in figure 6.

Figure 6. Field diagram of flexible terminal fault.

Fault cable terminal were dissected, found ground welding position has a breakdown point of the same size, found a peeling process, the main insulation layer of semi conductive cutting is smooth, no prominent sharp angle, the breakdown point in stress cone position, melt cave 2cm² in this position, the main insulation breakdown channel stress cone on the lower and the grounding wire welding point between.

3.4. Case 4  
December 2016, A 110kV cable fault, inspection found in the #2 tower A phase cable terminal stress cone at the bottom of the obvious signs of burns. The punch hole is located below the terminal stress cone. The scene picture of the fault cable terminal is shown in figure 7.

Figure 7. Field diagram of flexible terminal fault.

All of the above cases are caused by the failure of the fixed end of the prefabricated dry end, resulting in the displacement of the stress cone position. The key requirements for the reliable operation of cable accessories in electric power lines include three aspects: reasonable product design, correct installation process and reasonable distribution of thermal force electric field after installation. But because of different cables and accessories manufacturers, so the performance of different material parameters, different properties of the cable and accessories with attachment reliability can be unpredictable, it is one of the reasons causing frequent fault of cable accessories.
4. Cause analysis and preventive measures of fully prefabricated dry terminal fault

This section presents an adaptive-correction based weight system for the CEIS in order to meet the needs of different application objects and application phase of smart distribution grid evaluation.

4.1. Cause analysis of breakdown of fully prefabricated dry terminal

The prefabricated dry terminal typical fault cases of 110kV cable line analysis, fault time, has put into operation a year about the breakdown of terminal also has longer operation time breakdown, and relative to other types of terminal breakdown probability larger. Through the analysis of the breakdown of the whole prefabricated dry terminal in Shandong power network, the breakdown faults reason is as follows:

1) Cable terminal hoisting is not standard. At present, the production and installation of complete under the tower of precast prefabricated dry terminal, the terminal tower is high, up to 20 meters, not effectively fixed cable main insulation for the hoisting process, will be affected by the self weight effect caused by falling down, the body and the relative displacement of aluminum sheathed cables, and flexible cable terminal and cable aluminum sheath with accessories more closely (as one), cable main insulation and sheath aluminum relative displacement, also in conjunction with the set of flexible terminal accessories in the cable main insulation on the displacement, which is the main cause of stress shielding and accessory cone lap detachment cable main insulation, electric stress can’t be effectively evacuated, operation for a period of time later, it may cause the fracture of cable insulation breakdown fault.

2) Terminal is not reliably fixed. Due to the structural characteristics of prefabricated dry terminal determines the holding force is insufficient, the terminal breakdown, were used to install the platform, and not the reliable fixed, if the fixed is not solid, easy to run after the swaying in the wind, bending, causing stress cone displacement, causing the breakdown of insulation terminal.

3) The voltage withstand test of cable transmission line is not strict. The test code for the transfer of cable line shall be stipulated that the handover test shall be carried out after the installation of the cable line, but when the withstand voltage test is actually carried out, the pressure test shall be carried out after the whole precast dry terminal is installed under the tower. The stress cone displacement caused by the non-standard hoisting process can’t be tested through the withstand voltage test, which leads to the blind spot of the voltage withstand test, and may cause the terminal breakdown failure after the operation of the cable.

4.2. Preventive measures for breakdown of fully prefabricated dry terminal

In order to improve the reliability of the cable line and prevent the breakdown of all prefabricated dry terminals, the following preventive measures are put forward for the reason of the breakdown of the whole prefabricated dry terminal. The typical design of flexible cable terminal is shown in figure 8.

1) All prefabricated dry terminals of new cable lines shall be installed with installation platform. In view of the high installation position of the current 110 kV fully precast dry terminal, the new 110 kV cable line, using the prefabricated dry outdoor terminal, the installation platform is recommended, the platform height is 9 - 11 meters from the ground, and the cable terminal is reliable and fixed. The cable connection test shall be conducted after the hoisting of the cable terminal, and the installation and fabrication of the cable terminal shall be carried out on the platform when the conditions are satisfied.

2) In the transmission cable line, according to the profile characteristics of the flexible cable terminal, the special mould is used to improve the flexible terminal, by checking the distance between the fracture surface of the cable insulation shielding layer and the collecting ring, indirectly judging whether the stress cone and insulation shielding layer are overlapped effectively under normal conditions, so as to prevent the recurrence of such failure. The prefabricated dry terminal which is not reliably fixed is adopted to make it firmly fixed, and the live detection means such as infrared temperature measurement are used to strengthen the monitoring, and it is reformed if necessary.
5. Conclusions

The 110kV prefabricated dry cable terminal has the advantages of simple structure, installation of production process and the outage time is short, but the actual operation is self-sustaining power is insufficient, fix the unstable, if the installation is not standardized breakdown occurred easily. Based on the analysis of typical cases, determine the breakdown reason, according to the practical production and operation experience, put forward the new cable line prefabricated dry terminal installation using platform of cable line in prefabricated dry terminal comprehensive inspection, reliable fixation, strengthen the infrared temperature measurement means for measuring the charged state of the effective evaluation measures through these measures, can effectively reduce the failure probability of 110kV prefabricated dry terminal, improve the operation reliability of cable line. The next step, according to the characteristics of the diversified operation of the fully dry terminal of the cable line in the operation, make specific measures to improve the operational reliability of the cable line.

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