Research on a new type of 10kV cable connector

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ABSTRACT

10kV cable joints often cause cable failures during operation due to cable breakage, limitations of traditional connection methods, quality problems at construction site, etc.Which often lead to potential safety hazards, power outages for users, threats to the stable operation of the power grid, serious economic losses and other negative effects. This paper presents a design scheme of plug-in intermediate joint. The prefabricated intermediate joint designed in this scheme is simple in structure, convenient to carry, easy to operate and relatively easy to install, which reduces the operating difficulty of the construction personnel, and can improve the reliability of the intermediate joint to a certain extent. In this paper, a new type of 10kV prefabricated intermediate joint is designed. Two cables are inserted into the intermediate joint part and the plug-in part of the device respectively. The two cables are connected and connected through the copper tube guide inside the intermediate joint part, and then the intermediate joint part and the plug-in part are fixed. This scheme accelerates the recovery speed, saves manpower, shortens the operation time, greatly improves the work efficiency, greatly reduces the failure rate, and creates good conditions for the safe and stable operation of the medium and low voltage power grid.

Keywords: Prefabricated; Plug-in intermediate connector; Power cable; Intermediate joint

1. INTRODUCTION

With the continuous progress of urbanization, the development of the national economy and people's yearning for high-quality life have increased demand for electricity. The power supply lines in cities are more cable lines, especially 10kV power cables, which have the advantages of light weight, simple construction and operation, and high operation reliability. Therefore, they are widely used in 10kV distribution network, and have achieved good operation and economic effects[1-2]. 10kV cables are often produced and manufactured by manufacturers, while cable intermediate joints are usually made during on-site construction, which is a great test for the skills of operators. Problems such as inadequate installation, poor waterproof, and high air tightness may cause the intermediate joint failure, leading to the breakdown of the cable system[3-4]. Therefore, the quality of the intermediate joint directly affects the safe and stable operation of the power system and people's electricity experience.

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Generally, the cable intermediate joint needs to be made by construction personnel on site.The traditional intermediate joint can be divided into heat-shrinkable joint, cold-shrinkable joint, wraparound joint, fusion joint, etc.The construction of heat-shrinkable joint process requires large operating space, and requires additional heating equipment to heat, and requires welding. The operation process is complicated and the construction is slow. The installation temperature is different from the actual operating temperature, so cracks appear and the failure rate cannot be effectively controlled[3].As to the cold-shrinkable intermediate ,Installation process without heating welding will save time, labor and space, and the effect is more beautiful [5]. However, in the process of cable crimping, the connection is not close enough, which is easy to cause air contact and heat, thus threatening the safe operation of the cable.In addition, the mechanical properties are difficult to be guaranteed [6]; Wrapped intermediate joint recovers the structure and function of the cable through tape wrapping process. The self-adhesion and self-fusion also make the tape and cable, and tape and tape quickly integrate, which reduce the risk of partial discharge and water and moisture, and ensure the long-term reliable operation of the cable. However, its disadvantages of long construction period and high professional level of operators are difficult to make up [7-8]; Fusion type intermediate joint The intermediate joint in the fusion mode does not need a crimping tool to eliminate the hidden danger that the conductor connection is not tight and the contact resistance is high due to the mismatch of the crimping die; However, welding crack is a disadvantage that can not be ignored. Welding crack is a gap generated by forming a new interface under the joint action of welding stress and other adverse factors. There is also lack of penetration, which is the phenomenon that the root of the joint is not fully penetrated during welding, resulting in poor air tightness. Moreover, due to the high cost of on-site construction and maintenance, as well as the defects of long construction time and difficult installation, fusion welding technology has not been widely used in 10kV power grid.

Based on this, existing scholars have developed some new prefabricated intermediate joints that can solve such problems. However, such joints have more or less limitations in various aspects, such as difficult maintenance, air tightness and thermal insulation can not be effectively guaranteed, and the device is not economical and simple enough. Therefore, it is necessary to further study its fixing effect.

2. FAULT CAUSE ANALYSIS

As mentioned in the introduction, 10kV cable has gradually become the only choice for urban power supply due to its own advantages. However, 10kV cable is easy to break and there are many limitations in the traditional cable connection mode, which cannot provide a safe and reliable environment for the operation of the power grid [9-11]. Combined with the existing research and the actual situation, this paper analyzes the construction operation, connection mode and environmental impact through the fish-bone diagram, and summarizes the high failure rate caused by rush repair, high maintenance cost, difficult and time-consuming installation, insufficient mechanical strength, poor air tightness and other important reasons, which hinder the normal operation of the power grid. As shown in Figure 1.

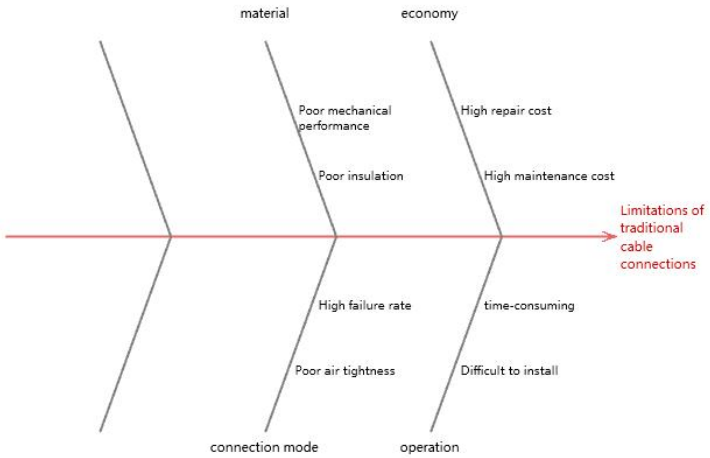

Figure 1. Fish-bone diagram

Then through the causal matrix method to further analyze the above reasons, the economy, physical resistance, installation difficulty, installation air tightness of the four main reasons. Based on the analyzed problems, we can further understand the actual needs, design the intermediate joint more accurately, and better solve the problem, this paper aims to solve the cable connection problem, While reducing the failure rate and intermediate joint failure rate, it brings convenience to production and installation, and can further improve the economic effect. providing a strong guarantee for the safe operation of medium and low voltage distribution network and the quality of people's electricity.

3. STRUCTURAL DESIGN OF CABLE INTERMEDIATE JOINT

This paper is committed to look for effective ways to solve problems based on the above reasons.In line with the principle of trying our best to solve the existing problems, combined with the analysis of the causes of the existing problems, this paper is devoted to the design of a simple and economical structure, high mechanical strength, low installation difficulty, good air tightness 10kv prefabricated intermediate joint, try our best to solve the existing problems, and provide a new idea for the further development of the safe and stable operation of the low-voltage power grid. Based on existing research and practical needs, the design of the intermediate connector is inspired by the process of inserting a plug into a socket, and the installation process is similar to that of inserting a plug into a socket. The device design is shown in Figure 2.Through investigation, we found that this connection method is simple and effective, so we decided to improve this connection method and use it as a new intermediate joint to repair the cable and turn on the connection.

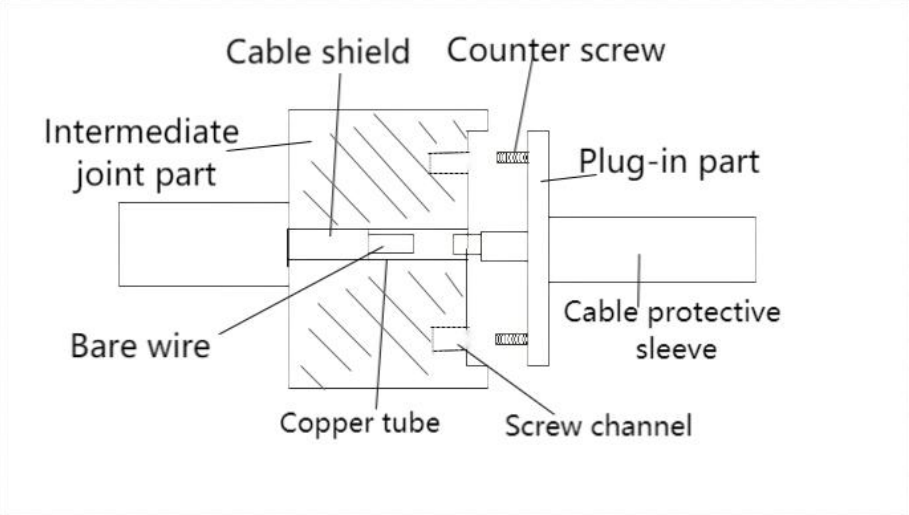

Figure 2. Intermediate joint structure

This paper designs a 10kV cable intermediate connector with plug structure. The cable intermediate connector is divided into two parts, one is the intermediate connector part and the other is the plug-in part. The inner part of the intermediate joint is guided by the copper tube, so that the two cables can be connected smoothly. The intermediate joint is equipped with a special counter screw, which can make the connection between the two parts of the device tight and not loose together with the screw channel inside the intermediate joint. In addition, the right connector part and the left intermediate connector part form a mortise and tenon structure, which can completely embed the plug-in part into the intermediate connector part. This structure can further strengthen the tightness of the two parts, making the two parts more compatible, with better air tightness and water resistance, and simple and convenient operation. The external material of the plug-in intermediate joint uses the thermal insulation explosion-proof shell, which realizes the mechanical protection of the device, increases the physical resistance of the device, and makes the internal structure of the joint completely isolated from the outside to play a protective role, reduces the contact resistance of the wire, and prevents the occurrence of faults. The interior of the left intermediate joint is filled with polymer insulation to ensure the insulation of the device, and carbon black powder is coated around the copper tube to ensure the conductivity of the wire.

Based on existing research and practical needs, theoretically speaking， The utility model has the advantages of low

installation and maintenance costs; High mechanical performance, strong moisture-proof, explosion-proof and thermal insulation capacity; The conductor is tightly and fully connected, the device is firm, and the air tightness is excellent; Intermediate joint with few accessories, low cost, low installation difficulty, short time consumption and easy operation. So as to improve the overall work efficiency, reduce the cable failure rate, save the economy, and ensure the normal operation of the power grid, and further improve the power quality of users.

The 3d diagram of the intermediate joint is shown in Figure 3.The connection mode of the device is simple, which greatly facilitates the operation of the construction personnel, improves the work efficiency, and also ensures the operation safety of the staff, avoids the tedious and laborious operation, and reduces the safety hazards and economic losses caused by the operation problems or connection mode problems.It generally meets the requirements of grid operation and can meet the display needs.

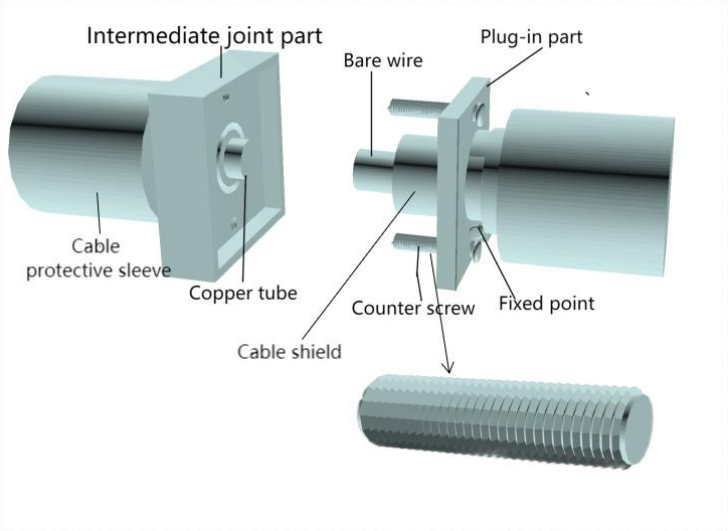

Figure 3. 3d drawing of intermediate joint

4. INSTALLATION OF CABLE INTERMEDIATE JOINT

The power cable intermediate connector device makes the connection of the cables at both ends through the connection of the two parts, and its installation effect is similar to inserting the plug into the socket hole. The length of the fixed copper tube shall be designed in advance, the cable protective sleeves of corresponding length shall be cut off at both ends of the cable, and the two parts of the cable intermediate joint shall be inserted respectively until the cables at both ends are tightly connected in the copper tube and the wires at both ends are tightly against each other, and then the fixing screws at the fixing point shall be tightened to make the intermediate joint and the cable tightly fixed. At the same time, the two anti-thorn screws have interacted with the screw channel to achieve the fixation of the two parts of the cable intermediate joint. The counter screw is a special product. Compared with the oblique pattern of the ordinary screw, the stripes of the screw are a group of parallel reverse transverse patterns. With the corresponding positive screw stripes channel, the screw and the channel can be closely connected and embedded together, so that the two parts of the device will not be loose, so as to prevent the intermediate joint from falling off and disassembling and causing failure. The process is simple and convenient without the help of tools. Based on the connection structure of the plug inserted into the socket hole, the plug-in part and the intermediate joint part are designed as a mortise and tenon structure, so that when the two parts are installed, the plug-in part can be embedded into the intermediate joint part, which can not only further guarantee the connection tightness of the two parts of the device, but also improve the air tightness and moisture resistance of the device, strengthen the protection of the internal structure, and reduce the failure rate. The whole installation process and installation effect solve the problems analyzed above and meet the requirements of power operation， It ensures the normal operation of power cables and improves the stability of power grid operation. The installation effect of power cable intermediate joint is shown in Figure 4.

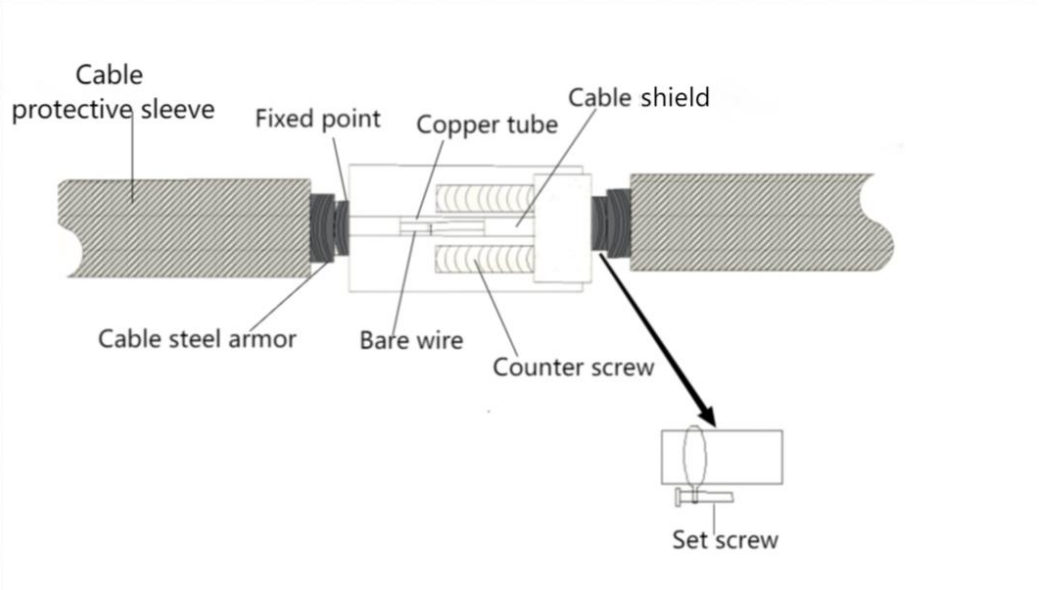

Figure 4. Installation status of intermediate joint

5. OPTIMIZATION AND IMPROVEMENT OF INTERMEDIATE JOINT

The fixing method at the fixing point of the device is single and There is a possibility of air leakage. Only one screw is used to fix the device and cable, which may loosen and cause problems such as separation of connector and cable, air tightness, conductivity, etc. In this paper, hollow screw is used to fix the device and cable. The inner wall of the wire inlet at both ends of the intermediate joint is designed with screw pattern, and then the hollow screw is installed at the wire inlet. At this time, the wire passes through the hollow screw and then enters the intermediate joint. When the wires at both ends are tightly connected, tighten the hollow screws. The squeeze force generated when the screw is tightened is used to realize the fixation of the device and the cable. At the same time, the air tightness of the device is further guaranteed, providing a strong guarantee for the stable transmission of electric energy. In practical application, strong waterproof tape can also be used here for winding and bonding, which can further increase the firmness and air-tightness of the connection between the device and the cable, strengthen the conductivity, reduce the contact resistance, reduce the heating, and reduce the occurrence rate of cable intermediate joint failure.It further reduces the risk of failure, ensures the safe and stable transmission of electric energy, can better solve the existing problems and provides a new way for reference.

6. CONCLUSION

Based on realistic conditions and discussion, the conclusions are obtained as below:

(1) In view of the fact that there are many parts and components of the power cable intermediate joint and the operation is cumbersome, this paper proposes a design scheme based on the optimization of prefabricated cable accessories. The plug-in cable intermediate joint connection mode is adopted, and the two cables can be directly inserted during installation. The components are simplified, reducing the production pressure, economical and practical, without installation tools, reducing the process requirements for operators, and improving the installation efficiency. The connectors designed in this paper are in line with the requirements of power grid in the connection of wires and wires, the fixation of devices and cables, and the fixation of devices, which make up for the shortcomings of other connection methods. It improves the safety of the normal operation of power cables and improves the reliability of users' power consumption.

(2) The existing prefabricated intermediate joint generally has a certain gap at the connection between the wire and the wire. In the device proposed in this paper, the copper tube is placed inside the intermediate joint part to realize the conduction of the wire inside the device. It is beneficial to reduce the contact resistance and better ensure the air tightness of the wire connection point. The special screw and screw channel can make the two parts of the device tightly connected. In addition, the mortise and tenon structure of the device makes the plug-in part embedded in the intermediate joint part, further ensuring the air-tightness and firmness of the device.

(3) According to the existing theoretical analysis and structural design, the mechanical and electrical properties of the cable designed in this study according to the plug-in structure can meet the long-term operation requirements of the cable, but the actual application and long-term operation in the field need to be further verified in the field environment.

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