Development of Auxiliary Tools for the Insulation Rod Method in Live Work of 10 kV Distribution Network

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Abstract. The live work of distribution network can effectively improve the reliability of residential power supply. Live breaking or connecting the drainage line is the most extensive project in the live work of distribution network. Due to the lack of the special fixing tool of the drainage line and the placement tool of insulation rods, the result is that the labor intensity of operators is large and the installation process quality of wire clip is difficult to guarantee in the process of live breaking and connecting the drainage line. Focusing on above problems, the special fixing tool of the drainage line and the portable insulation rod hanger are developed. The specific application method is introduced in this paper. The field application is carried out after the electrical test is qualified. The field application shows that applying the auxiliary tools can effectively reduce the labor intensity and improve the working efficiency.

1. Introduction

With the development of economy and society, the demand of power supply reliability from all walks of life is increasing. Using the live operation to eliminate defects can effectively make the power supply more reliable, and live breaking or connecting the drainage line project is the most extensively applied project in the live work of distribution network [1-5]. Restricted by the terrain, in some areas, the insulated bucket arm car with rural network line cannot reach the working position, so it is necessary to use the insulating rod to perform the live breaking or connecting the drainage line project. When the special clamp (throat clamp) is used for live connecting the drainage line, only one operator on the pole needs to use the shotgun-type insulation rod to lap the throat clamp which has fixed the drainage line onto the live main line and tighten it. However, due to the stress of the drainage line itself, it is difficult to keep the drainage line and the main line parallel after the lapping and tightening,
which will affect the installation process of the clamp, and cause the hidden danger and risk of heating or falling off of the clamp in subsequent runs. When using the insulation rod method to break the drainage line, it needs the cooperation of two operators. The No. 1 electrician has to control the drainage line to be broken by holding the insulating lock rod, while the No. 2 electrician is responsible for unscrewing the clamp bolt or cutting off the drainage line, and then the No. 1 electrician uses the insulating lock rod to move the drainage line away from the live main line smoothly. Two operators are needed to complete the method. The limited space on the pole gives rise to difficult operation and low work efficiency[6-8].

In addition, more rod tools have to be used in the insulation rod method, so it is necessary to use the placement tools of rods. However, the existing hoop hanger with heavy weight and inconvenient installation and operation results in high labor intensity of operators.

According to the structural characteristics of cross arm and wire diameter parameters of 10kV line, the special fixing tool of the drainage line and the portable insulation rod hanger are developed. It is shown by trial operation that they can facilitate the insulation rod operation.

2. Development of auxiliary tools for insulation rod operation

2.1. Development of the special fixing tool of the drainage line

At present, when it comes to the reconstruction of business expanding network or the fault elimination joint, and the upper line cannot be cut off, it is a must to carry out the project of the live breaking and connecting the drainage line. Currently, there are mainly two ways of the project: insulation glove method and insulation rod method, and there are mainly the following shortcomings[9-12]:

1) Live connecting the drainage line by the insulation glove method

One operator cannot complete the operation project, so two operators must be required. The reason is that it is necessary to control the drainage line close to the main line and keep it relatively parallel, and install the drainage line and the main line into the lead clamp and keep them stable. Then use the wrench to tighten the clamp bolt. Therefore, this process cannot be completed by one operator, and the assistant must hold the insulation lock rod to fix the drainage line so that the drainage line will be close to the main line and keep relatively parallel. The other main operator has to connect the lead clamp stably and tighten the clamp bolt.

2) The existing insulation lock rod and the drainage line are in approximate point contact. Due to the stress of the drainage line itself, it is difficult to control it and the main line in a relatively parallel position through the insulation lock rod, thus affecting the installation of the clamp, and there is a hidden danger of clamp heating or falling off in the subsequent runs; the operation may cause large physical consumption of the auxiliary personnel. If the auxiliary personnel fail to hold insulation lock rod, major safety hazards will arise.

2) Live connecting the drainage line through the insulation rod method

Using the special throat clamp of insulation rod method, only one operator on the pole can use the shotgun-type operation rod to lap the throat clamp which has fixed the drainage line to the live main line and tighten it. However, due to the stress of the drainage line itself, it is difficult to ensure that the drainage line and the main line keep parallel after the lapping and tightening, thus affecting the clamp installation process. There is also a hidden danger of heating or falling off of the clamp in subsequent runs.

3) Live breaking the drainage line through the insulation glove method or insulation rod method

At present, two operators inside the bucket (or on the pole) have to cooperate to complete the current work, whether it is the insulation glove method or the insulation rod method. The No.1 operator controls the drainage line to be disconnected by holding the insulation lock rod, and the No.2 operator is responsible for the screw off of the clamp bolt or the cutting of the drainage line, then the No. 1 operator should use the insulating lock rod to move the drainage line away from the live main line smoothly and stably[13-15].
In order to overcome the shortcomings in the process of live breaking or connecting the drainage line at present, a special fixing tool for drainage line is developed in this paper. The tool includes the insulating rod assembly and two parallel line clamping mechanisms. The device carries such advantages as simple structure, less operators and the guarantee of the stable installation of clamps.

![Figure 1. Schematic diagram of the special fixing tool of the drainage line](image)

The drainage line can be fixed on the live main line by using the developed special fixing tool, so that only one person can complete the live operation of breaking or connecting the drainage line, which is helpful to reduce the labor cost and the labor intensity, and improve the work efficiency; Meanwhile, the device is equipped with two parallel line clamping mechanisms, which can be used to clamp and fix the drainage line and the live main line respectively when live connecting the drainage line. And the drainage line will be placed near the live main line in a relatively parallel position, which is conducive to the stable installation of the clamp and the fastening of the clamp bolts. In addition, the clamping mechanism of the device adopts the angle adjustable design, so the drainage line can be fixed quickly when the operators are in different positions. Such design has stronger applicability.

2.2. Development of the portable insulation rod hanger

According to the structure of the cross arm, the designed insulation rod hanger is shown in Figure 2, which is mainly composed of the upper end fixing device, insulation rod, hanging board and hanging ring. When it is used on site, the fixing device on the upper end of the hanger is fixed at the position of the cross arm. The olecranon structure can make it more firmly. And it can be applied to various types of cross arms (angle steel). When installing the fixed hanger on site, it can be fixed conveniently by rotating the insulation rod.

Considering the convenient transportation, storage and on-site operation of the hanger, the hanging board is composed of four sections, all of which can be folded up during transportation because of the foldable structure. During the field operation, the hanging board can be partially folded according to the actual operation. It adopts a cross shaped symmetrical structure, and each section is provided with an open hanging hole and three rectangular hanging holes on the outside. The hole can be flexibly selected for hanging based on the tool structure on site. At the same time, the hanging board can rotate 360° along the insulation rod, facilitating the use of tools on site. In order to conveniently pass the tools on site, a hanging ring is set at the lower part of the insulation rod to hang the jack and pulley. Compared with the traditional hoop type hanger, the developed portable one carries the advantages of simple structure, light weight, portable transportation, convenient installation, flexible operation and strong applicability.
3. **Trial operation**

In order to ensure that the developed tools can be safely applied to field operation, electrical tests are carried out on the developed drainage line fixing tools and insulation rod hanger. After the tests are qualified, the live connecting the drainage line lead with the insulation rod method and insulated bucket arm car method are tried in practice field. As there is no problem in the application, it is applied in the field of live breaking or connecting the drainage line, as shown in Figure 5 and Figure 6. The application results show that the drainage line can be operated by only one person by using the developed tools, whether the insulation rod method or the insulated bucket arm car method is adopted, and the working efficiency is improved. Besides, the drainage line can be controlled in the relatively parallel position near the live main line, so as to ensure the clamp is firmly installed. At the same time, the portable multifunctional hanger is easy to install and fixed firmly, reducing the labor intensity of the operators.

4. **Conclusion**

In the field operation, live breaking or connecting the drainage line is the most extensively applied project. The special fixing tool of the drainage line is developed for both the insulation rod method and the insulated bucket arm car method. The adjustable design method can realize fast fixing of the drainage line when operators are in different positions. The insulation rod hanger is easy to install, and the folding structure makes the field application and transportation more convenient. By using the special fixing tool of the drainage line and the portable insulation rod hanger, the operation efficiency can be effectively improved, reducing the labor intensity and enhancing the operation safety of the operators.
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