Research of Power Cable Non-destructive Detective Based on X-ray Digital Imaging Technology

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Abstract. With the rapid development of the scale of this year's grid line failure caused by defects in the cable is gradually increasing, therefore, non-destructive testing of cable and more important. By using X-ray imaging technology to 10kV, 3 ×70mm and 3 ×150mm two types of cables for internal testing, can be effective, intuitive, and quickly detect common defects in the process of running. By copper cable connectors do tensile testing, can be drawn from it can withstand the maximum tension. Hanging on the cable network and the safe operation of the defect detection is important.

Keywords: X-ray, Power cable, Defects, Non-destructive.

1. Introduction

With the development of society and economy, power cable rate gradually increased. The rapid development of line scale, making cable and reliable operation for safe and reliable operation of the power grid increasing the degree of influence, while cable fault defects is relatively concentrated in the external damage, the cable line construction technology and equipment product quality. Cable defects to failure except penetrating external damage, a process needs a run. Such as non-penetrating force injury, crushed, etc., when in the middle and both ends of the connector cable in the safe operation of the power system weakest link [1], and therefore need for a more effective means of detection in the case without damaging its cables fast defect detection and analysis, thus providing a reliable basis for treatment strategies defects.

The X-ray digital imaging technology used in power cables and accessories detection, technically traditional detection methods, providing an intuitive and convenient detection method, based on the device without damaging the cable, look inside the case and cable equipment in a timely manner cable equipment found potential run risks, such as the main external damage hurt cable insulation, cable stress cone displacement, poor semi-conductive handle, copper at poor contact, avoid cable equipment breakdown caused by accidental power outages. In the case of minor defects in the normal operation of the cable is not a threat, reducing the frequency of replacement cable equipment, network equipment to avoid duplication of investment.

2. X-ray Digital Imaging Detection System Introduced

In this paper, digital imaging X-ray inspection system for wire crimping quality testing, including digital imaging, image processing, protective devices and auxiliary facilities of the four systems, the system principle diagram shown in Figure 1, the system can be realized on power equipment defects and hazards of non-destructive testing and accurate positioning perspective, has been widely used in the perspective of critical equipment to detect upcoming production of key parts, sampling electrical equipment, production run accident occurred analysis of diagnostic equipment, etc., using the system for a steel core Crimp dimensions transillumination experiments, the set system is equipped with a portable X-ray machine (0.3Mv, 3mA, focal spot size of 3.0mm (EN12543), 1.0mm (IEC336)), amorphous silicon flat panel detector (imaging area of 410mm × 410mm , image resolution 2.5Lp / mm), control box, mobile workstations, and additional data transmission network lines and control cables [2].

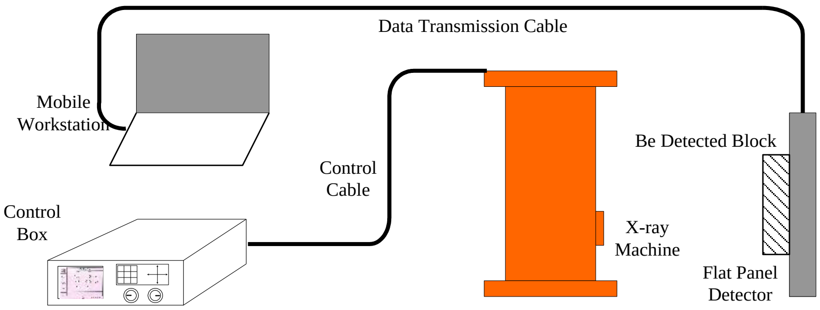

Fig.1 CV-1 electrical equipment X-ray digital imaging system detection principles

3. Power Cable Common Faults and Diagnostic Methods

Electricity distribution network more reliable power transmission cables, and without affecting the wind and rain. For this reason, more and more valued powered construction. However, due to the long-running cable and construction problems, power cables buried in the ground there will still be many failures.

Mechanical injury: cable fault caused by mechanical damage accounts for a large proportion of cable accident. Main cause mechanical damage when the damage has installed directly affected by external damage, damage vehicles traveling rolling land subsidence caused by cable damage joints and questions. Insulation damp: power cables in the ground during the long run, due to geological reasons, joints Mifengbuyan water, bad cable manufacturing, metal protective cover by external crack or corrosion damage as a result of the cable connector and conductor electrical performance degradation. Insulation aging deterioration: power cables affected electrical, thermal, chemical, environmental and other factors during operation, the cable insulation will occur in varying degrees of aging. Overvoltage: Atmospheric and cable internal over-voltage action, so that the cable insulation breakdown, the formation of the fault. Material defects: cable manufacturing process, the insulation material cables and accessories maintenance mismanagement, not manufactured in accordance with regulations.

From practical point of view, the main reasons for these failures occur cables are the manufacture of Cable Joints machine is not in place at both ends of the joint contact or bad contact, construction workers during the installation and poor technical level is not strong sense of responsibility, some do not installation of cable channel but directly to the cable buried in the ground, so that the cable box direct contact with the soil. Resulting in some power cables damaged skin torn, soil moisture will penetrate into, the cable is vulnerable to corrosion penetration, increased impedance of the cable; multiple units constructed without considering laying underground cables, the resulting cable skin damage or wire breakage. These failures result in reduced insulation or conductive properties of the cable, lack allowed withstand voltage levels and load flow. If the line appears overloaded or too high harmonics, etc., it will cause the outer layer of insulation breakdown failure [3,4].

Currently cable fault location method is mainly someone ears method, high-frequency induction method and infrared diagnostic technology. High frequency induction method is the use of high-frequency signal generator generates a high frequency, and then to test the cable through the high-frequency current, therefore, with the high-frequency current will produce a high-frequency electromagnetic waves on the cable. People on the ground holding the probe along the buried cable route to go, you can sense the high-frequency electromagnetic waves emitted by the cable, after the instrument processed according to the size of the displayed values can determine the exact location of the fault. It includes bridge method, low-voltage pulse reflection method, the DC high voltage flashover method, high-pressure shock flashover France, the second pulse method, three pulse method. Since the use of infrared diagnostic techniques, and achieved good results, but also bring huge economic benefits for the power cable. Once the power cable overload phenomenon, which leads to increased heat resistance also increases, so wire core temperature rises sharply, even more than the maximum withstand temperature. The maximum impedance fault fever also the largest, so just check wire core temperature can be determined according to the temperature level of the fault zone [5,6]. Radiographic X-ray digital technology with an intuitive, convenient, accurate, real-time characteristics, its application has its unique advantages in the diagnosis of faults on cables, especially the fault diagnosis of internal cables are particularly effective, such as the stress caused by the failure stress cone shift, semi-conductive poor contact, poor contact Copperbelt at both ends and the middle connector crimping not in place.

4. X-ray Inspection

At present, domestic and on the power cable fault testing with multiple different methods, the test steps are basically the same, the first preliminary diagnosis, and fault diagnosis based on the results of pre-positioning, and finally pinpoint [7]. The most common location of cable faults both ends and the middle joint. Failure may occur include intermediate connector crimp in place, steel anchor crimp significant bending, copper connectors at both ends slippage, an insulating layer between the copper destruction, insulated rubber interior presence of pores and inclusions and other defects, detected by X-ray can quickly and accurately find the point of failure. Because the X-ray penetration with increasing obstructions and recession, so the cables of different materials, different parts and different types of cables you need to set a different test parameters [8,9]. By changing ray machine tube voltage from 70kV-150kV, to observe the parameters of different parts and different types of cables inside the same model, X-ray machines are shown in Table 1, X-ray test results shown in Figure 2-7.

Tab 1 The parameters of DR X-ray digital imaging technology

No.	Focal lengt(mm)	Voltage (kV)	Electric Current (mA)	Exposure time (s)	Collection time(s)
1	600	70-150	3	2	4

Fig. 2 X-ray detection cable location map

Fig. 3 50kV cable copper end under X-ray map

Fig. 4 100kV at 3 ×70mm cable ends

Fig. 5 120kV at 3 ×150mm cable ends

Fig. 6 130kV, 3 ×70mm cable middle connector

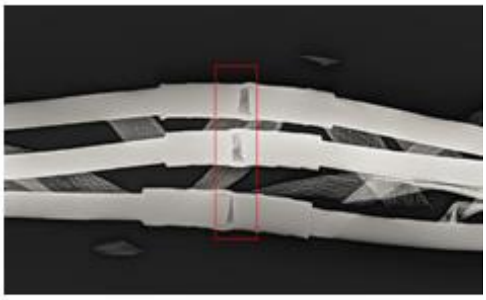

Fig. 7 140kV, 3 ×150mm cable middle connector

Figure 2 shows the location of the X-ray detection cable placed physical map. Figure 3 is 10kV, 3 × 70mm of the cable ends in the voltage rating of 50kV under imaging map can be seen that the insulation rubber, the manufacturing of copper and copper contacts are good, no obvious defects. Figures 4 and 5 respectively, 10kV, 3 × 70mm 3 × 150mm and the voltage rating of the cable in the X-ray imaging 100kV and 120kV under FIG can be seen a good crimped brass former and the latter there is a large gap, the failure will affect the electrical properties and mechanical properties of the cable. Figures 6 and 7, respectively, for the two joints in the middle of the cable voltage rating of 130kV and 140kV X-ray imaging map, you can see the middle joints of two cables are there are some gaps, crimping the cable is caused by defects.

5. Rally Detection

To ensure safe and reliable operation of the cable, the need for mechanical properties of gold with the cable and its accessories supporting research to ensure that it can withstand in the course of tensile load, bending wear, vibration fatigue, such as multiple load [10,11]. Rally experimental model used for 100t / 30t (Detection Equipment Co., Ltd. Shenzhen Hi). Rated voltage of 380V, rated power of 8kW. Cable model for 10kV, 3 × 70mm and 3 × 150mm, the three-phase connector cables were hanging on the tensile testing machine, tensile limit were detected to know to get the cable tension limit. Observed region and type of failure damage. The last record of the most vigorous and the corresponding cable connector clip off when the time - tension curve, as shown in Figure 8, and 9, respectively. Thus can draw maximum tension cables can withstand the power grid operation and prevent the cable connector so that put too much tension and failure.

Fig. 8 Cable Pulling physical map

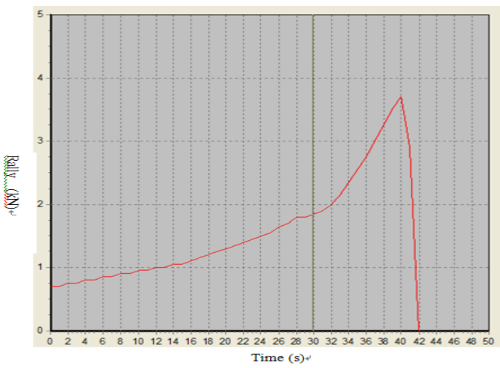

Fig. 9 Cable Time - Rally graph

Cable during operation of the grid, the two ends of copper fittings, though not withstand a major pull-off force. But in the hanging process due to different terrain, the natural environment and other conditions, so both ends of the cable will also bear part of the rally. From Figures 8, 9 can be seen with the increasing tension of the cable, copper cable connectors fall off, and to withstand the maximum pulling force of 3.6 kN.

6. Conclusion

On the basis of traditional detection methods, by X-ray digital imaging technology for 10kV, 3 × 70mm and fault defective cable 3 × 150mm models for testing, such as the main external damage to hurt the cable insulation, cable stress cone displacement, semi-poor conductive treatment, poor contact at the Copperbelt. Detected by X-ray diagram and lead time - Rally detection map, get both ends of the copper contact wire crimping head is not in place, the gap is too large, the middle joints there are insufficient crimping size, the gap is too large, such as failure, but also get cable power cable at both ends of the process of running copper connectors can withstand the maximum tension. Cable fault detection and on-site installation is important.

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