Fault Analysis and Detection of Electric Power Cable

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Abstract

The stable operation of power cables plays a vital role in people's production and life. It is related to the power supply in vast areas and directly affects the electricity consumption of millions of households and some commercial users. However, in practice, the working environment of power cable is relatively complex, and it is easy to be affected by various factors and cause problems. In order to ensure the safe and stable operation of China's power system, it is necessary to do a good job in the analysis of power cable faults. This paper makes a powerful analysis of the significance and causes of power cable fault detection, and further explores the methods and key points of power cable fault detection and location.

Keywords

Power cable; Fault analysis; Detection Technology.

1. Introduction

With the increase of power consumption in China, the coverage area of power lines is expanding. In order to reduce the cost of overhead lines occupying land and the safety of line operation, power cables have been widely used. Because the power cable will not be affected by the ground, buildings and climate conditions, it has a strong economic, security and concealment compared with overhead lines. But if power cable is laid in cable trench or underground, long-term contact with soil, moisture and moisture will cause cable failure because of insulation corrosion or local defects in line installation, which directly affects the stability and economy of power system operation. Therefore, how to strengthen the fault detection of power cable has become an important work in distribution network operation. Through certain technical means, we can quickly detect cable fault points, shorten maintenance time, reduce maintenance costs, and lay a solid foundation for the efficient operation of power system.

2. Causes of Power Cable Faults

In practice, due to the relatively complex operation environment of power cables, there are many reasons for power cables failure. The common causes of failure are the following aspects.

2.1 Mechanical Damage

Mechanical damage is mainly caused by physical collision, pulling and other causes of cable damage. According to relevant statistical data, mechanical damage is the most common cause of cable failure, specifically the following. First, the cable is directly affected by external forces, the common reason is the damage caused by construction or transportation; secondly, due to improper operation in the installation process, the cable is damaged, pulled or bent excessively; finally, due to natural conditions,

the cable protection is caused by the natural tension and expansion of internal insulation glue at the middle or terminal joints of the cable. The bushing breaks down and causes trouble.

2.2 Insulation Damp

The insulation dampness of power cable mainly refers to the insulation dampness caused by the water vapor entering from the outside due to the poor sealing of the intermediate or terminal joints of power cable. In addition, if the quality of the cable is poor, defects such as holes or cracks in the protective sheath will also cause the cable to be damped.

2.3 Cable Overheat

In practice, the air gap dissociation in the insulator of power cable will lead to the partial overheating of the insulator, which will lead to the carbonization of the cable insulation. Installation in dense or poorly ventilated areas, and parts close to thermal pipes can cause overheating of cables. In addition, the long running time of power cables under overload will also lead to overheating of cables.

3. Analysis and Summary of Common Fault Location of Power Cable

3.1 Short-circuit or Grounded Fault

Short-circuit fault is a common fault in the operation of power cables. There are two kinds of short-circuit faults: high resistance short circuit fault and low resistance short-circuit fault. When the cable short-circuit fault occurs, the fuse in the cable protection device will be fused and tripped. Because the fuse is fused, the cable insulator will be burnt at high temperature. At this time, the fault point of the power cable is short circuit fault. Grounding faults of power cables are also divided into low resistance grounding faults and high resistance grounding faults. Grounding fault is different from short-circuit fault. There is a big gap between the two types of grounding fault. It can be clearly divided by tools and fault nature. Generally, low-resistance grounding fault needs to be detected by low-voltage bridge, and grounding resistance is less than 20-100_, while high-resistance grounding fault needs to be detected by high-voltage bridge, and the resistance value needs to be greater than 100_. In practice, if there is a grounding fault, the device specially used for grounding detection in power system will send out a fault signal, and the leakage protection device will also trip the control syste.

3.2 Broken Line Fault

There are mainly two kinds of power cable breaking faults, one is high resistance breaking faults, the other is low resistance breaking faults. The main reason for this type of fault point is that the fault current is too large, which causes the cable to be burned out. In addition, if the cable is affected by external factors, it is easy to cause cable to be pulled off and break down.

3.3 Open Circuit or Flashover Power Cable Failure

Open circuit fault of power cable is also a common fault point. Mainly refers to the damage of the insulation part of the circuit, while the metal part of the cable is broken. In addition, power cables are also prone to flashover failure, which mainly occurs after the voltage value is too large or continuously rising, so that cable insulation material is broken down and suffered serious damage.

4. Fault Detection and Location of Power Cable

4.1 Rough Measuring Distance

After determining the nature of cable fault, the appropriate method to test the fault distance is selected according to the specific fault nature. This work is rough distance measurement. The whole process requires high efficiency and accurate data, which requires testers to have solid professional theoretical knowledge, technical level and rich practical experience. Previously, many rough measurement

methods have been summarized, of which low voltage pulse method and pulse current method are the two most widely used methods in daily work. With the continuous improvement of the quality of cable production and the application of various new insulation materials in cable, the insulation of cable is continuously improved and the safety of cable is increased. According to the investigation, the cable faults are mostly high resistance faults, while the low voltage pulse method is mostly suitable for testing low resistance cable faults. When long distance cable high resistance faults can not be fully discharged, it is necessary to increase the applied voltage, the capacity of energy storage capacitors, etc. to increase the impulse voltage, increase the duration of the voltage in the cable, or use the "cumulative effect" to shock the cable faults with high voltage for many times. Through insulation, reduce resistance, determine the fault point has been fully discharged by the swing amplitude of ammeter or voltmeter of high voltage signal generator, the waveform recorded by instrument or the sound of discharging in spherical gap, and then use low voltage pulse or pulse current method to measure the distance.

4.2 Precise Fixed-Point

Precision measurement point is a very important step in cable detection process. Because the rough fault distance has a certain practical deviation, it is necessary to precise measurement point to determine the specific location of the fault point accurately, which effectively compensates for the distance error of rough measurement. The most commonly used method is acoustic-magnetic synchronous receiving method, which applies high-voltage pulse signal to the fault cable to discharge the fault point. At the same time, the pulse magnetic field signal with very fast transmission speed and the sound signal with relatively slow transmission speed will be generated around the cable. The location of the smallest time difference between the two is the fault point. Very few cases of ultra-low resistance (i.e. metal short circuit) fault will be located by audio signal induction method. This is an indispensable link in the process of detecting cable faults. Only by finding accurate fault points can we repair and solve the faults and reduce unnecessary losses.

5. Conclusion

As an indispensable power cable in power system construction, we need to pay more attention to its security and stability in the actual operation process. Practice has proved that, due to the complexity of power cable operation environment, it is easy to be affected by various external factors in the actual situation and cause failure problems. Therefore, it is necessary to combine the common causes of power cable faults, in-depth analysis of common cable faults, and do a good job in the research of fault point detection methods, so as to ensure timely maintenance of power cable faults in the first time. Provide necessary power supply support for our modernization drive. In the process of continuous development and application of electronic technology and multi-functional equipment, new cable fault detection equipment and technology reduce the cost and difficulty of fault detection and other security issues. With the widespread use of power cables, fault detection instruments will play a greater role, and cable and its fault detection technology will also get greater development.

References

[1] DONGLIANG WU. Design on Fault Online Detection Device of Thermal Test Low-Frequency Cable Based on M Sequence Correlation Algorithm[A]. Wuhan Zhicheng Times Cultural Development Co., Ltd.Proceedings of the 4th International Conference on Vehicle, Mechanical and Electrical Engineering(ICVMEE 2017)[C]

[2] Zhenxin Chen. Research of the fault detection and repair technology for submarine cable[A]. Wuhan Zhicheng Times Cultural Development Co., Ltd. Proceedings of 2016 International Conference on Automotive Engineering, Mechanical and Electrical Engineering(AEMEE 2016)[C].

[3] Seltzer-Grant, M.,Winter, K.,Mackinlay, R.,Renforth, L.. On-line partial discharge detection and control on MV cable networks with ground fault neutraliser [P]. ,2013.
[4] Qinghai Shi,Kanoun, O.. Detection and location of single cable fault by impedance spectroscopy[P]. Instrumentation and Measurement Technology Conference (I2MTC) Proceedings, 2014 IEEE International,2014.
[5] Okai, M.,Sugiura, H.,Mori, T.,Motoyama, K.,Kawano, F.,Iihoshi, K.. Cable fault detection system employing remote terminals without DC power supply using digital communication over optical fibres [P]. Developments in Power System Protection (DPSP 2014), 12th IET International Conference on,2014.
[6] Mei Wang,Chen Yang,Wen-Yuan Chen,Hsiung-Cheng Lin. Power Cable Fault Classification Using Improved Bayesian Decision Algorithm[J]. International Journal of Advancements in Computing Technology,2012,4(23).
[7] J.H. Kim,M. Park,I.K. Park,S.R. Lee,J.D. Park,Y.K. Kwon,I.K. Yu. A study on the improvement of protective relay system for the utility application of HTS power cable[J]. Physica C: Superconductivity and its applications,2009,469(15).