Application of DR Detection Technology in Defect Detection of Composite Insulators

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Abstract: The main reasons for the failure of composite insulator are the fracture of core rod and the breakdown of interface, however, due to the particularity of composite insulator, the traditional insulator detection method is not fully applicable to it. The development of composite insulator needs the emergence of new detection technology. In this paper, DR (Direct Digital Radiograph) detection technology is used to detect the artificial simulated defects of composite insulator, and the clear imaging of composite insulator's core rod defect, core rod and sheath interface defect is obtained. The research results can provide research basis for the application of DR detection technology in the field of composite insulator defect detection.

1. Introduction

Due to low weight, high tensile strength and strong resistance to stain, composite insulators are widely applied in high-voltage power transmission systems. Due to impact of manufacturing technique, working life and operation environment, the transmission cable accidents often occur due to brittle rupture of core rods resulting from internal defects of composite insulators. In order to guarantee safe operation of transmission cables, how to effectively detect the internal defects of composite insulators becomes a remarkable problem in the power sector [1, 2].

The terminal of composite insulators is made by connecting fiberglass epoxy resin core rod and end metallic fixture. The connection area is stably connected by the friction between end metallic fixture and fiberglass epoxy resin core rod. During production of insulators, some defective products often occur, such as poor connection quality of the interface, unsecure connection between core rod and sheath. If the moisture in the air enters, the abrasion and aging may be caused between fiberglass epoxy resin core rod and sheath of the composite insulators. Due to the influence of tensile load and dynamic torsion load, the rupture of composite insulators may occur [3,4]. A lot of research indicates that the rupture of core rod and breakdown of the interface are the main reason for the failure of composite insulators. Therefore, it is necessary to make research on relevant detection technology, find the potential defects of core rod and the interface between the core rod and sheath [5,6]. This thesis will make research on DR technology in detecting the potential defects of composite insulators.
2. Sample preparation

2.1. Preparation of defects of core rod
During fabrication of composite insulators, the defect was artificially made on the core rod. The following is the size of scratch. 1) width-1mm, depth-1mm, 2) width-1mm, depth-3mm, 3) width-3mm, depth-5mm. The sheath is made by compression molding or sheathing on the defective core rod so as to make insulators with defective core rod.

2.2. Preparation of debonding defect on the interface of core rod sheath
During fabrication of composite insulators, the debonding defect was made by coating coupling reagent in the interface between the core rod and sheath. The following is the debonding size. The width of defect is 1mm, 2mm, 3.5mm and 4.5mm respectively. The defect location shall be remembered after fabrication so as to detect the test process in the future.

3. Detection results

3.1. Core rod defects
DR detection method was adopted to detect the sample of core rod with defects. The detection results can be seen in Figure 1, Figure 2 and Figure 3. Figure 1 indicates that when the defect is 5mm deep, DR technology can accurately detect the defect of core rod, and the indicative width of the defect approximates to the actual width, which is 3mm. The contrast in the defective position differs from that in the normal position, indicating that DR technology can detect the defect which is 5mm deep.

![Figure 1](image1.png)
Figure 1 voltage: 65kV, current: 20mA, defect depth: 5mm, defect width: 3mm

Figure 2 indicates DR detection results of the defect which is 3mm deep. DR technology can also effectively recognize this defect. Its indicative width is about 1mm, which is identical to the actual width. Among the radiograph parameters, the voltage is 65kV and the current is 2.5mA. As the radiograph current is large, the sheath has been totally radiographed, and not shown in the image, but the defect of core rod is visible, indicating that DR technology can detect the defect which is 3mm deep.
Figure 2 voltage: 65kV, current: 2.5mA, defect depth: 3mm, defect width: 1mm

Figure 3 indicates the defect which is 1mm deep. DR technology fails to detect the defect. The defect contrast does not differ from that in the surrounding. DR detection technology is sensitive to three-dimensional defect. It can effectively detect the defect whose width and depth are equal to or greater than 3mm. It fails to effectively detect the defect which is 1mm deep. However, we find in Figure 3 that it can effectively observe the interface between the core rod and sheath through adjustment of the parameters of voltage and current, the material of core rod is fiber glass reinforced epoxy resin and the material of the sheath is vulcanized rubber. When the voltage is 65kV and the current is 2.0mA, the clear interface between the core rod and sheath can be observed.

Figure 3 voltage: 65kV, current: 2.0mA, defect depth: 1mm, defect width: 1mm

3.2. Debonding defect in the interface between the core rod and sheath

DR detection method was adopted to detect the debonding defect between the core rod and sheath. As DR technology is sensitive to three-dimensional defect, the detection effect of debonding defect is not good. As shown in Figure 4 and Figure 5, when three-dimensional defect exists in the rubber sheath of composite insulators, DR technology can recognize this defect. As shown in Figure 4, the prepared debonding defect in the interface of sheath and core rod does not fully extend from the sample end to the inside, but enter the inside of the sheath. Figure 5 is consistent with Figure 4. The defect extends from the interface between the sheath and core rod to the inside of the sheath.

However, when the interface between the sheath and core rod is debonded, three-dimensional defect does not take shape inside, DR may not detect the debonding defect. As shown in Figure 6 and Figure 7, the defect imaging is not apparently observed in the figure. It is more suitable to detect this defect through ultrasonic detection technology.
4. Conclusion
DR detection technology can effectively identify the defect of core rod of the composite insulators. In this thesis, DR detection technology can detect the core rod defect which is 3mm deep to a minimum, but it fails to detect the defect which is 1mm deep. Meanwhile, this detection technology can detect the
debonding defect in the interface between core rod and sheath of the composite insulators, but this defect is limited to tearing and three-dimensional defect. This detection technology fails to effectively detect the debonding defect.

References:
[1] Lu Ming, Zhang Zhonghao, Li Li, Liu Zehui, Reason Analysis of Decay-like Aging for Composite Insulator, Power System Technology, 2018 (42) 1335-1340
[2] Sun Wenjian, Liu Xuandong, Deng Tao, Zhou Jun, Zhang Qiaogen, Research on Detection Methods for Composite Insulator Internal Defects, Shaanxi Electric Power, 2016 (44) 52-56
[3] Li Jicheng, Kong Lingchang, Li Huan, Application of X-ray Digital Imaging Technology in Analysis of defects of Ultra High Voltage Basin-type Insulators, Nondestructive Testing Technology, 2018 (42) 22-24
[4] Yan Wenbin, Wang Dada, Li Weiguo, Zhao Xianping, Yu Hong, Peng Qingjun, Xu Zhuo, Zhang Hui, Application of X-ray Technology in Composite Insulators Defect Diagnosis, High Voltage Apparatus, 2012 (48) 58-64
[5] Yin Kuilong, Chen Cong, Sun Xuewu, Li Zhengli, Feng Yunguo, Research on the Application of Industrial CT/DR Detection System in the Detection of Basin-type Insulator, Shandong Electric Power, 2018 (45) 33-36
[6] Li Xiaoming, Ren Guiqing, Liu Yaoqiang, Chen Guangzheng, Study on Adhesion Performance of Interface between Insulator Shed and Sheath, Insulators and Surge Arresters, DOI: 10.16188 / j.isa.1003-8337.2019.03.038