The visualized detection research of transmission line internal defects based on X-ray digital radiography

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Abstract. This paper proposes an X-ray visualized internal defect detection method for high-voltage transmission line. Introduced the CV-1 X-ray digital imaging system composition and working principle, verified the radiographic ability of X-ray digital imaging system for 500kV transmission line, determined the irradiation parameters and methods; According to the internal defects characteristics of transmission line and defect location, simulated transmission lines internal defects detection of steel core wire off shares, steel core surface scratches, inclusions, bulk shares, crimp depth insufficient, and compared with no defects transmission lines under laboratory conditions, obtained the X-ray digital images characteristic of transmission line internal defects. The experimental results show that the detection effectiveness and feasibility of digital radiography for transmission line internal defect and provide a new method and reference basis for the internal defect detection of high-voltage transmission lines.

Keywords: Digital radiography; High-voltage transmission line; Visualization; Defect detection.

1. Introduction

Transmission wire as an important part of electricity, general is made of steel core aluminum stranded wire, which play a crucial role in the power grid. Since most of high-voltage transmission conductor installation in remoter unmanned region, environment, bad weather, poor operation condition, wire broken stocks, such as injury accident often happened [1-3]. Serving the transmission conductor is hard to do and substation equipment within the same monitoring, regular inspection at any time, so the early stage of the installation of power transmission wire after inspection and accident cause analysis to be control transmission wire quality and running stability of the important means.

In recent years, researchers will focus primarily on the study of transmission conductor wire ice disaster [4-8], wire dancing performance [9-11] and transmission conductor mechanical properties research [12, 13], with little internal defect detection of wire were studied. Transmission wire is not easy to find the defect, wire steel reinforced broken stocks, steel reinforced surface scratches, inclusions, broken stocks, insufficient depth of internal defects such as serious pressure to reduce the transmission lines carrying capacity and mechanical strength, influence the safe operation of transmission lines. Traditional transmission wire detection method can only through the test result analysis, judge transmission wire performance, can't check more intuitive power transmission wire of internal defects, such as pressure welding quality [14]. Therefore, need a more intuitive, convenient and effective means to test the transmission wires? X-ray digital imaging as an ongoing study of the latest technology applied in power system, has proved effective technology is a kind of power equipment testing, the test characteristics of direct-viewing, convenient, quickly makes the more accurate the detection results of power equipment, testing more efficient [15].

In this paper, X-ray digital imaging technology was applied to transmission wire defect detection, can be in on the technology of traditional detection methods, provides an intuitive and convenient detection method, the material defect of the transmission wire, steel reinforced broken stocks, shares, surface defects such as scratch and mixed steel reinforced more detailed testing. Combining the traditional detection methods, can be more accurate to judge the quality of transmission conductor, it is concluded that more accurate analysis results, for testing and failure analysis of the causes of the transmission conductor provide new method and reference.

Based on this, this article first to the 500 kv high-voltage transmission conductor LGJ - (400/35) the X radiographed ability test, and obtained a set of suitable for the parameters of the transmission wire X-ray detection, then under laboratory conditions, respectively for common defect is simulated and the test conductor, affirmed the X-ray digital imaging nondestructive testing technology of high-voltage transmission conductor to detect the feasibility and effectiveness of internal defects detection.

2. introduction X-ray digital imaging system

X-ray digital imaging technology is a kind of direct digital X-ray photography, it used flat-panel detector through X-ray, work piece tested again by the internal crystal flat-panel detector circuit according to the X-ray dose intensity is transformed into electrical signals, finally presented in the form of digital images on the computer terminal, and the computer X-ray photography imaging (computer radiography (CR), compared with simple operation, short, device is small in size, no replacement imaging plate and high image resolution, signal-to-noise ratio is strong advantages, such as [16].

In this paper, using X-ray digital imaging detection system to test the transmission wires, including digital imaging, image processing, protective equipment and auxiliary facilities four big system, the system principle diagram as shown in figure 1, the system can realize the power equipment defects and hidden trouble of nondestructive detection and accurate positioning of perspective, has been in the production of the key parts of the key equipment of X-ray detection, power equipment checking and production accidents occurred in the operation of the equipment diagnosis is widely used in aspects of analysis, the author high-voltage transmission conductor to make use of the system simulation test, the system will provide a set of portable X-ray machine (0.3 Mv, 3 ma, focus (EN12543) size is 3.0 mm, 1.0 mm (IEC336)), the amorphous silicon flat panel detector (imaging area is 410 mm * 410 mm, image resolution 2.5 Lp/mm), control box, mobile workstation, and additional data transmission cables and control cables [16].

3. Wires X-ray simulation testing internal defects

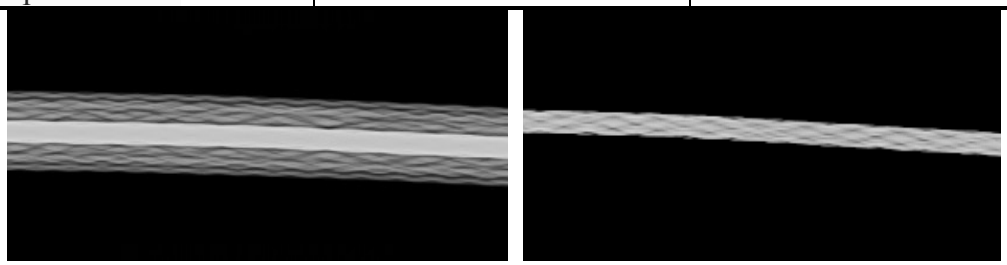
First under laboratory conditions for 500 kv power transmission conductor LGJ - (400/35) trans illumination ability experiments, preliminarily determines the X-ray transmission wire internal defect detection is feasible, then according to the different types of defects and defect parts, test parameters and irradiation methods, and use this parameter for a lot of wire steel reinforced broken stocks, steel reinforced surface scratch, loose strands, defects such as inclusions, inadequate pressure simulation experiment, has obtained the good detection effect, fully demonstrated the X ray imaging technology for power transmission conductor is feasibility and effectiveness of the internal defect detection.

3.1 Trans illumination ability test and parameters.

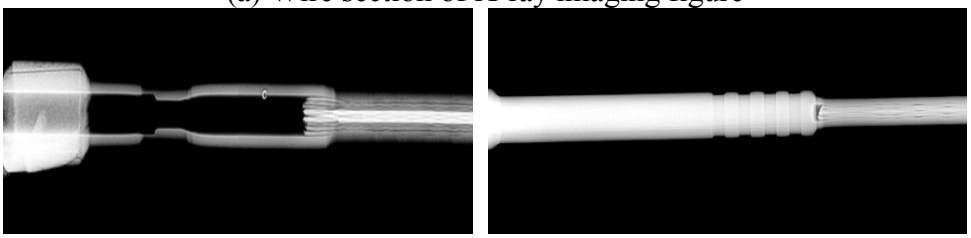
In the X-ray nondestructive testing equipment, the determination of parameters directly affect the sharpness of digital image and contrast, using X-ray digital imaging detection system for power transmission wire trans illumination ability experiments, the main parameters include U tube voltage, tube current I, the focal length F T and exposure time, in trans illumination ability is verified at the same time, to determine the best image quality parameters as shown in table 1, the use of the different parameters on the conductor section trans illumination ability to experiment on the digital image obtained is shown in figure 1:

Tab.1 X-ray detection experimental parameters

Parameter	Conductor section	Pressure welding area
Tube voltage /kV	80~120	120~160
Tube current /mA	3	3
The focal length /mm	700	700
Exposure time /s	8	8



(a) Wire section of X-ray imaging figure



(b) Regional pressure to X-ray imaging

Fig.1 X-ray image of transmission line detection ability experimental

In figure 1 (a) is the conductor section of X-ray digital image, for 500 kv power transmission conductor steel reinforced the lateral three layer of aluminum envelope, as shown in the left (a), 80 kv tube voltages texture of aluminum braid is clearly visible, and steel reinforced shone through. Tube for detection of steel reinforced defects, to increase the voltage to 120 kv, the aluminum envelope is completely shone through, steel reinforced lines clearly visible, as shown in (a) in the picture on the right. (b) the graph area pressure to X-ray imaging figure, figure in the steel core wires in the steel anchor port broken stocks, take out the steel anchor respectively, left for the strain clamp, right for the steel anchor, because of the steel anchor is hard, must adjust tube voltage to 160 kv to clear steel reinforced depth pressure was observed. X-ray transmission wire crimping area and wire segment trans illumination experiment obtained X-ray digital image can be seen that the image is clear, trans illumination ability is good, that X-ray transmission wire detection is feasible.

The following this paper to simulate the various defects of transmission wire, using X-ray test, the test when adopt the above the identified parameters.

3.2 steel reinforced broken stocks defect simulation test.

Due to its own gravity, in actual operation of wire subjected to great tension, due to reasons such as wind, temperature change, yes stress alternating long-term effects cause conductor fatigue, steel core wire is the main bearing unit, the force is too large or steel core broken stocks are the main defects of the conductor. Truncation test will first test the wires and aluminum covered wire, then the steel core cut; To ensure the holding force of aluminum envelope, select new aluminum envelope will cut steel reinforced bound up again, simulate the steel core broken stocks defects caused by excessive tension. X-ray digital images obtained is shown in figure 2.

Three wire in figure 2, the bottom of a have a defect, for comparison, a middle wire steel reinforced was cut out a setting and fracture end interval, can be seen from the diagram there is a gap; All cut steel reinforced by a wire to the top, the fracture diagram such as box is clearly visible, consistent with the actual simulation defects.

The results show that the use of X-ray visual detection of wire steel reinforced broken stocks deficiencies in the feasibility and effectiveness.

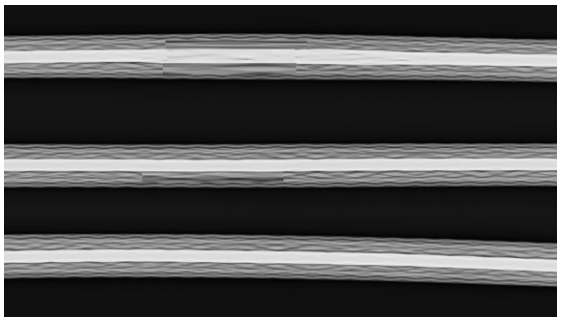
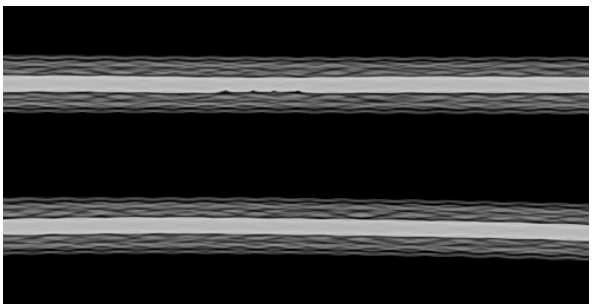


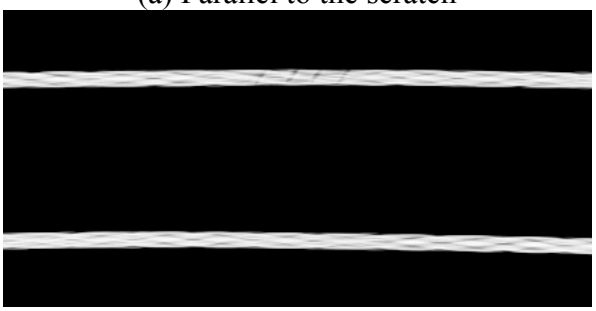
Fig.2 Steel core off shares simulated defect detection

3.3 Steel reinforced surface scratch defect simulation test

In wire production actual operation of the operation is not standard or steel core aluminum stranded wire cut, may hurt steel reinforced, in most cases fracture of the steel reinforced damaged for aluminum stock, but when aluminum stocks are lie between period of time, the defects in the macro is easy to observe, without using X-ray technology to observe, so the test will test truncation, wire and aluminum covered wire stripping out steel core, use file add four minor scratches in the surface of the steel reinforced (scratches depth of about 1 mm, ca. 4 mm long, lean), then use the new aluminum envelope bound up, simulation for manufacturing of steel reinforced surface scratches. The X-ray digital images as shown in figure 4. In figure 4 (a) for 80 kv tube voltage parallel to scratch illuminate the X-ray imaging effect, box of a figure for scratches, (b) of 120 kv tube voltages is perpendicular to the scratch illuminate the X-ray digital images obtained, box of defects in figure are consistent with actual simulated defect.



(a) Parallel to the scratch



(b) Perpendicular to the scratch

Fig.3 Steel core surface scratches simulated defect detection

X ray is illustrated by the results of the above surface scratch defect of transmission conductor steel reinforced the feasibility and effectiveness of the visual inspection.

3.4 Lead inclusion defect simulation test.

Will test wire truncation, and bound up again after stripping aluminum envelope, tiny grains of sand in the bound up process gap, wrapped in layers of aluminum braid simulation wire inclusion defects, due to line construction in the process of X-ray digital image obtained as shown in figure (4). Diagram with grains of sand in aluminum package lines with wider, box department for dot sand flaws and simulation.

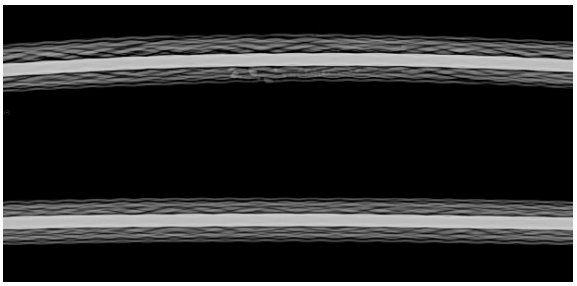


Fig.4 Transmission line inclusions simulated defect detection

X-ray transmission wire is illustrated by the results of the inclusion defect the feasibility and effectiveness of the visual inspection.

3.5 Inadequate pressure welding defect simulation test.

Wire pressure welding quality is unqualified lead to traverse the main factor of the accident. Pressure welding area lead defects mainly include crimping degree is not enough and steel core insert depth is not enough, the lack of steel core insert depth directly observed, using X-ray transmission observation is the best way to detect the defect.

Will test wire truncation, stripping aluminum envelope after take out the steel core, insert one end steel reinforced steel anchor, allow 15 mm gap, then using the pressure welding wire crimping machine, to simulate wire steel core insert depth caused by insufficient pressure welding defects, X-ray digital images obtained are shown in figure 5.

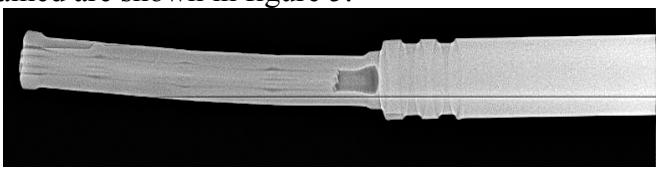


Fig.5 Crimp depth insufficient simulated defect detection

4. Conclusion

1) X-ray digital imaging on the depth of transmission wire pressure welding, steel reinforced broken stocks, steel reinforced surface scratches, typical internal physical defects such as inclusions, and loose strands have certain ability of diagnosis and detection, defect detection for the inside of a high-voltage transmission conductor provides a new method and reference;

2) due to the different material properties and thickness detection position obtained by X-ray digital image quality will be affected, so need to choose according to need to observe the location and damage characteristics of test parameters;

3) Simulation testing experiment, the transmission conductor surface scratch defects due to different irradiation Angle, obtained by X-ray digital image defect feature is very different, so in the defect detection, in key monitoring area to select different irradiation direction multi-faceted observation, can obtain more intuitive digital image, improve the accuracy of detection.

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