A comparative study on the detection of tension clamp DR and phased array for transmission line

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Abstract—In this paper, the tension clamp of high-voltage overhead transmission line is taken as the research object, and the stress analysis is carried out by using ANSYS finite element software, and the stress distribution state of tension clamp of in-service transmission line is obtained. At the same time, the tension clamp samples with different types of defects are made, and the ultrasonic phased array and X-ray digital imaging dead-end clamp crimping quality detection are carried out respectively. According to the detection results, the different characteristics and advantages of the two detection methods are compared and analyzed, which provides a scientific basis for the accurate detection and evaluation of the dead-end clamp crimping quality of transmission lines.

1. INTRODUCTION
High voltage overhead transmission is the main way of modern long-distance power transmission. As an important power hardware, tension clamp is widely used in high voltage overhead transmission lines. The reliability of tension clamp crimping quality has a greater impact on other infrastructure and transmission network security. In this test, the special scanning system for ultrasonic phased array testing of tension clamps is developed, and the advanced phased array testing technology and X-ray digital imaging testing technology (DR Testing Technology) are applied to the testing and evaluation of the crimping quality of tension clamps. The phased array testing atlas and Dr of tension clamps under different crimping conditions are given Detection map. At the same time, the two detection results are compared and analyzed, and the different characteristics of the phased array pattern and Dr pattern of the tension clamps under different crimping defects are obtained. According to the different characteristics and advantages of each type of crimping defects, the two detection methods provide a scientific basis for the accurate detection and evaluation of the crimping quality of the tension clamps of transmission lines.

Fig.1 tension clamp
2. STRESS ANALYSIS OF TENSION CLAMP

The main function of tension clamp in overhead transmission line is to fix the transmission line to bear its tension. In this paper, the hydraulic strain clamp (ny-400 / 35) of jlg1a-400 / 35 steel cored aluminum strand is taken as the research object, and the clamps with different defects are made by using ghs-200 hydraulic pressure welding system for strain clamp. The defects are respectively located in three parts that are directly related to the crimping quality of tension clamp, i.e. the crimping part of aluminum tube and steel anchor (Zone I), the crimping part of steel anchor and steel core (Zone II), and the crimping part of aluminum tube and wire (Zone III) as shown in Figure 2.

In this paper, ANSYS finite element software is used to analyze the stress characteristics of the hydraulic tension clamp, as shown in Figure 3. Tetrahedral elements are used in the model, with 129355 grid nodes and 64955 grids. [3]

This paper mainly simulates the stress of each part of the tension clamp under the axial tensile stress caused by the dead weight of the overhead conductor. From the results of finite element analysis, it can be seen that among the crimping parts of tension clamp, the steel anchor and steel core crimping part, i.e. the end of zone II, bear the most stress; in addition, the aluminum pipe and steel anchor crimping parts and aluminum pipe and wire crimping parts also bear higher stress. The crimping quality of the above parts plays a key role in the overall crimping quality of the tension clamp, so it should be focused on in the detection of the crimping quality. [4]

3. DR DETECTION AND EVALUATION OF TENSION CLAMP

By using the eresco 65mf4 type X-ray digital imaging detection system (DR), the transmission line tension clamp with various crimping defects was tested and evaluated, and the Dr Atlas of various defects of the tension clamp was formed. The marked range of red wire frame in each drawing is the parts with crimping defects, and the typical crimping defects are shown in Figure 4. The transillumination parameters selected for Dr detection are as follows: transillumination voltage 120kv, transillumination current 1.5mA, exposure time 1.5s, and transillumination distance 500mm.
It can be seen from the above Dr spectrum of tension clamps with various types of crimping defects that the use of Dr detection technology can achieve visual, intuitive and clear detection of the crimping quality of various parts of tension clamps, and also can clearly reflect the existing parts, defect types and sizes of crimping defects contained in each clamp.

Fig.4  DR spectrum of typical defects of tension clamp

4. ULTRASONIC PHASED ARRAY INSPECTION AND EVALUATION OF TENSION CLAMP

In this experiment, phascan PA32 / 128 ultrasonic phased array detection system is used to cooperate with the special scanning transducer developed by the research group for tension clamp detection, and the tension clamp joints with various types of crimping defects are tested and evaluated. Three 5l10-0.5 *6 probes are used for longitudinal wave linear scanning, and three channels are used for data acquisition and display at the same time. With the linear guide encoder, the three crimping surfaces at the crimping part of the tension clamp can be tested at one time to obtain the continuous C-scan map.

(a) 3D model

(b) Physical object

Fig.5 Special scanner for ultrasonic phased array testing of tension clamp
Through the ultrasonic phased array testing of the tension clamp, the ultrasonic phased array Atlas of the aluminum tube and steel anchor crimping parts (Zone I), steel anchor and wire steel core crimping parts (Zone II) and aluminum tube and wire crimping parts (Zone III) of the tension clamp under various defects are obtained, as shown in Figure 6.

![Fig.6 Phased array test pattern of tension clamp](image)

It can be seen from Fig. 6 (a) that for the crimping quality of steel anchor groove and aluminum tube in zone I, the ultrasonic phased array C-scan can clearly show the crimping position and quality of each groove on the three detection surfaces. In case of groove leakage, a cavity is formed between the steel anchor groove and aluminum tube, and the ultrasonic wave cannot reach the steel anchor groove, and the corresponding groove echo display will be missing in the C-scan. For the detection of the crimping position of steel anchor and wire steel core, because the aluminum tube and steel anchor in zone II will not be crimped after the complete crimping of the clamp, and there is a cavity between them, so ultrasonic phased array detection cannot be carried out, so the detection of this position can only be carried out after the steel anchor and wire steel core are crimped. For the inspection of the crimping quality of aluminum tube and wire in Zone III, it can be seen from Figure 6 (c) that the arrangement of dark zone and light color zone is the normal echo display of the clearance between the single wire wire and wire in the aluminum strand, which proves that the aluminum wire of the conductor is not broken and the crimping quality is in good condition; if there is a continuous dark zone or light color zone, it indicates that there is a large zone cavity and wire in the aluminum tube Broken strand or poor crimping.

5. **Comparative Analysis of Test Results**

By comparing and analyzing the testing process and results of the two different methods, it can be concluded that the X-ray digital imaging testing (DR) method, which shows intuitively and clearly, can reflect the crimping state of each part of the tension clamp, is also the non-destructive testing technology mainly used in the in-service "three span" transmission line tension clamp testing. By using the special scanning system for ultrasonic phased array testing of tension clamp developed in this experiment, three zones of tension clamp are tested, and the C-scan spectrum can basically reflect the crimping quality of each zone, and at the same time, the defect can be measured and located. Ultrasonic phased array detection has no radiation damage, which is the unique advantage of this method compared with X-ray detection. This method also provides a new idea for online detection of tension clamps of transmission lines.
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