Technical inspection of high strength bolts in hydropower plant: nondestructive examination

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Abstract. Bolt connection is widely used in hydraulic power plants as an important connection mode of metal parts. However, the phenomenon of bolt breakage often occurs in hydropower plants, which seriously affects the stable operation of hydropower plants. During the maintenance of the unit, non-destructive testing of high-strength bolts is able to effectively detect the bolt defects and ensure the safety of the unit

1. Introduction

Bolt connection is widely used in industrial equipment as an important connection mode of metal parts. However, the high-strength bolt, as an important bearing part of the connecting bolt, plays a very important role in the normal operation of the equipment [1-4]. In recent years, a number of bolt fracture accidents have occurred in hydropower plants in Hunan province, which has brought great hidden dangers to the safe operation of hydropower plants, and caused many non-stoppage accidents. This greatly affects the stable operation of hydropower plants [5-6]. Therefore, it is necessary to inspect and supervise the critical components of the hydraulic power plant. It should be established the important bolt ledger according to the importance of the bolt to manage the bolt gradually. It is supposed to use the opportunity of unit maintenance to conduct non-destructive test for the important bolt and replace the bolt found defects, to ensure the safety of the unit.

2. Experimental

Non-destructive testing of bolts is carried out on site, mainly by means of ultrasonic testing and penetration testing.

3. Results and discussion

3.*1 The stator of the generator fixed with embedded screw*

During the repair process of unit A, ultrasonic testing of embedded screw fixed by generator stator was carried out, and the waveform of ultrasonic testing was shown in Figure 1. There was reflection waveform display at 1274 mm from end face position signal. At the bottom of the 1700 mm, it appeared a strong reflected signal. The appearance of the defect base wave reflection intensity reduced

from 80% down to 73.5%, the decrease of strength of bottom wave was not large. As the probe in the whole face moves, it occurred the disappearance of reflected signal at 1274 mm position, which indicated that slag defects existed at 1274 mm from the bolt end.

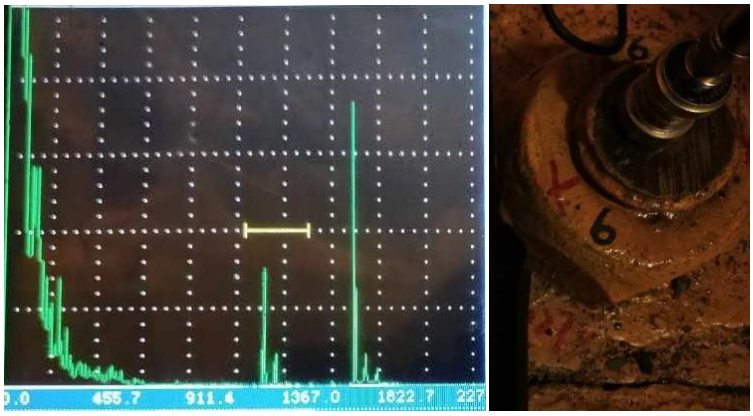

Figure 1. Ultrasonic testing stator fixed embedded screw internal defects.

3.2 Volute manhole door bolt

Volute manhole door is an important channel of access for maintenance staff in the unit during the volute. Volute manhole door bolt is critical, once the bolt failure, it will lead to water plant of major accidents during the running of unit's shell manhole door is opened. Therefore, the volute manhole door closed bolt is also important metal technical supervision object. During the period of grade A, the screw thread of #9 bolt (M30 × 90) of the volute manhole door knob was found to be 20mm away from the standard (Figure 2), so the failure of the bolt of the volute manhole door knob was judged and the replacement was organized.

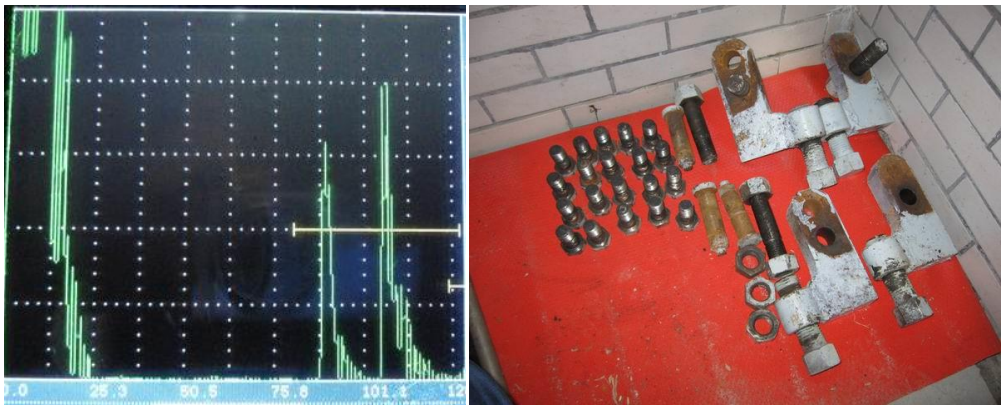

Figure 2 Ultrasonic testing of volute manhole door bolt

3.3 Rotor yoke tightening bolt

During UT inspection of bolts, it was found that there was crack reflection echo at 74mm of the upper thread buckle of rotor magnetic yoke tightening bolt #96, and the bottom wave was completely covered. The bolt was completely broken during pulling out of the tightening screw. It was observed from the section that the crack originated at the root of the thread and extended to the 1/2 radius (Figure 3).

Figure 3. The tension bolt of rotor magnetic yoke is broken.

3.4 Generator coupling bolt

The connecting bolt of generator shaft is used to connect the large shaft of generator with the lower broken shaft. It was found that the coupling bolts of the generator were found to have excessive defects (stratification) during UT inspection, as shown in Figure 4, which was determined to be unqualified and replaced.

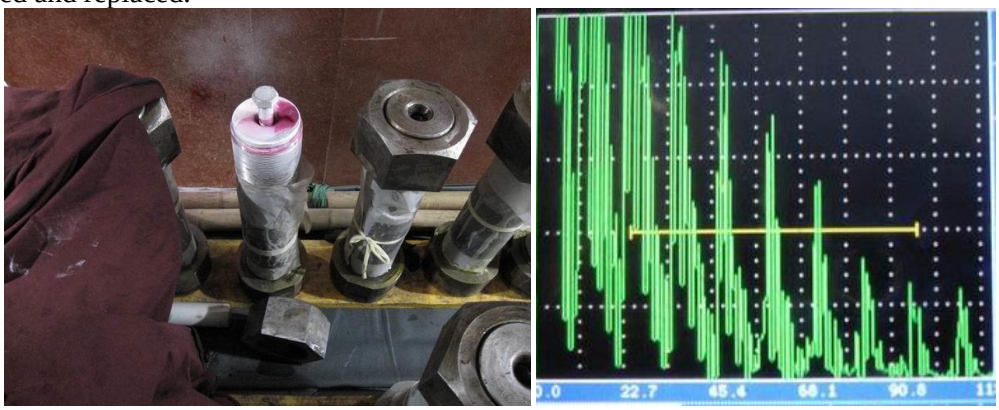

Figure 4. Stratified defect of generator coupling bolt.

3.5 speed regulating ring combination bolt

One bolt of the speed-regulating ring combination bolt was found to have excessive defects during UT inspection. The defect was located at the connection between the screw and the bolt head (175mm from the end down). The defect echo covered the bottom wave, which was judged as beyond standard defect and the bolt was rejected (Figure 5).

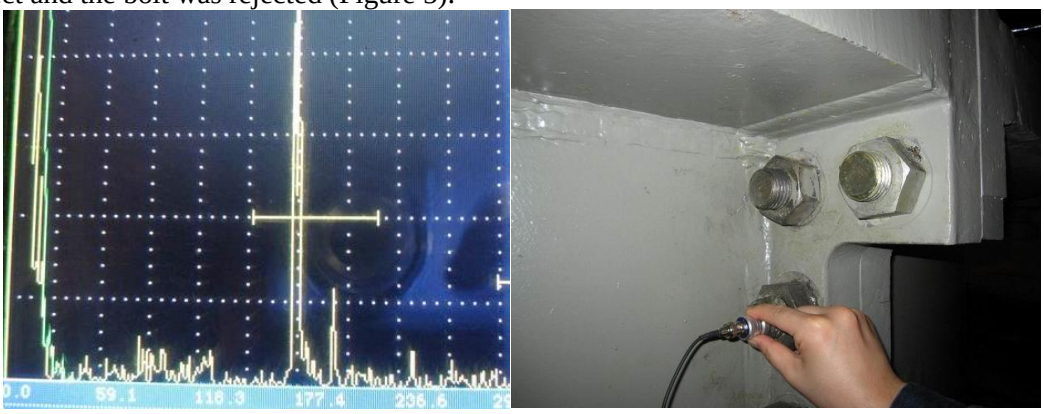

Figure 5. Excessive defect of speed regulating ring combination bolt.

3.6 Seat ring bolt for top cover

The bolt of top cover setting ring will be closed on the setting ring, which is the bolt with the highest bearing stress in the hydrogenerator set. The direct cause of the accident in the flooded workshop of the Sayang hydropower plant in Russia was that the bolt of the top cover setting ring fell off or broke, which led to the damage of the unit and the serious accident in the flooded workshop. During the maintenance of a unit, all the bolts of the top cover sitting ring of the unit were penetrated 56 bolts in total. It was found to have cracks at the root of the thread (Figure 6) through penetrating. The cracks were all distributed at the stress concentration at the root of the thread.

Figure 6. Penetration detection of hold-down bolts with cover setting ring.

4. Conclusion

For the incoming inspection of new bolts, physical and chemical properties and ultrasonic testing can be used to ensure the quality of bolts. In the service process of high-strength bolts, it is widely used by ultrasonic flaw detection, it is also used by penetration detection if necessary. The defects can be effectively founding the service process of bolts through non-destructive testing, preventing defective bolts to continue to operate and ensuring the safety of the unit.

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