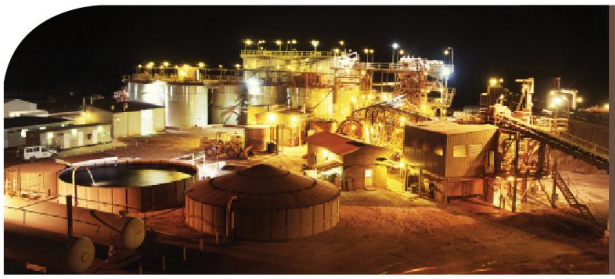
ALS Asset Care



AssetCare Counts #16

November 2012

Advanced Phased Array Ultrasonic Testing (PAUT) Development – Complex Turbine Blade Roots

The last stage blades of low pressure steam turbine rotors are among the most highly stressed components in modern power generating plants. Among the various blade root fixing designs a popular configuration, especially in older designs, is the pinned finger root as illustrated in Figure 1.

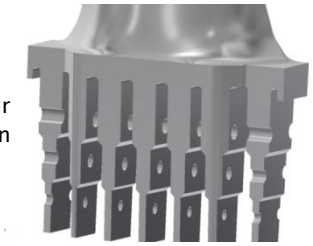


Figure 1 - Pinned finger root design

This consists of varying numbers of blade root fingers designed to interleave matching slots in the rotor disk and locked in place by steel root pins. The tendency of blade roots to suffer failure induced by stress corrosion cracking, high-cycle fatigue cracking, or low-cycle high strain fatigue, is well documented, and can be shown to be most likely to occur in the upper pin holes of the blade root. Finite element analysis and actual failures confirm the regions under highest risk and have driven developments in ultrasonic phased array techniques to achieve detection of defects in these regions. Due to the complexity of the root geometry there are many difficulties in applying ultrasonic techniques due to limited scanning surfaces, inter-blade spacing, and disorientation of the active ultrasound trajectory and the region under test. In order to achieve sensitivity and coverage of complex blade root designs it is necessary to utilise the latest advanced phased array simulation and modelling tools which facilitate the development of highly complex and targeted inspections.

A recent inspection requiring advanced development methodology to inspect a GE derivative Hitachi/Toshiba rotor was undertaken at an ALS Industrial major client with significant success. Spare blades were laser scanned and modelled in-house to produce parametric solid models and advanced simulation tools were then used to target the critical regions of the upper pin holes on each finger. Each individual hole-finger corner combination was targeted with a complex ultrasonic wedge designed to normalise the ultrasound trajectories to the target zones, see Figure 2.

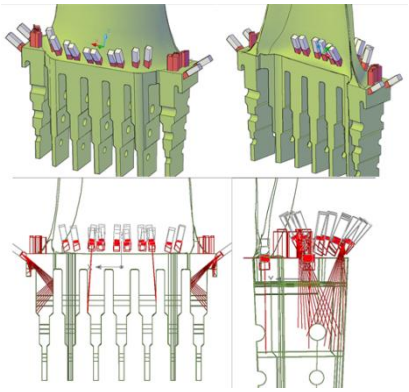


Figure 2 – Advanced design and simulation

To facilitate the accurate and repeatable positioning of each inspection, bespoke scanning jigs were designed and manufactured, see Figure 3.

Using scrap blades containing simulated defects, each target inspection position was validated to prove the accuracy and sensitivity to each position.

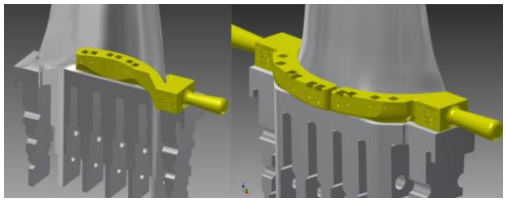


Figure 3 – Bespoke positioning jigs

After deployment of this inspection at the client premises, the inspection was successful in identifying a number of blades containing cracks in the critical positions which unchecked could have led to catastrophic failure of the rotor. Figure 4 shows some of the phased array images taken during the inspection while Figure 5 shows the actual defects which were confirmed after removal of the blades from the rotor. The results showed that not only could the defects be positively detected but they could be characterised and accurately measured using the bespoke inspection technique.

The results from this development and inspection package illustrate how advanced design and simulation tools employed by ALS Industrial Power Services, offer an unprecedented level of accuracy, sensitivity and repeatability; facilitating the application of phased array ultrasonic testing to highly complex components which would otherwise prove difficult if not impossible to inspect. These methodologies have been developed over many years on many different complex component designs and offer significant improvements and cost savings to our clients. An engineered approach using the latest in modelling, simulation and ultrasonic technology has led to significant advances in what is achievable in non-destructive testing.

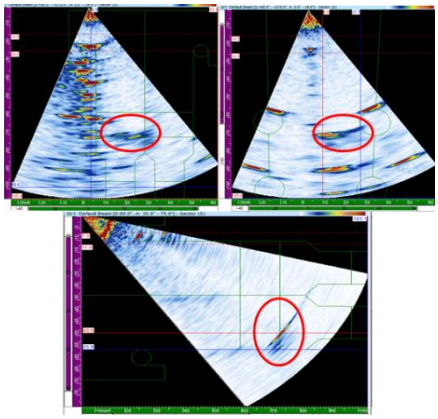


Figure 4 – Phased array images of root finger crack

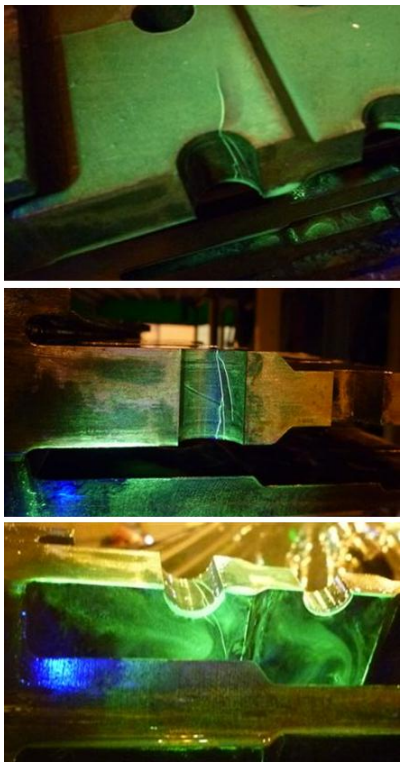


Figure 5 – Cracking to outlet side leg enhanced by FMPI

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