Case study: Recovery turbine blade shroud separation

1. Background

The 17MW Geothermal steam turbine had been operating for many years with a leak in the casing half joint. The leaks that were at the same position on both sides of the casing could be traced back three outage cycles and each time an attempt was made to resolve the leak.

The leak was such that a draining system was installed to drain the water away from the turbine casing and insulation.

During the first cylinder overhaul outage by ProGen, a plan was proposed to address the problem that was investigated and executed to address the issue of the cause of the leak and the reason it has been reoccurring.

2. Findings

Upon stripping the casing, care was taken not to damage the evidence surrounding the area of the leaks.

Figure 1 Casing half joint leak in operation

Figure 2 Leak position in the bottom casing

Clear evidence was found that steam leaked through the half joint from the diaphragm circumferential slot to the bolt hole as shown in Figure 2. With the casings cleaned and bolted together the contact blue check revealed contact in the area of the leak as was also reported during previous outages. A surface plate blue check was done and the result showed that the joint was not 100% flat in the unbolted condition with the leak area showing no blue contact. This gap was however very small and no gap could be measured with the casings in the unbolted condition assembled. This indicated that the casing was deformed during bolting to make contact and that the contact was not constant along the half joint surface.

No other problems such as diaphragms or keys could be identified that would restrain the closure of the half joint with all components fitted. Sufficient thermal expansion clearance was present for all components to ensure adequate clamping force of the half-joint bolts.

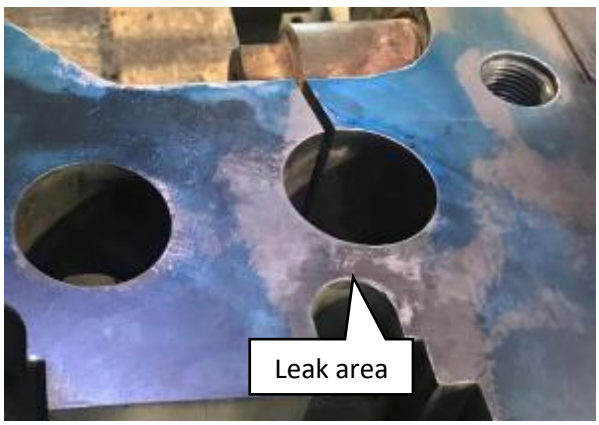

Figure 3 Surface plate blue check result

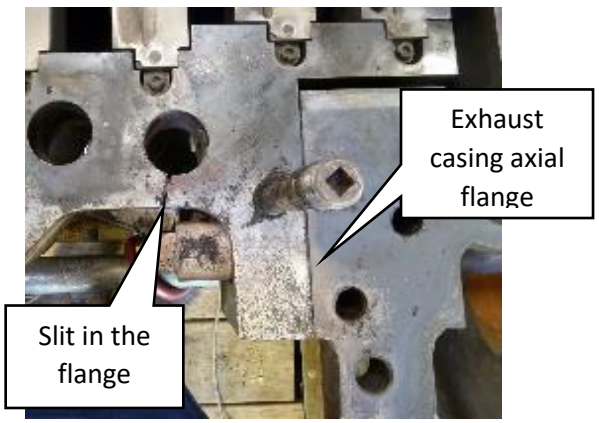

Figure 4 the exhaust casing flange and interface

3. Analysis and solution

The above evidence was considered to search for a possible phenomenon because of operational parameters acting on the casing that could affect the half joint clamping force. The specific casing geometry and operational conditions that would influence the casing geometry were evaluated and a theory for the phenomenon formed. It was formulated that the exhaust casing section, connected to the casing via an axial flange at the position to the rear of the leak area, is restricting the normal thermal expansion of the casing which was causing distortion in the casing during operation. The leak area has a design feature to increase flexibility, in the form of a slit from the flange outer surface to the bolt hole, which was causing a reduction in the clamping force from the bolts.

This analysis was then considered in terms of developing a solution which then lead to the following actions:

1. the leak area was brazed up and worked down to the same level as the surrounding surface;
2. following this, a surface plate and scraping was used to ensure the mating surfaces were 100% flat for both casing halves;
3. the casing was then scraped to improve the leak prone area clamping force according to the analysis;
4. for the re-build, a customised bolting procedure was devised to ensure maximum clamping force of the joint while staying within the bolt tightening specifications; and
5. the joint sealant was changed to a compound more suitable for the specific casing and the bolting procedure.

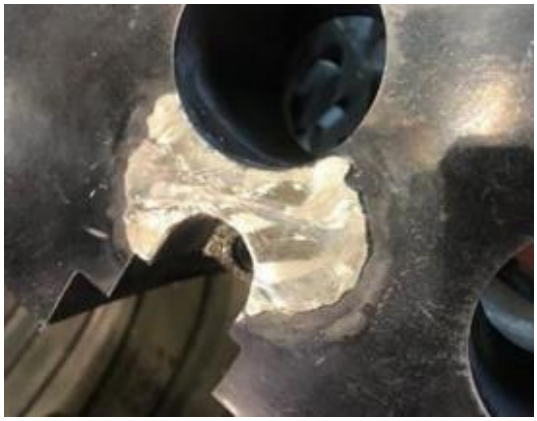

Figure 5 The leak area build up with Brazing

Figure 6 Scraping of the casing to improve clamping

4. Result

The turbine was returned to service without the leak and is operating satisfactorily without problem.

Following the outage ProGen carried out an FEA study on the casing that determined the behaviour from the cold-bolted condition to the hot operational condition. The results compared remarkably well with the analysis done during the outage and it proved that the actions taken during the outage were correct to address the problem.

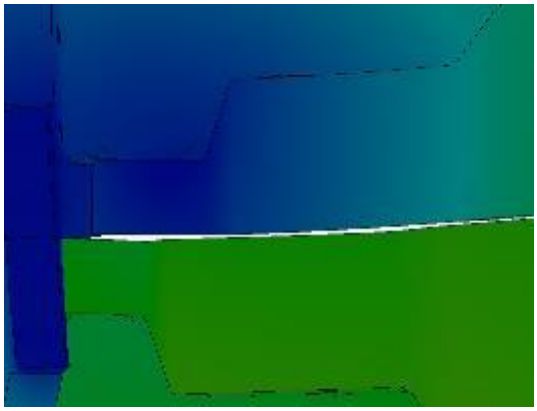

Figure 8 FEA results showing an opening force

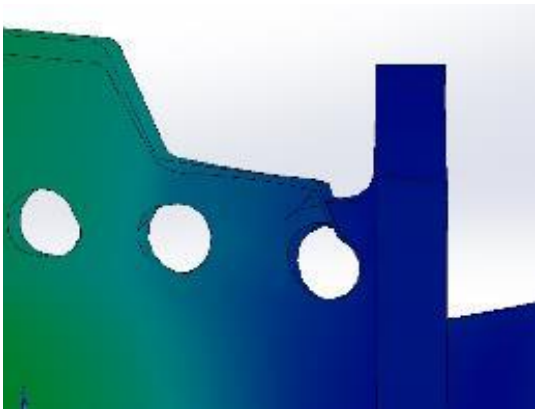

Figure 8 FEA results showing axial the distortion