QUARTZELEC TECHNICAL BULLETIN

Industry has moved to adopting 18/18 as its latest 'standard' steel for retaining rings. These high quality steels are fully stainless to prevent SCC, but are not fully corrosion resistant and Quartzelec have found incidents where corrosion has proven to cause critical damage. This article discusses how smart engineering studies and considered decisions could salvage retaining rings which otherwise would be scrapped.

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HOW

TO RECOVER CORRODED RETAINING RINGS

INTRODUCTION

When Quartzelec has been contracted to perform generator major overhauls including the removal of rotor retaining rings, we have found that the industry standard stainless 18/18 material, under certain conditions will corrode. This in turn could lead to fatigue cracking and increase the risk of Stress Corrosion Cracking (SCC) even in 18/18 steel. SCC (in particular) has in the past been known to cause catastrophic generator failure or at a minimum, has extended planned shutdown times, to enable repair work.

Theory

Most generator designs will have a separate damper winding with copper 'fingers' placed underneath the retaining rings. Very often, damper cage contact points are silver plated to improve the conductivity. Such a design allows the large circulating currents seen on Gas Turbine (GT) "motor" starting (whereby the generator is used to start the machine rotation) to flow safely around the damper cage, similarly it prevents damage during undesirable generator transient conditions.

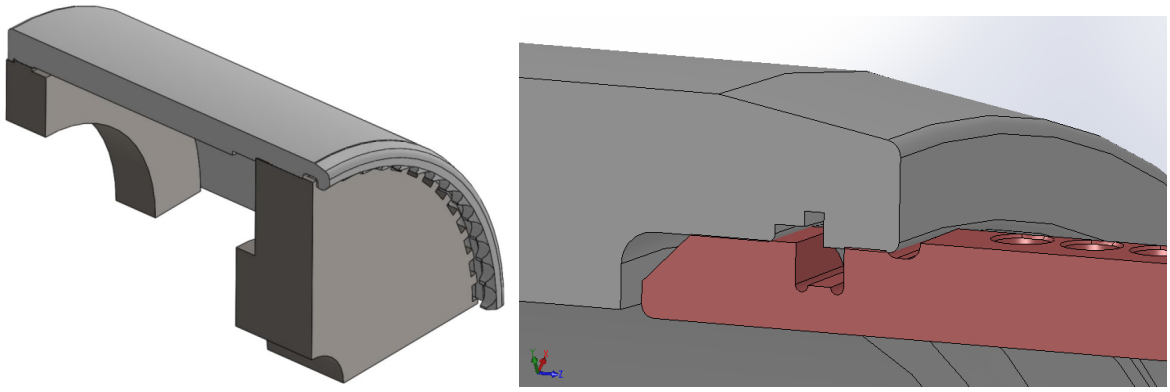

Figure 1. Rotor retaining ring shrink fit

Most retaining rings are secured to the rotor using an interference fit between the nose and the rotor body. The ring deflection from the asymmetric load from the end-winding copper is homogenised with a centring ring at the outboard end, which is also held with an interference fit and located axially with a spigot. During assembly, the rings are heated (expanded) in a controlled manner and fitted over the rotor body shrink fit area.

Example

On one particular and very recent occasion during the routine outage of a 200MW generator, a simple visual and (subsequent) dye penetrant inspection located a high level of pitting mapping the position of mating components in the retaining ring bore, inboard of the centring ring and at the nose in the axial locking groove and around the damper segments. Local polishing appeared to make the defects more prominent indicating occluded pitting.

A more detailed NDT including Replica and Ultraviolet dye penetrant test were performed, and the report confirmed that the indications were formed from corrosion rather than electrical arcing.

Figure 2. Shrink fit pitting

Figure 3. Shrink fit pitting after polishing

Figure 4. RR groove pitting

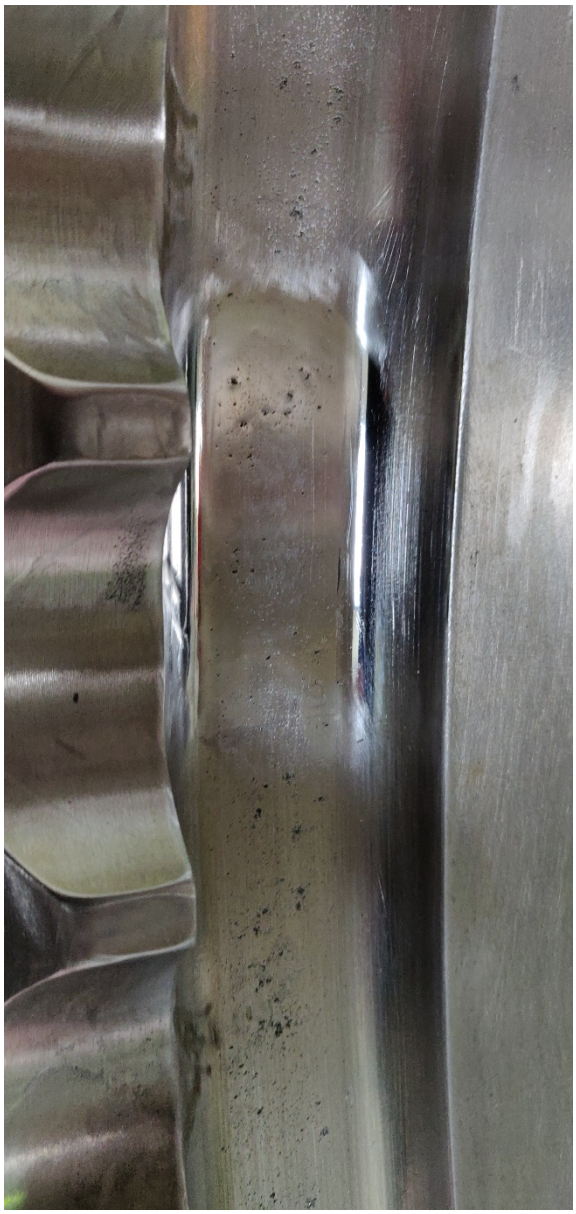

Figure 5. RR groove pitting after polishing

Corrosion Mechanism

Corrosion develops where surface passivity films have been destroyed, and the corrosion products from a pit attack are often found to create a lid on top of the pit, with only a very small opening; very similar to these occluded pits found by Quartzelec.

Moisture, if present, is drawn into crevices, often by being centrifuged outward by the rotation of the shaft and the moisture becomes entrapped or drawn into gaps under capillary action. When deprived of oxygen, stainless steel lacks the ability to re-form a passivating film of chromium oxide and crevice corrosion occurs.

SHOULD WE SCRAP THE RINGS?

Does such corrosion automatically render the rings as end-of-life? In many cases, that may well be the outcome, however Quartzelec has been able to offer alternative approaches backed up by rigorous engineering.

Retaining rings stress analysis

For the 200MW generator project, the existing retaining ring stresses and interference fit were calculated at standstill and overspeed using thin cylinder theory and Finite Element Analysis. The calculations were repeated to simulate the machining needed to radially remove material from the retaining ring to rotor interference fit diameter, bore diameter and inboard groove to remove the defects found.

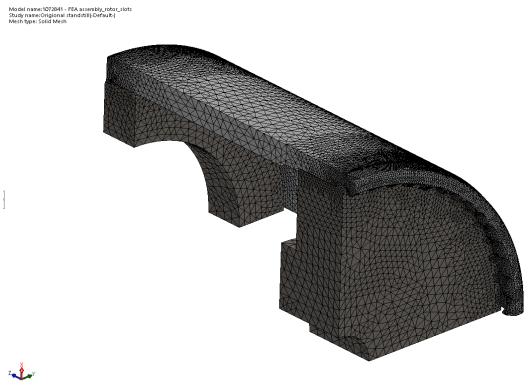

Figure 6. Mesh details

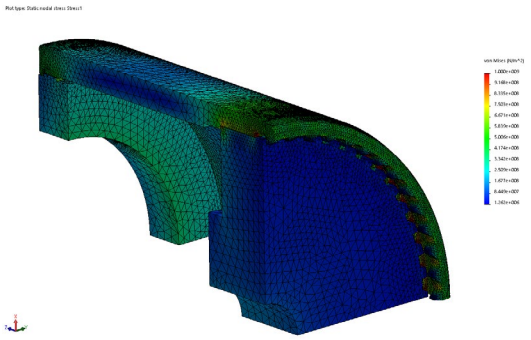

Figure 7. Von Mises stress

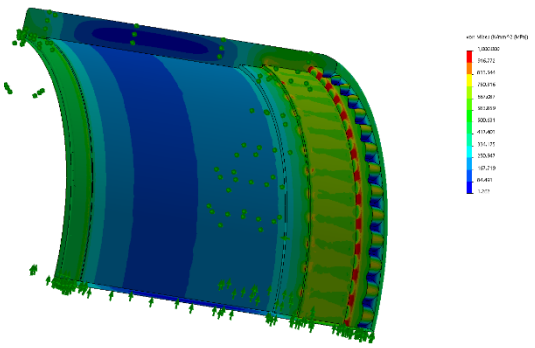

Figure 8. Displacement

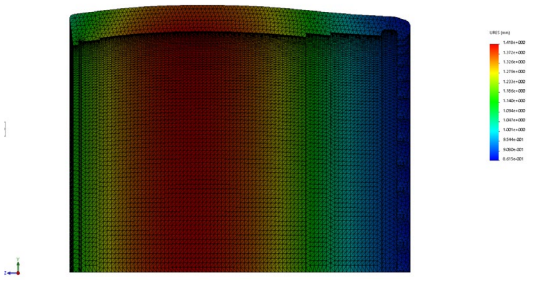

Figure 9. The ring loses fit due to rotation and copper load

On this particular occasion, we concluded that the rings would be safe after machining and we instructed the machinist to carefully remove the corroded material.

CONCLUSION

For the mentioned 200MW generator project, Quartzelec was able to successfully rehabilitate the rings and they have been back in successful operation until the time of writing. Due to lack of availability of replacement rings this saved the customer circa nine months of generation.

Defects in a retaining ring can lead to in-service failure, the consequences are catastrophic and the potential for loss of life is real. As a result, Quartzelec will always take a safety-first approach when considering any repair strategy.

18/18 stainless steel is not fully resistant to corrosion and if not corrected can lead to failure and early-stage pitting is difficult to detect without removing the retaining rings.

Our experiences show that such pitting is more likely to appear on generators coupled with Gas Turbines if they use frequency converters and the main generator during the run-up process. This does not mean that similar conditions could not be created on generators connected to Steam Turbines and controlling the environment within the generator is vital – such as ensuring anti-condensation heaters are operational, and cooling water is off when the generator is shutdown.

RECOMMENDATION

Our recent engineering studies have confirmed that machining away a certain amount of material radially, even from the shrink fit diameter, may not adversely affect the retaining ring mechanical integrity and function. Depending on the design and safety factor applied by the generator manufacturer, some reduction in interference fit could still maintain the shrink fit up to 120% overspeed.

To allow a thorough non-destructive inspection of the inner diameter of the retaining rings, it is prudent to perform a “rings off” inspection every time a generator major overhaul takes place.

During periods of shutdown, generator temperatures should always be kept above the dew point to prevent condensation on cold metal surfaces.

If corrosion or pitting is found on the shrink fit diameters, it might still be possible to rehabilitate the retaining rings by careful modification guided by an appropriate engineering study.

Do you have a question?

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