CASE STUDY

Fitness-For-Service Assessment of Turbine Headcover

Challenge

During the late 1980s, leakage was discovered in the headcover (see Figure 1) of a 30MW Francis Turbine operating in water with large amounts of pumice sand. According to Mercury, these erosive conditions damaged the turbine headcover. In an attempt to reduce the erosion rate, stainless steel inserts were installed; however, by the mid- 1990s, the leaking had returned. Mercury again installed stainless steel inserts, which are still present, although considerably eroded. A recent NDT inspection indicated that in some areas, erosion of the inserts was significant enough to have exposed the carbon steel from the original headcover. It was Mercury's concern that damage to the headcover caused by the erosion-corrosion would comprise the safe operation of the turbine.

- A fitness-for-service assessment including 3D elastic and elastic-plastic finite element analyses (FEA) was conducted on three headcover models (see Figure 2).
- The elastic FEA determined the location and magnitude of peak stresses based on normal to extreme loading conditions. The results were then compared to calculated maximum allowable stresses.
- The non-linear elastic-plastic FEA was conducted on the completely eroded model to determine the magnitude of an applied load that would result in overall structural instability (prediction of a failure pressure).

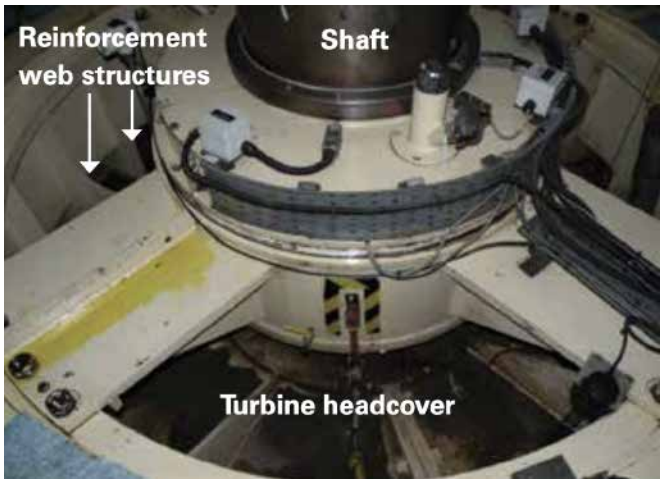
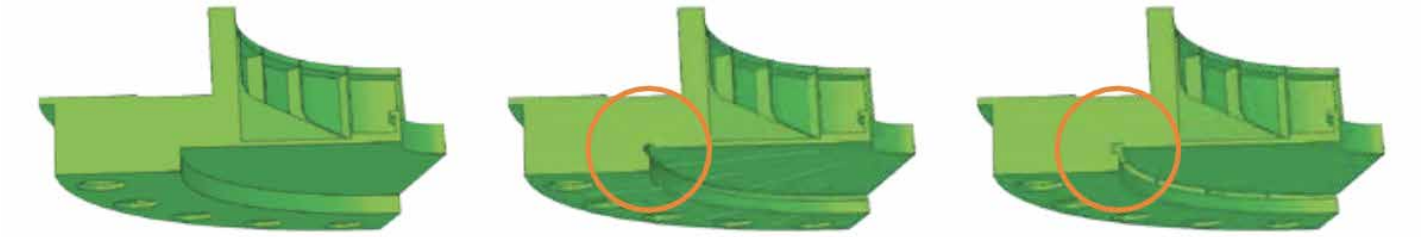


Figure 1: Shaft, bearing housing and headcover of 30MW Francis Turbine

- This approach was in accordance with API 579-1/ ASME FFS-1 Fitness-for-Service guidelines and provided quantitative evidence to Mercury for the continued service of the headcover.

Finite Element Models



Model 1: Headcover model without erosion damage (as designed)

Model 2: Headcover model with actual erosion damage

Model 1: Headcover model with through thickness erosion

Figure 2: Finite element models which represent the various levels of erosion damage

Results

- The finite element models with assumed erosion profiles were developed and linear elastic analysis was carried out for the headcover subject to operating pressure to determine the stresses.
- From the assessment it can be concluded that the acceptability criterion specified in API 579/ASME FFS-1 were met, indicating that the current erosion damage and/or possible future damage in the headcover, under the current operating conditions, is considered acceptable.

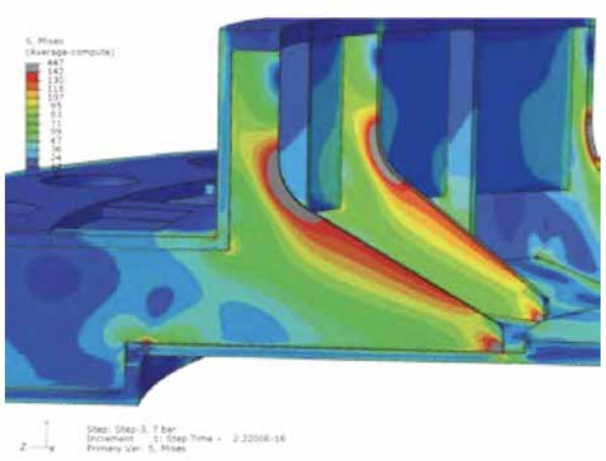


Figure 3: Paths for stress categorization from the linear-elastic FEA

- The failure pressure or a global plastic collapse load of the headcover was established by performing an elastic-plastic FE analysis of the headcover (see Figure 4). The maximum applied load (internal pressure) that the headcover model was stable without incurring plastic collapse was 319 psi (22 bar).
- In summary, it can be concluded that the erosion damage detected on the headcover was acceptable for fitness-for-service of the turbine unit, as the normal operating pressure in the headcover is approximately 1 bar, and even under abnormal conditions can not reach 7 bar.

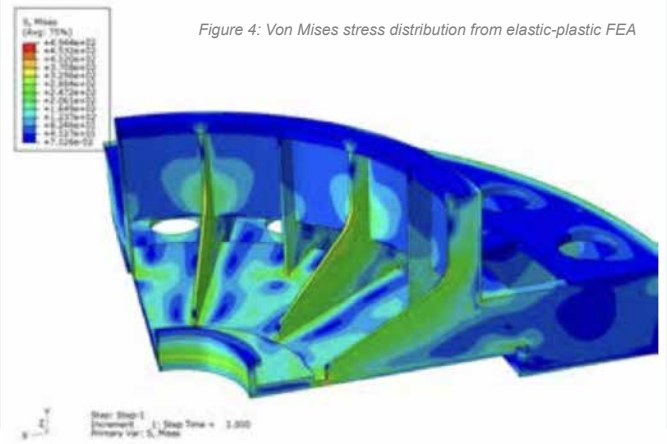


Figure 4: Von Mises stress distribution from elastic-plastic FEA