Creep Assessment of Boiler Gas Seal

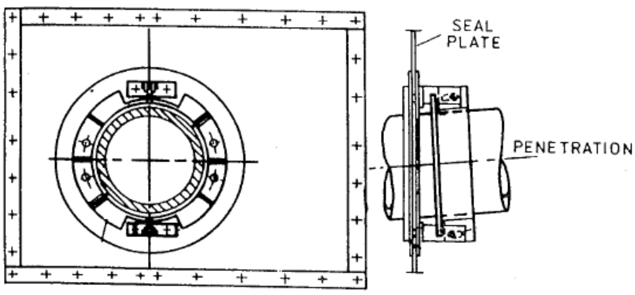
Case study

The client wanted a safety case to extend the operating life of a power station boiler gas seal by several years. The component is a seal plate through which a steam penetration passes into the boiler casing. The gas seal operates at high temperature in a carbon dioxide environment and following a review of the effects of corrosion, concerns were highlighted over possible thinning. Owing to its location, inspection of the component was deemed impractical. Previous assessments had considered only the uncorroded state, and it was considered that creep damage for the corroded state could undermine the proposal to extend the plant life.

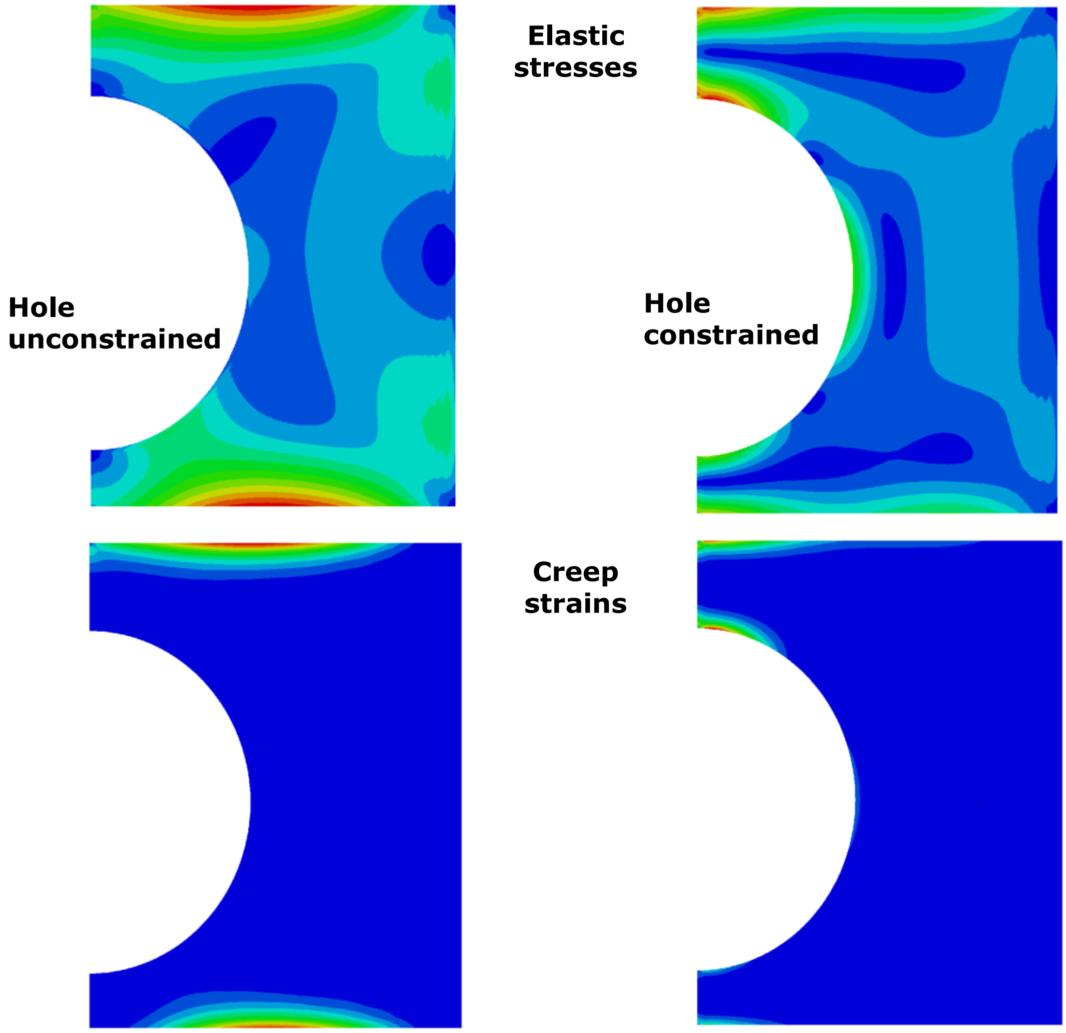
Our approach

The seal plate under consideration forms part of the pressure boundary between the lower pressure boiler gas within the boiler casing and the higher pressure gas in the surrounding annulus. A labyrinth seal is formed between the plate and a pair of flexible discs attached to the penetration. The plate is sandwiched between the two discs producing an effective seal.

From consideration of previous assessments it was clear that creep was the only significant damage mechanism affecting the component and differential pressure loading provided the only significant source of stress. A revised assessment was planned, based on a new finite element analysis of one half of the plate. In order to reduce any unnecessary conservatism inherent in the modelling, changes were made to more accurately model the loading and boundary conditions affecting the component.



Firstly, the new finite element model only included the unsupported portion of the plate, as those parts which are backed by the frame are considered to be effectively unloaded. Secondly, two alternative sets of boundary conditions were modelled, one in which the hole edges were unconstrained and another in which the hole edge nodes were constrained to lie in a plane, with symmetrical displacements on either side of the hole. The two cases were considered to represent minimum and maximum constraint conditions, with the real case somewhere in between.



With the new model constructed, three types of analyses were run. An elastic stress analysis was run to obtain maximum elastic stresses. An elastic-perfectly-plastic (limit) analysis was run to determine the point of collapse and hence a reference stress for the component. A creep analysis was also carried out with a user subroutine implementing an RCC-MR creep deformation law for stainless steel.

The result

Consideration of potential sources of secondary stress made it clear that there would be no influence of cyclic loading on creep and that fatigue damage would be negligible. It was considered appropriate therefore to provide a time-fraction (creep rupture) damage. This was calculated using a rupture reference stress based on the results of the limit analysis enhanced to account for the effects of stress concentration as determined from the elastic analysis. In addition, the maximum creep strain obtained from the creep analysis was used to provide a creep damage as a fraction of the material creep ductility.

The creep damages calculated were small and in fact improved upon the results of previous analyses due to refinement of the finite element modelling.

EASL demonstrated that creep damage over the proposed extended life would remain low even allowing for significant levels of material loss through corrosion. By repeating the assessment at a hotter temperature, EASL demonstrated that a significant increase in operating temperature could be justified.

If you'd like to know more, please contact us or take a look at our website.

engineering analysis services ltd.
2 Edward Court, George Richards Way, Altrincham, WA14 5GL
0161 923 0070 www.easl-stress.co.uk