Analysis and Assessment of Abnormal Trip Transient for AGR Boiler Components

Case study

During August 2007, one of the client's advanced gas reactors underwent an unplanned automatic trip during which there was post-trip overfeeding to one quadrant. As a result, there were rapid reductions in measured steam temperatures in instrumented parts of the boiler. Immediately, the structural integrity implications of the event were assessed and the ensuing report recommended a programme of boiler modelling, structural analyses and assessments to underwrite the ongoing integrity. This programme of work was completed by EASL. The benefit to the client was the long term confidence in the integrity of the plant following the unplanned operational event.

Reducing stress

The superheater penetration tubeplate was one area of particular concern. The tubeplate forms part of the reactor gas pressure boundary and operates in the creep regime.

Transient thermal loading during normal trip transients and during initial boiler feeding give rise to the potential threat of creep-fatigue crack initiation at the tube bores – the main integrity concern.

The transient thermal loading during the abnormal transient was expected to be far more severe than a normal trip. Sequentially coupled transient heat transfer and stress analyses of the tubeplate were carried out.

As expected stresses well beyond the shakedown limits of the structure were predicted using an elastic analysis and the transient was re-run using a non-linear analysis to assess shakedown and fatigue damage accumulation by considering strain accumulation during cyclic loading.

It was shown that the strain accumulation for the limited number of severe loading cycles experienced was low and that the state of residual stress in the body following the transient was actually beneficial for future operation, as the residual stress field induced was compressive at the tube bores.

A whole boiler unit model was created to facilitate analysis and assessment of other critical boiler components. One complete boiler platen was modelled extending from the economiser inlet to the superheater outlet. The support and constraint provided by the boiler casing was also modelled. Each boiler unit contains 44 such platens.

The project

Quasi-steady state transient heat transfer and stress analyses were carried out to determine the state of stress at various critical time steps during the transient. By necessity these were elastic analyses and owing to the limitations of the available whole boiler heat transfer modelling used as an input to the study, thermal inertia effects could not be represented. Arguments based on the relative thermal transient effects in the various platen components were used to justify the use of quasi-steady state analysis.

Creep-fatigue initiation assessments for various components were carried out including transition joints between different boiler tube materials, the bifurcations where pairs of boiler tubes join to form a single tailpipe for steam exiting the boiler and the spacers which are designed to maintain the correct spacing between the serpentine tubes forming the main boiler heat transfer surfaces.

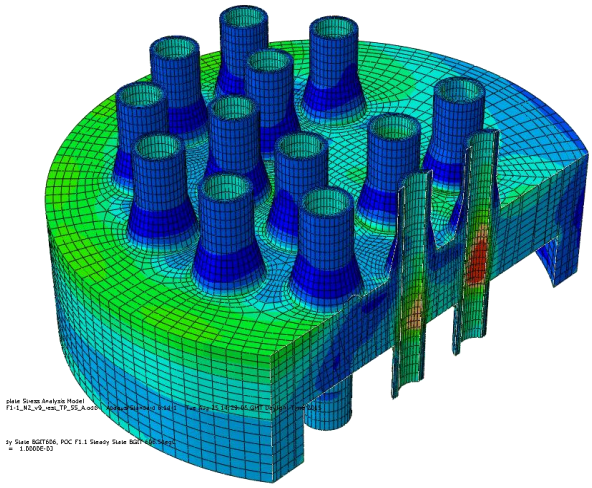

Figure 1 FE modelling of the tubeplate

Other applications

The complex technical challenges on this task were met within the tight timescales specified. EASL's work was used to underwrite the ongoing integrity of the plant to the client's satisfaction following the unplanned operational event.

EASL always work with clients to identify cost effective solutions to operational challenges.

If you would like to discuss how EASL can help your business please get in touch.

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