Thermal Stresses in the COGD Skirt Under Flooded Conditions

Case study

Fracture assessments of the gas baffle and circulator outlet gas duct (COGD) for normal operation and overpressure fault loading have recently been carried out as part of the second periodic safety review of two of the client's nuclear power stations.

These assessments were carried out principally to take account of the latest estimates of the maximum pressure differences across the gas baffle and also to incorporate the latest information on the welding residual stresses. More recently, the work has been extended to consider the fracture assessment at the gas baffle doubler plate and small nozzles in the COGD. A requirement arose as part of the consolidated boiler tube failure safety case to consider the integrity of the gas baffle under a postulated post-trip natural circulation cooling fault.

Our approach

A series of postulated scenarios were analysed in MACE and the results were assessed to determine the likelihood of a significant challenge to the integrity of the gas baffle. It is understood that in the event of multiple boiler tube failure a COGD quadrant may fill with water raining out from saturated steam.

One potential adverse consequence arising from this is the heating of pressure vessel cooling water (PVCW) supplied to the insulated lower part of the COGD skirt. This was also assessed, as well as the return in an uninsulated section of pipes bridging between the pre-stressed concrete reactor pressure vessels (PCPV) and the COGD across the lower annulus under flooded conditions. The assessment showed that boiling of the PVCW would not occur but that significant temperature increases in the PVCW supply to the COGD skirt could occur whilst the liner floor

temperature would remain substantially unaffected.

The thermal stresses arising from the temperature differential between the PVCW supply to the skirt and the temperature of the liner floor were analysed. The consequences for the integrity of the COGD and liner anchor ring were assessed. The analysis and assessment is equally applicable to flooded or unflooded quadrants.

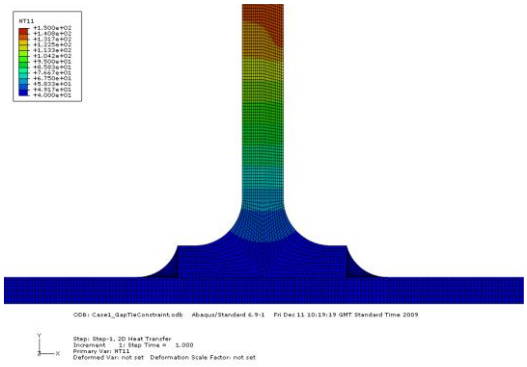

Figure 1 Model with tie node constraint

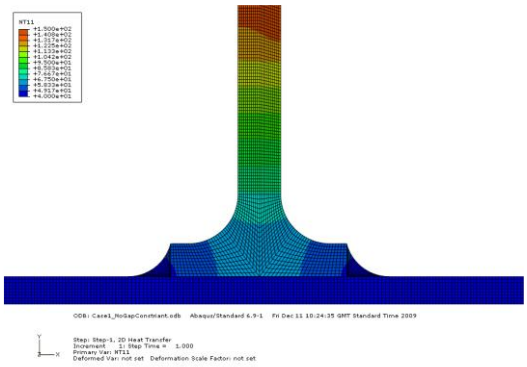

Figure 2 Model without the node constraint

Axisymmetric finite element models of the COGD skirt were created and analysed using ABAQUS. The resulting hoop stresses were compared with those used in the existing fracture assessment of the axial skirt welds.

Results

The assessment showed that boiling of the PVCW would not occur but that the temperature of the PVCW supply to the COGD skirt could increase by up to 150°C whilst the liner floor temperature would remain substantially unaffected. Axisymmetric finite element models of the COGD skirt have been created and analysed. No significant differences in the hoop and axial stresses are evident between the two configurations.

High axial bending stresses occur at the COGD to anchor ring weld and the maximum value is approximately 440 MPa calculated on a linear, elastic basis. Since this weld is not IoF, and there are no known defects, there is no requirement for a fracture assessment for an infrequent fault such as that, and, since thermal stresses are secondary, the code assessment is trivial and acceptable.

Stresses used in the existing fracture assessments of the COGD and the COGD nozzles have been reviewed for comparison. These found that the maximum tensile hoop stresses evaluated for this fault are bounded by those considered in existing fracture assessments of axial defects in the COGD skirt.

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