T73S03 (R5V4/5/7) – Session 43 Homework

Mentor Guide Questions

[1.46] Describe the R5 V4/5 Appendix A3 procedure for calculating a relaxing reference stress under combined primary and secondary loading.

[1.47] Describe in outline how the calculation of the relaxing reference stress is modified if the crack growth is a significant fraction of the remaining ligament.

[1.48] Write down the R5 V4/5 Appendix A3 estimation formula for C(t) in terms of the relaxing reference stress under combined primary and secondary loading. Identify the physical meaning of the two factors in this expression with reference to the estimation formulae from 1.42 and 1.44.

[1.49] Describe how the C(t) estimation formula in 7.7 is changed when account is taken of plasticity.

[1.50] State the relationship between the power-law creep index n and the exponent q in the creep crack growth law $\dot{a} = AC(t)^q$. Explain why this is relevant in estimating C(t).

[1.51] Derive an expression for the creep crack growth in terms of K for sufficiently early times ($t << t_{red}$) starting from the law $da/dt = AC(t)^q$. Discuss the temperature dependence of the resulting expression.

[1.52] State the simplified C(t) estimation formula from R5 V7 applicable to primary plus secondary stresses. Explain the main differences between the R5V7 approach and that of R5V4/5A3. State the plant features to which the R5V7 approach is applicable.

[1.53] Define the datum of time or strain to be used in calculating C(t) for a service induced crack.

PTO...

Numerical Question

During an outage, repairs have been carried out to a region of main steam CMV pipework by inserting some new CMV spool pieces. You are to assess crack growth rates of a fully circumferential crack which is postulated to initiate immediately on return to service in a new narrow-angle MMA weld connecting two new CMV spool pieces. The crack may lie within any of the weldment zones. An incubation period of 250 hours can be claimed. The weld is of 2.25%Cr1%Mo consumable, as is usual for CMV weldments in our plant. The operating temperature is 525°C.

The new weld was subject to PWHT before return to service, but some residual stresses are assumed to remain. For the postulated defect the operating pressure produces a reference stress of 75 MPa and a SIF of 4 MPa√m. The remnant residual stress produces a SIF of 7 MPa√m. There are no other sources of stress.

Because the only primary load is pressure you should assume hoop dominance (*Hint: check carefully what strain and strain rate should be used, and in what parts of the calculation k should be used, for each weldment zone. Further Hint: this considerably eases your task because you will only need to code the parent deformation equation, not the other zones*).

Fatigue and cyclic effects may be neglected.

Use the methodology of R5V7 to calculate the crack growth of all the weldment zones in a 3 year operating period (100% load factor). For simplicity assume that the crack growth does not significantly alter the reference stress or the SIFs. For this exercise use best estimate creep deformation and best estimate ccg laws (a full assessment would require the LB/UB and UB/LB combinations also – you can do these too if you are keen). Rank the weldment zones in order of crack growth (addressing weld, coarse HAZ, mixed HAZ, Type IV region and parent).

Use materials data from R66 Rev.009. Use the parent deformation equation.(5.5) “theta fit”.

In addition use,

- k factors from R5V7 Figures A7.2(a), A7.3 and A7.4;
- Crack growth laws from R66. This does not give lower bounds for parent and coarse HAZ, so use “A” equal to one-third of the mean;
- E = 171 GPa (for parent and weld);
- Define n in the C(t) formula by $n = \dfrac{q}{1-q}$.

You will need to integrate over time because the crack growth rate varies markedly over the period.