T73S03 Tutorial Session 40A: Homework – Mechanisms and Preliminaries

Mentor Guide Knowledge & Skills Questions

(1.7) State the main mechanisms which might lead to creep crack initiation in BE plant.

(1.8) Define what is meant by "Type IV" cracking in low alloy ferritic weldments. State the key factors leading to Type IV cracking. State the best means of mitigating against Type IV cracking.

(1.9) Describe the reheat cracking mechanism and the key contributing factors to its occurrence. Compare and contrast the reheat cracking threat for ferritic and austenitic weldments. State the phase of operating life in which the initiation of reheat cracking is most likely for both ferritic and austenitic materials under AGR plant conditions. State the best means of mitigating against reheat cracking.

(1.10) State what is meant by 'creep-fatigue initiation'. State under what conditions a creep-fatigue crack is likely to initiate.

(1.11) Describe the threat from thermal fatigue cracking, for BE and conventional power plant, in respect of: (a)the bore of main steam pipework; (b)the ligaments of superheater headers; (c)thick section components such as steam chests, turbine casings, valve bodies and tubeplates; (d)small bore branches on steam pipes or headers. State the best means of mitigating against these threats in each case.

(1.12) Discuss other fatigue crack initiation mechanisms and the applicability and limitations of R5 to their prediction and/or assessment.

(1.13) State the prescription within R5 Volume 4/5 for determining whether creep is significant

(1.14) Describe the conditions required by R5 for cyclic loading to be considered as insignificant, both as regards the uncracked ligament and the crack tip region.

(1.15) State the conditions under which it is necessary to apply fatigue crack growth data obtained from tests including creep dwells.

(1.16) State how the stability of the crack, e.g. against fast fracture, should be determined.

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Numerical Question

Consider again the question from session 39:-

"*A crack on plant was formed during fabrication but only incubates (i.e., starts to grow) after 10,000 hours. It has K = 20 MPa√m and E = 160 GPa. Assuming no plasticity, no secondary stresses and purely secondary creep, evaluate C(t) assuming the short time expression is valid and that the material has a creep exponent of n = 4. If the creep crack growth law is* $\frac{da}{dt} = A.C(t)^q$ *with A = 0.221 and q = 0.891, where the units are MPa, metres and hours, find the initial rate of crack growth in mm/year*."

The above crack is hypothesised to arise as a welding defect due to a repair carried out in the current outage. You are assessing the case for running to the next-but-one statutory outage before re-inspection (i.e., 6 years). PWHT was carried out, so residual stresses can be ignored. The loading is as stated above (primary only) and the constant secondary creep strain rate (evaluated at the reference stress of 100 MPa) is 0.36×10^{-8} absolute/hour.

Find the total crack growth over a six year period. Compare this with the crack growth that would be estimated if the initial growth rate after incubation were assumed constant.

For this exercise assume that,

a) The short-time formula for C(t) applies until it reaches the C* asymptote, and,

b) It is sufficiently accurate to ignore the effect of crack growth on the reference stress, the SIF and the creep strain rate. (A more accurate assessment would take account of these variations).

Hint: Consider three time periods: (i)incubation, (ii)the C(t) regime, and, (iii)the C* regime. Identify at what time (ii) gives way to (iii). Use the session 39 notes to find suitable estimation formulae for C(t) in period (ii) and C* in period (iii). Remember that crack growth rate will vary over period (ii), requiring integration.

NB: This is not the way C(t) would normally be estimated in assessments. The recommended C(t) estimation formula will be dealt with in later sessions.