Tutorial Session 40B Homework – Incubation Assessment

Mentor Guide K&S Questions

1.25 Describe the "critical crack opening displacement" method for calculating the incubation time of a crack.

1.26 Define how a Failure Assessment Diagram may be devised for creeping conditions, and outline how the creep toughness may be found. Hence explain how this approach may be used to calculate the incubation time.

1.27 Explain the σ_d method for calculating the incubation time of a crack under creep-fatigue loading. Contrast the value of 'd' with the conceded crack increment.

Numerical Question

A 316H boiler tube has outer diameter 38mm and wall thickness 4mm. It operates normally at 540^{o}C. It contains a fully circumferential, sharp, internal edge crack of uniform depth 1mm in parent material. The uncracked elastic axial stress in operation is 100 MPa and should be approximated as a uniform membrane stress for the purposes of this question. The differential pressure is 12 MPa. All loads are primary. The reference stress accounting for the crack has been evaluated to be 133 MPa. The adjusted Young's modulus at operating temperature is $\bar{E} = 180$ GPa. The monotonic stress-strain curve at the operating temperature is $\varepsilon = \frac{\sigma}{\bar{E}} + \left(\frac{\sigma}{270}\right)^{8.6}$. The number of load cycles is small and fatigue can be assumed negligible.

Calculate the best estimate and lower bound incubation times using rupture properties for 316H from either R66 or the revised Sarah Spindler model.