Assessment of a multiscale fatigue damage model associated with stress gradient effects

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Introduction

• Development and validation of a fatigue damage model implemented in the FE code Lagamine.
• Adapted to any cyclic loading:
  ➔ constant cyclic loading
  ➔ blocks loading
  ➔ cycle by cycle
• Integrated multiaxial fatigue analysis tool for research and industry

Multiscale model

- The computation of the mesoscopic accumulated plastic strain is based on Zarka method (Direct Method).
- The accumulated mesoscopic strain is based on Lemaitre-Chaboche damage increment per cycle

Mesoscopic accumulated plastic computation

![Image](image.png)

Lin-Taylor stress localization law

\[
\sigma = \frac{\Sigma}{2} - 2\mu \cdot \bar{\epsilon}^p
\]

\[
\bar{\epsilon}^p = \frac{\partial f}{\partial \bar{\epsilon}^p}
\]

\[
f(\sigma, \bar{\epsilon}^p) = \sqrt{\frac{1}{2} (s - \bar{\epsilon}^p) : (s - \bar{\epsilon}^p)} - k(p)
\]

Stress gradient effects

Finite element integration point

Volume Averaged Method (VAM)

\[
\bar{\chi}^{ip} = \frac{1}{V} \int \chi^{ip}(x_i^{ip}, y_i^{ip}, z_i^{ip}) \cdot dv
\]

Relative Stress Gradient

\[
\bar{\chi}^{ip} = \chi^{ip} - \bar{\epsilon}(\text{grad}(\chi^{ip}))
\]

Fatigue endurance criteria

• Global criteria:
  ➔ Papadopoulos
  ➔ Crossland
  ➔ Sines
  ➔ TOS (based on stresses or plastic strain)

• Critical plane criteria:
  ➔ Dang Van
  ➔ Findley,
  ➔ Modified Wöhler Curve method

Results

Prediction of SN curves of V-nothed samples (R=0.1), TOS criterion

Conclusions

• Multiscale Lemaitre-Chaboche model adapted to HCF damage modelling
• Significant influence of the stress gradient effects (VAM)

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References

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