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

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Introduction

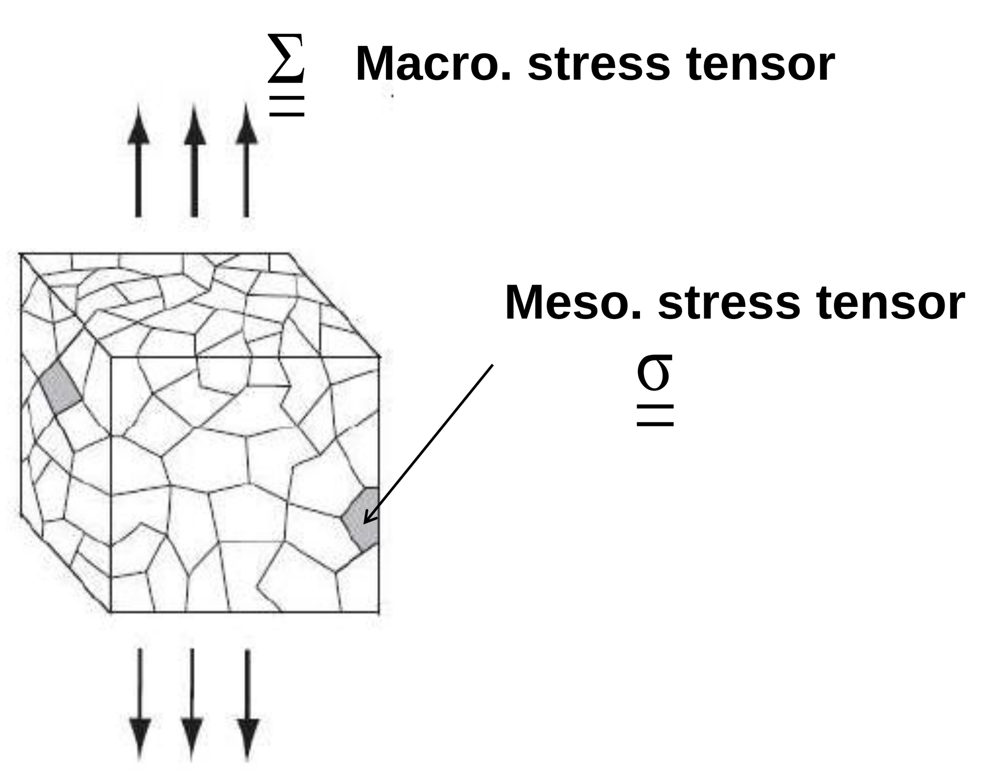
- Development and validation of a fatigue damage model implemented in the FE code Lagamine.
- Adapted to any cyclic loading:
  - ➔ constant cyclic loading
  - ➔ blocks loading
  - ➔ cycle by cycle

➔ 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

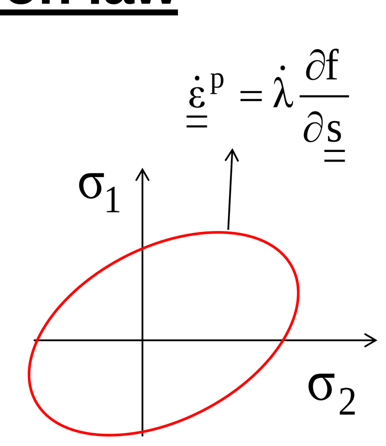
Mesoscopic accumulated plastic computation



Lin-Taylor stress localization law

$$\underline{\underline{\sigma}} = \underline{\underline{\Sigma}} - 2\mu \cdot \underline{\underline{\varepsilon}}^{p}$$

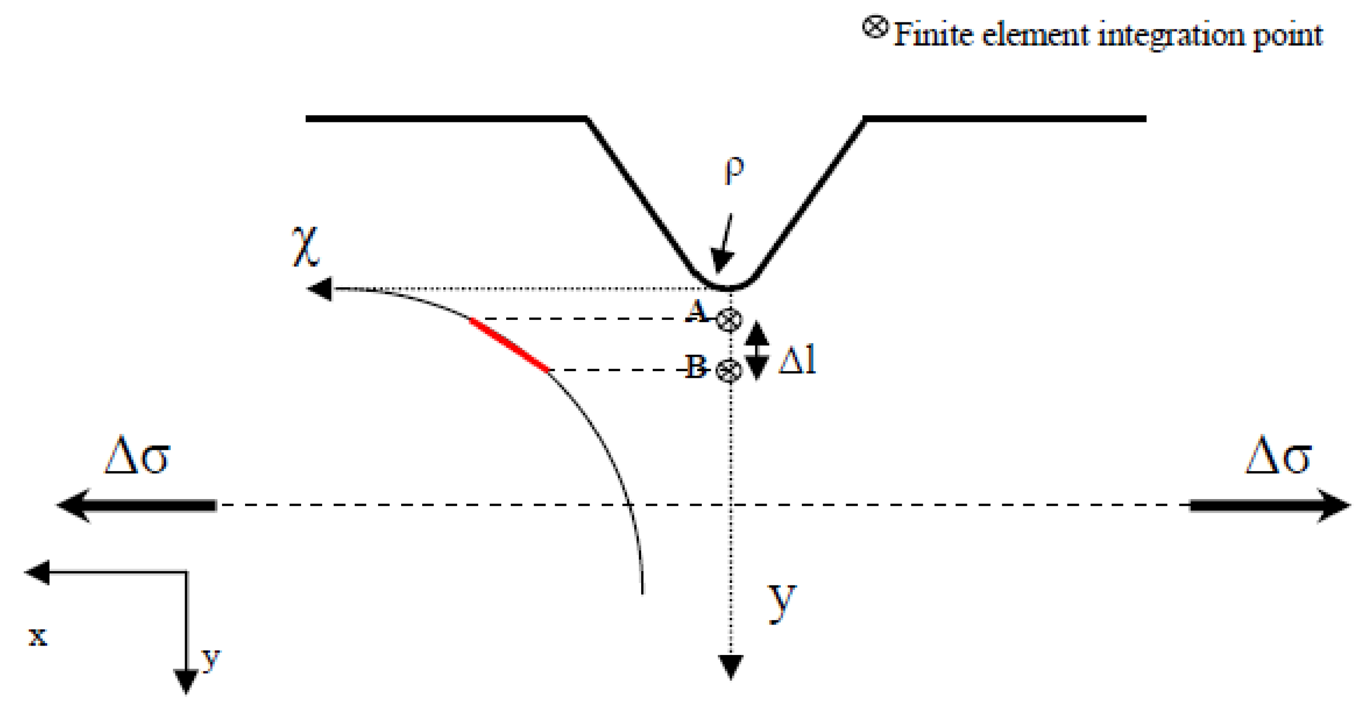
$$\dot{\underline{\underline{\varepsilon}}}^{p} = \dot{\lambda}\frac{\partial f}{\partial \underline{\underline{s}}}$$



$\underline{\underline{\varepsilon}}^{p}$: meso plastic strain tensor computed from a mesoscopic yield surface

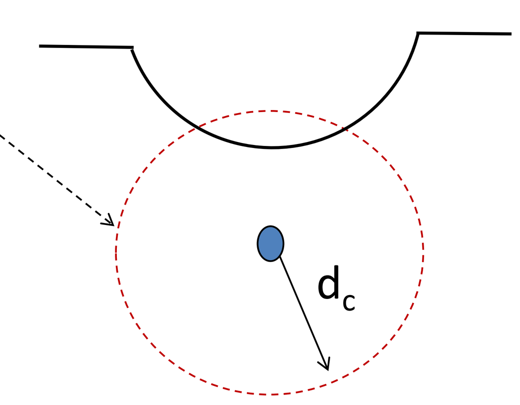
$$f(\underline{\underline{\sigma}}, h\underline{\underline{\varepsilon}}^{p}) = \sqrt{\frac{1}{2}(\underline{\underline{s}} - h\underline{\underline{\varepsilon}}^{p}) : (\underline{\underline{s}} - h\underline{\underline{\varepsilon}}^{p})} - k(p)$$

Stress gradient effects



Volume Averaged Method (VAM)

$$\overline{\chi}^{ip} = \frac{1}{V}\int_{V} \chi^{ip}\left(x_{ip}, y_{ip}, z_{ip}\right) \cdot dv$$



Relative Stress Gradient

$$\overline{\chi}^{ip} = \chi^{ip} - \overline{c}\left(\mathrm{grad}(\chi^{ip})\right)$$

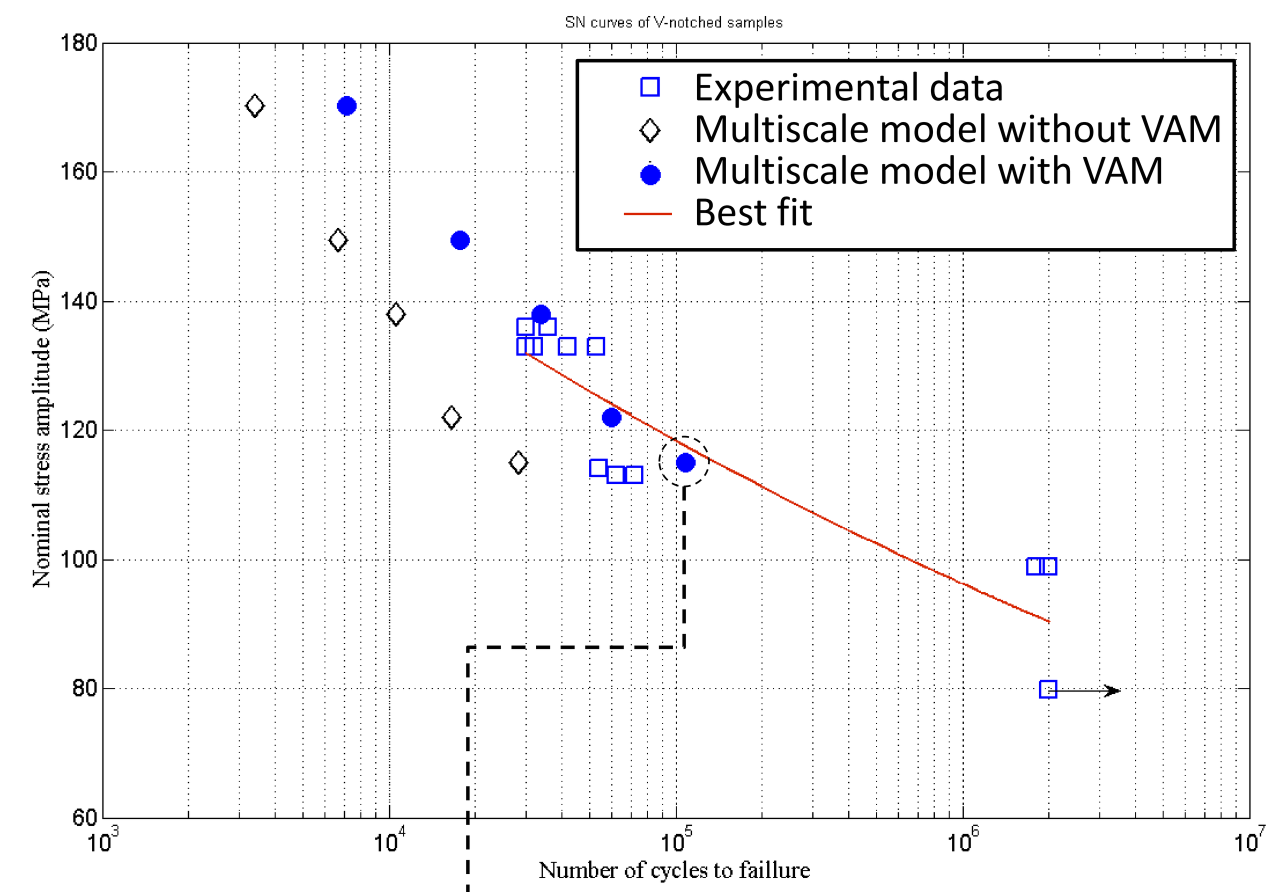
$$\mathrm{grad}(\chi^{ip}) = \sqrt{\left(\frac{\partial \chi}{\partial x}\right)_{ip}^{2} + \left(\frac{\partial \chi}{\partial y}\right)_{ip}^{2} + \left(\frac{\partial \chi}{\partial z}\right)_{ip}^{2}}$$

Fatigue endurance criteria

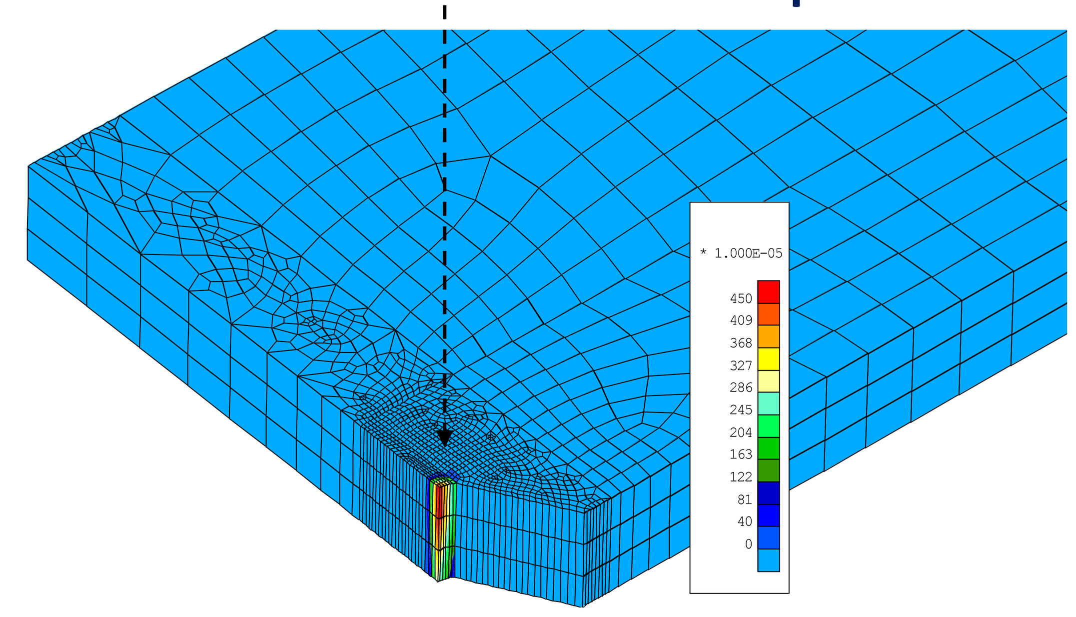
- Global criteria:
  - ➔ Papadopoulos
  - ➔ Crossland
  - ➔ Sines
  - ➔ TOS (based on stresses or plastic strain)
- Critical plane criteria:
  - ➔ Dang Van
  - ➔ Findley,
  - ➔ Modified Wöhler Curve method

Results

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



Distribution of mesoscopic accumulated plastic strain



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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