Chemically assisted stress corrosion in polycarbonate

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Content

- Introduction to stress corrosion
- Comparison with classic fracture mechanics
- Crack growth experiment
- Crack growth simulation
- Comparison between the experiment and simulation.
Introduction to stress corrosion

- Corrosive environment
- Susceptible material
- Load (external or residual)
Introduction to stress corrosion

- Occurs frequently in nature.
- Stress corrosion cracks grow at relatively low loads.
- Hard to detect and distinguish from general corrosion.
Chemically assisted cracks branches frequently.
Linear fracture mechanics

- The crack tip is treated as a singular point.
- The crack propagates when a criterion is fulfilled.
- The direction of the crack growth is determined by a criterion.
- Branching would lead to crack arrest.
Different approach

• The crack surface is a part of the body surface.
• Crack growth is merely the evolution of the body surface.
• The cracks grow and branch due to dissolution of material.
• No crack propagation and crack path criteria.
The experiments

- Conducted in polycarbonate with acetone as dissolvent.
- The polycarbonate plate was glued to an aluminium bar.
- The plate was loaded according to the figure.
- Acetone was dropped in a notch between the loading points.
Observations

• After branching the width of the individual crack branches decreases.

• The total width is approximately constant.

• The width of the crack corresponds to dissolved material.
FEM analysis
Theoretical model

• The surface moves where the strain exceeds a threshold value, e.g. in the vicinity of the crack tip.
• The crack mostly follows a mode I path.
• Branching occurs spontaneously.
• The total crack width is approximately the same after branching.

Experiment and simulation are consistent.
Measurements of the crack width

- Mean value: 1.24
- Standard deviation: 0.37
Measurements of the crack width and angle

**Experiments**
- Mean angle: 155
- Standard deviation: 11

**Simulation**
- Mean angle: 151
- Standard deviation: 13

![Graph showing crack width and angle](image)

Ratio $\alpha / (l_1/l_2)$

- Large ratio
- Small ratio
Measurements of the crack width and angle

**Experiments**
- Mean angle: 32
- Standard deviation: 12

**Simulation**
- Mean angle: 47
- Standard deviation: 9

![Graph showing the ratio $\beta / (l_1/l_2)$ and dividing angle $\beta$.](image)

Pärletun, 79

Large ratio

Small ratio
Conclusion

- Stress corrosion can be modelled as a moving boundary problem.
- Crack growth and crack path criteria are not needed.
- Experiment and simulations are consistent:
  - The crack follows a mode I dominated crack path.
  - The total width of the crack is the same or slightly larger than before branching.
  - The angle at which the crack branches is approximately 150 deg.
  - The angle dividing the crack branches is approximately 40 deg.
- Neither in the experiments nor in the simulations it was possible to exactly predict the position of a crack branch.