Macroscopic Indentation Testing

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Motivation

- Determination of local stress-strain properties using instrumented indentation testing.
- Parameter identification for numerical modelling and simulation.

Method

Indentation Test

- Zwick/Roell Test Machine ZH0.2
- Macroscopic indentation

<table>
<thead>
<tr>
<th>Force (N)</th>
<th>Indentation depth (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Viscoplasticity with rate-independent non-linear isotropic and kinematic hardening and rate-dependent stress

- Armstrong-Frederick hardening rule
- Large deformation theory
- Finite deformation plasticity and visco-plasticity (revisited)
- Nonlinear visco-elastic hardening rules

Model & FEA

- Training with FEA
- Model formulations
- Application modules
- Force-depth data / Recovery
- Young's modulus / Viscosity parameter
- Equilibrium strain curve / SigmaNet
- Kinematic hardening / X-Net

Neural Network

- Overstress / ε / ε^2
- Elastic / Kinematic hardening

Stress-Strain Curve

- True stress, True strain

Case A

γ-based Titanium-Aluminide
Polycrystal with fully-lamellar grains

- Extruded bar: 17 indentation points
- Polycrystal simulation: 64 grains

- Stress-strain curves
- Indentation tests

- Microstructure

Case B

Weld joint of rolled 3 mm thick Al 5083-H321 sheet

- Macroscopic stress-strain curves
- Stress-strain curves - comparison

Summary

- Good coincidence between indentation and crystal simulation.
- Indentation testing provides large variation of local stress-strain curves.

- Stress-strain curves from indentation test of weld- and base-material are similar to conventional tensile tests.
- Improvement of the method is required: Preparation of welded thin sheet specimens.
- Influence of residual stresses.