ANALYSIS OF STRESS-STRAIN RELATIONSHIPS IN SILICON RIBBON

UNIVERSITY OF KENTUCKY

O. Dillon

Stress vs Strain for Si (Temperatures in °C)

\[ \text{Material: Si} \]

\[ \text{Stress} = \text{Strain} \times \text{Young's Modulus} \]

\[ E = 3 \times 10^4 \text{ psi} \]

\[ \text{Strain} = \frac{\Delta L}{L} \]

\[ T = 1200°C \]

\[ T = 1500°C \]

\[ T = 1800°C \]

\[ T = 2100°C \]

\[ \text{Legend: Temp} \quad \rightarrow \quad 1000 \quad \rightarrow \quad 1200 \quad \rightarrow \quad 1500 \]

\[ \text{Note: Data from Ref.} \]

\[ \text{Data at} \quad 1000°C \]

\[ \text{Data at} \quad 1200°C \]

\[ \text{Data at} \quad 1500°C \]

\[ \text{Data at} \quad 1800°C \]

\[ \text{Units: psi, psi} \]

\[ \text{References:} \]

1. N85-32438
2. University of Kentucky
3. O. Dillon

\[ \text{Stress vs Strain for Si (Temperatures in °C)} \]
SILICON SHEET

Y, J STRESS

USED IN MODEL

TEMPERATURE (°C)

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Approaches

(1) CONVENTIONAL APPROACH
A SERIES OF MODELS TO PRESENT EACH INTERMEDIATE STAGE
(QUASI-STATIC ANALYSIS)

ADVANTAGE: SMALL MODEL IN EARLY STAGES

DISADVANTAGE: 1. A SERIES OF MODELS (LABOR INTENSIVE)
2. POST-STRESS HISTORY IGNORED

(2) RECOMMENDED APPROACH
A MODEL TO PRESENT ENTIRE PROCESS (DYNAMICAL TRANSIT ANALYSIS)

ADVANTAGE: 1. ONE MODEL ONLY
2. ALL POST-DEFORMATION INCLUDED

DISADVANTAGE: COSTLY AT EARLY STAGE ANALYSIS
SILICON SHEET

Model

Diagram of a model with axes labeled X and Y.
Deformed Shapes by Steps

STEP 1

$\phi \theta 1 = .1271-2$
$\lambda x \theta 6 = -.5005-3$

STEP 5

$.1129-2$
$.2301-2$

STEP 10

$.5279-3$
$.2979-2$

STEP 15

$.2150-3$
$.3134-2$

STEP 20

$.9347-4$
$.3202-2$

(INCHES)
Stress Contours of $\sigma_y$ by Steps

STEP 5
$\delta = \text{max} = 149$
$\delta = \text{min} = -117$

STEP 10
$\Sigma = \text{max} = 128$
$\Sigma = \text{min} = -159$

(PSI)

STEP 15
$\Sigma = \text{max} = 869$
$\Sigma = \text{min} = -469$

STEP 20
$\Sigma = \text{max} = 1012$
$\Sigma = \text{min} = -1122$

ORIGINAl PAGeS
OF POOR QUALITY
Stress Contours of $\sigma_x$ by Steps

STEP 1
$\Delta = \text{max} = 0.05$
$0 = \text{min} = -0.02$

STEP 5
$\text{max} = 374$
$\text{min} = -657$

STEP 10
$\text{max} = 782$
$\text{min} = -314$

STEP 15
$\text{max} = 1293$
$\text{min} = -1159$

STEP 20
$\text{max} = 1885$
$\min = -858$

(PSI)
SILICON SHEET

Stress Contours of $\tau_{xy}$ by Steps

<table>
<thead>
<tr>
<th>Step</th>
<th>Diagram</th>
<th>$\sigma_{max}$</th>
<th>$\sigma_{min}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><img src="5" alt="Diagram" /></td>
<td>91</td>
<td>-167</td>
</tr>
<tr>
<td>10</td>
<td><img src="10" alt="Diagram" /></td>
<td>180</td>
<td>-209</td>
</tr>
<tr>
<td>15</td>
<td><img src="15" alt="Diagram" /></td>
<td>556</td>
<td>-337</td>
</tr>
<tr>
<td>20</td>
<td><img src="20" alt="Diagram" /></td>
<td>$\tau_{xy, max}$ = 712</td>
<td>$\tau_{xy, min}$ = -416</td>
</tr>
</tbody>
</table>

Conclusion

- DYNAMICAL TRANSIT APPROACH WORKS
- PAST-STRAIN HISTORY IS SIGNIFICANT