Manufacturing Applications of Exploding Foil and Wire and use of PDV as a Diagnostic Technique

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Andrew Skrepnek, Summo Steel Corporation
SHEARING

Exploding foil

Die

Shim

Spring steel plate

Clamping force

Fixture

Dies

For spring steel

For TrIP Steel
SHEARING: Some results

Velocity of the Flyer > 400 m/s
Sample No.  | 1  | 3  | 4  
---|---|---|---
Burr height(µm) | 0  | 33.29 | 48.03 

Burr height will increase with decreasing energy.
• Capacitor bank discharges large current into actuator
• Actuator transfers current to metal foil
• Foil explodes due to large current, creating a high-pressure wave
• Pressure wave pushes flyer into part at high velocity
Part is completely within dimensional tolerances

- Part remains in T6 temper condition throughout entire process – no heat treatment required
- Exploding foil process shows significant improvements over hydroforming or electromagnetic forming

- Hydroforming only:
- Hydroforming then explosive foil calibration:
TUBE EXPANSION

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TUBE EXPANSION:
Instrumentation-Current, Voltage and Velocity

- 9.6 kJ Energy
- Ø0.06" Al Wire
- ID 1" Annealed Copper Tube

- Net Δr:
  - PDV: 8.3 mm
  - Calliper Measurement: 7.6 mm

Current (kAmps)
Channel 1 Velocity (m/s)
Channel 2 Velocity (m/s)
Voltage (100 V)
Pressure = Force/Area
Force = Mass * Acceleration
Acceleration = \( \frac{dV}{dt} \) where V is velocity, t is time
Mass = Density * Volume
Volume of tube \( \sim \) Area of curved surface * Thickness
\implies \text{Pressure} = \frac{(\text{Density} \times \text{Area} \times \text{Thickness} \times \frac{dV}{dt})}{\text{Area}} = (\text{Density} \times \frac{dV}{dt}) \times \text{Thickness}

Sample Calculation:
Density of copper = 8940 kg/m^3
Thickness of tube = 1.5875 \times 10^{-3} m
\( \frac{dV}{dt} = 19.6 \times 10^6 \text{ m/s}^2 \)
\implies \text{Pressure} = 8940 \times 0.0015875 \times 19.6 \text{ Mpa} = 278.1681 \text{ Mpa}
# TUBE EXPANSION:
## Result summary

![Ohio State University Logo](image)

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<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Energy (kJ)</th>
<th>Wire material</th>
<th>Max Current (kAmps)</th>
<th>Rise Time (μs)</th>
<th>Max Velocity C1, C2 (m/s)</th>
<th>First dV/dt (m/s²)*10^6</th>
<th>Peak Pressure (Mpa)</th>
<th>Max dV/dt excluding first value (m/s²)*10^6</th>
<th>Peak Pressure (Mpa)</th>
<th>Final OD (inch)</th>
<th>% Radial Strain</th>
<th>Comments</th>
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<tbody>
<tr>
<td>1</td>
<td>6.4</td>
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<td>126</td>
<td>20.4</td>
<td>90,101</td>
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<td>571.0477</td>
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<td>164.6301</td>
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<td>19.6</td>
<td>112, 106</td>
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CONCLUSIONS

- Very high pressures to move workpieces very fast
- PDV can be used for validating models for this process
- Quick estimates of pressure by PDV
- Optimization of process: velocity of impact, travel distance before impact etc.