Investigations on automotive high strength Aluminum hot and warm forming processes and first full scale pilot

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Introduction

Lotus Door Inner
AA6082 – 2mm
Locolite EU-FP7
High strength Aluminum Forming technologies by AP&T: Hot Forming

- 6xxx: 530–560 °C
- 7xxx: 460–490 °C

Automotive Alloy examples
- » 6016
- » 6082
- » 6070
- » 7021
- » 7075

<table>
<thead>
<tr>
<th>TIME</th>
<th>TEMPERATURE</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>t1</td>
<td>SHT temperature</td>
<td></td>
</tr>
<tr>
<td>t1→t2</td>
<td>Soaking</td>
<td></td>
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<tr>
<td>t2</td>
<td>Transfer</td>
<td></td>
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<tr>
<td>t2→t3</td>
<td>Forming &amp; Quenching</td>
<td></td>
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<tr>
<td>t3→t4</td>
<td>Natural aging / stabilizing</td>
<td></td>
</tr>
<tr>
<td>t4→t5</td>
<td>Artificial aging</td>
<td></td>
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</tbody>
</table>

SHT: Sintered Hollow Tube
High strength Aluminum Forming technologies by AP&T: W-temper forming

- W-temper forming
- SHT temperature
- t1
- Soaking
- t1–t2
- Transfer
- t2
- Transfer
- t2
- Quenching – in water or between steel plates
- t2–t3
- Cold Forming
- t3
- Natural aging / stabilizing
- t3–t4
- Artificial aging
- t4–t5

Automotive Alloy examples
- 6016
- 6082
- 6070
- 7021
- 7075

6xxx: 530–560 °C
7xxx: 460–490 °C
High strength Aluminum Hardening - Artificial Aging

Aging after Solution Heat Treatment (SHT)

Evolution of Hardness:

Heat Treatment

Product tempers

Cold forming tempers

T6

T7

0.5–24h @ 100–200°C

T4

T6

T7
High strength Aluminum Forming technologies by AP&T: Warm forming

6xxx: Up to 350 °C
7xxx: Up to 225 °C

- Heating to elevated temperatures
- Forming at elevated temperature
- Air cooling

Automotive Alloy examples
- 5083
- 5182
- 5754
- 6016 T4
- 6022 T4
- 6111 T4
- 7075 T6
High strength door inner – “One shot Hot forming”

Lotus – door inner
Max strain according to simulation: 50%
Locolite EU FP7 project

Tested material: 6082
FE-Simulation
Comparison SIMULATION vs. SCAN – Hot Forming AA7075

Simulation mesh after stamping

Scan

Distance between simulation and scan after springback

Distance between simulation and scan after springback

Min = -4.2
Max = 2.8
FE-Simulation
Thickness comparison with measurement – Hot Forming AA7075

Min = 1.094
Max = 1.873
Challenges:
Importance of process monitoring

Higher alloy content

→ higher product strength

→ smaller process window (typical 25°C in AA6082)

www.google.com/patents/US20120186706
Challenges: Galling

Uncoated tool and no / wrong lubricant

Coated tool and right lubricant
Global challenges for our Talents

- Material applications
- Material data for FE Simulation
- Material testing
- Material properties

- Process know-how
  - Heating, Forming, Post processing

- Tooling know-how
  - Cooled dies
  - Cooling strategies
  - Tool coatings
  - Die materials

- New FE-Simulation approach
  - Forming
  - CFD Simulation

- Formability
  - Part integration
  - Function integration

- Net shape geometries
- Assembly
Summary and Process dependent total cost

**Raw Material** – Aluminum price regulated by London Metal Exchange (LME) ±1.5 $/kg last years

**Key** – Holistic thinking with respect to material selection, product design and process development

A few examples on this approach

» F- and 0-temper material for Hot and W-temper Forming → **cheaper raw material**

» Aluminum can take fast heating and cooling - **shorter cycle times**

» Fast aging alloys – **shorter aging time**

» Aluminum is softer than steel → less press force is needed – **less capital investment**

» Aluminum can be trimmed conventionally, compared to press hardened steel

→ **No Laser cutting is needed**

» Larger components with part and function and integration → **less assembly**

» Net shape forming → **less tooling invest**
World’s first production line for Hot and Warm forming processes of high strength Aluminium

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