ALUMINUM EXTRUSION ALLOY DEVELOPMENT
FOR AUTOMOTIVE APPLICATIONS

DAVID LUKASAK
AUGUST 20, 2015
BACKGROUND
Driving force for lightweighting

- Economical, environmental and political pressure:
- Reduce fuel consumption and CO2-emissions

Source: www.theicct.org

[1] China’s target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
Mild steel will be replaced by a mix of materials, including:

- Aluminum
- High strength steel
- Fibre-reinforced-plastics

Aluminum has the highest weight saving potential
8 focus points for aluminum extrusions in mass reduction strategies
Create the Safest and Most Cost-Effective Design
Which profile would you like to have in your car?
Lightweighting across the full range
Full Range - Lightweighting as intended
Optimization for production and performance
Melting

Homogenizing

Casting

Optimized Billet Microstructure
Billet Heating

Quench

Strong Presses

Optimized Extruded Microstructure
Focus on crash properties
What physical property is important for aluminum energy absorption in a crash?

- Elongation/Ductility
- Strength
- Other property?
Alloy comparison – same strength and elongation

Rp0.2 / Rm / A5 / crush grade
~ 290 / 306 / 13-14 / 9 (alloy A), 3 (alloy B)
Alloy comparison – same strength and elongation

Alloy A

Alloy B

Rp0.2 / Rm / A5 / crush grade
~ 290 / 306 / 13-14 / 9 (alloy A), 3 (alloy B)
3 different grades are defined

<table>
<thead>
<tr>
<th>Class (Alloy)</th>
<th>$R_{p0.2}$ (MPa)</th>
<th>$R_m$ (MPa)</th>
<th>$A_5$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (CA20)</td>
<td>200 - 240</td>
<td>≥220</td>
<td>≥11</td>
</tr>
<tr>
<td>B (CA24)</td>
<td>241 - 280</td>
<td>≥260</td>
<td>≥10</td>
</tr>
<tr>
<td>C (CA28)</td>
<td>281 - 330</td>
<td>≥305</td>
<td>≥10</td>
</tr>
</tbody>
</table>
Standardized tests for crash performance
3-POINT BEND TEST

Quantitative material test

- Bending punch
- Specimen
- Bending line
- Bending line normal to the direction of extrusion

6082
(330/345/10)

- 90°
- 45°
- 0°

- α 14°
- α 27°
- α 56°

Crash alloy
(310/325/11)

- α 33°
- α 61°
- α 120°
- Material and component test
- Quantitative force energy absorption
- Subjective crash grading
- Peak and average force
DYNAMIC COMPRESSION

Material and component test, expensive and complicated
Properties for 6xxx-alloys can be considered to be independent of strain rate.

Dynamic testing and quasistatic testing should give the same results.

....which is our experience as well
Focus on **strength critical performance**
Sapa has developed higher strength alloys that are available

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Standard Tempers</th>
<th>Tensile Strength</th>
<th>Yield Strength</th>
<th>Elongation (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6061 AA</td>
<td>T6/T6511</td>
<td>260 MPa</td>
<td>240 MPa</td>
<td>8%</td>
</tr>
<tr>
<td>6082 AA</td>
<td>T6/T6511</td>
<td>310 MPa</td>
<td>260 MPa</td>
<td>6%</td>
</tr>
<tr>
<td>Sapa HS6X</td>
<td>T6/T6511</td>
<td>337 MPa</td>
<td>320 MPa</td>
<td>8%</td>
</tr>
<tr>
<td>Sapa 6082 (RX82)</td>
<td>T6/T6511</td>
<td>310 MPa</td>
<td>290 MPa</td>
<td>8%</td>
</tr>
<tr>
<td>Sapa 6061*</td>
<td>T6/T6511</td>
<td>285 MPa</td>
<td>275 MPa</td>
<td>8%</td>
</tr>
<tr>
<td>Sapa 340**</td>
<td>T6/T6511</td>
<td>360 MPa</td>
<td>340 MPa</td>
<td>10%</td>
</tr>
</tbody>
</table>

* High ductility – 3mm bend radius no cracking (~4mm max thickness)
** Under development – tentative target minimums
7XXX Alloy Development – High Strength

- New alloy developed with 370 MPa minimum yield.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Standard Tempers</th>
<th>Tensile Strength</th>
<th>Yield Strength</th>
<th>Elongation (min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sapa 7003</td>
<td>T5</td>
<td>375 MPa</td>
<td>345 MPa</td>
<td>10%</td>
</tr>
<tr>
<td>Sapa 7046A</td>
<td>T7*</td>
<td>410 Mpa**</td>
<td>370 MPa</td>
<td>10%</td>
</tr>
<tr>
<td>Kobe Z35B</td>
<td>T5</td>
<td>350 MPa</td>
<td>285 MPa</td>
<td>10%</td>
</tr>
<tr>
<td>Kobe Z6W</td>
<td>T5</td>
<td>410 MPa</td>
<td>390 MPa</td>
<td>10%</td>
</tr>
</tbody>
</table>

* Enhanced SCC Resistance  
** Tentative minimum

- Sapa continued development  
- 450 MPa yield strength  
  - Demonstrated capability in trial  
  - SCC testing in progress
7XXX Elevated Temperature Effect

- Aging kinetics of 7XXX are fast compared to 6XXX alloys.
- Significant loss of strength for short exposure times at elevated temperatures >165°C.

<table>
<thead>
<tr>
<th>Alloy-Temper</th>
<th>As-Aged</th>
<th>20' @ 180°C</th>
<th>60' @ 180°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS6X-T6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7003-T5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7003-T7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z6W-T5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Z6W-T7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7046A-T5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7046A-T7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Higher temperatures will have a bigger effect on the strength.
PROS

• Best opportunity for yield strengths above 350 Mpa

• Not quench sensitive (to a point) and improved dimensional capability.
CONS

• Much more difficult to extrude

• Cost higher
  • Extrusion productivity
  • Die costs increased (shorter life span)
  • Alloy cost increased

• Scrap segregation requirements
  • Impact on recyclability (Europe doesn’t use in BIW for this reason)

• Paint bake cycle effects on strength
• Long aging cycles
Recycling for sustainability
● Energy consumption for producing 1000kg prime aluminum is 30 000 kWh

● Recycling only requires 5% of the energy input

● Scrap segregation is very important
  ● Keep to one alloy series...
  ● ...or make sure separation is possible

● 7XXX alloys in particular have the potential to have the biggest negative effect on recycling efforts.
Joint development for optimal solutions
Joint development with Sapa at an early stage in terms of...

- Alloy choice
- Profile design
- Avoiding dimensional restrictions
- Process routes

IS THE KEY TO SUCCESS AND OPTIMAL EXTRUSION SOLUTIONS!
Partner with Sapa for a lighter and stronger future!
DAVID A. LUKASAK
Director of Metallurgy

SAPA EXTRUSIONS NORTH AMERICA
53 Pottsville Street
Cressona, PA 17929

Office Phone: 570-385-8566
Dave.Lukasak@sapagroup.com