ALUMINUM EXTRUSION ALLOY DEVELOPMENT
FOR AUTOMOTIVE APPLICATIONS

AWMI Annual Conference 2015
Tuscon, AZ

DAVID LUKASAK
NOVEMBER 13, 2015
SEIZING OPPORTUNITIES, JOINING FORCES
The clear leader in aluminium solutions, Sapa delivers:

- **1** A unique network and offering
- **2** Global reach and local presence
- **3** Leading process capacity and industry knowledge
- **4** Unmatched R&D expertise
You will find our products all around you

**AT HOME**
- Front doors
- Windows
- Stepladders
- Designer furniture

**IN YOUR OFFICE**
- Building construction
- Windows
- Partition walls
- Computers

**IN YOUR CAR**
- Lots of components
- Accessories
- Side impact bars
- Airbag deployment doors

**TRAVELING**
- Train carriage bodies
- Hand rails
- Luggage racks
SHAPING A SUSTAINABLE FUTURE THROUGH INNOVATIVE ALUMINUM SOLUTIONS

VALUE-ADDED PROFILES

PROFILE-BASED BUILDING SYSTEMS

PRECISION TUBING
Sapa opens 1st production facility in Vetlanda, Sweden

Hydro builds its first aluminium operation in Karmøy, Norway

Sapa opens 1st production facility in Vetlanda, Sweden

Builds first extrusion plant outside Norway

Acquires plants in Europe from Alcan

Enters South America, Brazil

Builds a tubing plant in Suzhou, China

Indalex acquired

JV between Sapa/Hydro

Expansion Asia

Opens first extrusion company outside Sweden

First foothold in America

‘09

‘10

2015

‘05

‘07

‘00

‘97

‘86

‘71

1963
Meeting customer needs – Globally and locally

- With presence in more than 40 countries
- With more than 100 production units
- 23,500 employees
- 46 Bn.NOK Sales
- 1.4 million tonnes

- 21 cast-houses
- 14 welding lines
- 39 anodizing lines
- 155 presses
unmatched global R&D network
EHS, CSR, and compliance – integral parts of our business

TOTAL RECORDABLE INJURY RATE (YTD)

2007
YTD
2015

12.8
3.4

* JAN-MAY 2015

Safety performance at industry benchmark

YTD 2015 performance*

3.4
SAPA EXTUSIONS AMERICAS

America’s Leader in aluminium solutions

6,450 employees

Presence in 4 countries

25 PRODUCTION UNITS
USD 2.4B SALES
1.2B LBS SHIPMENTS
1.4B LBS CASTING CAPACITY
N.A. CAPABILITY SNAPSHOT

68 PRESSES

10 PAINT LINES

9 CAST HOUSES

8 FABRICATION CENTERS

5 ANODIZING LINES
FINISHES

10 PAINT LINES
- VERTICAL & HORIZONTAL
- AMMA CERTIFICATION

5 ANODIZING LINES
- CLEAR, BRONZE, CHAMPAGNE & BLACK
- ACID ETCH
- BRITE DIP ~ 18’
FABRICATION

PUNCHING
DRILLING
CUTTING
HEAT TREATMENT
FILL & DEBRIDGE
DEBURRING
DIE MANUFACTURING
MILLING
PUNCHING
ASSEMBLY
CNC MACHINING
BENDING
WELDING
FRICION STIR WELDING
Driving force for lightweighting

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

Source: www.theicct.org
MATERIAL IN 2025

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
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?
Crush test
Energy absorption

<table>
<thead>
<tr>
<th>Material</th>
<th>Energy (kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crush alloy (310 Mpa)</td>
<td>14,27</td>
</tr>
<tr>
<td>600SA (295 Mpa)</td>
<td>12,95</td>
</tr>
<tr>
<td>Crush alloy (225 Mpa)</td>
<td>12,36</td>
</tr>
<tr>
<td>6082 (330 Mpa)</td>
<td>12,23</td>
</tr>
<tr>
<td>6060F22</td>
<td>10,91</td>
</tr>
<tr>
<td>6063</td>
<td>11,18</td>
</tr>
<tr>
<td>Water</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td></td>
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<td>10,28</td>
</tr>
<tr>
<td>Air</td>
<td>10,70</td>
</tr>
</tbody>
</table>
Lightweighting across the full range
Full Range - Lightweighting as intended
Optimization for production and performance
Melting

Homogenizing

Casting

Optimized Billet 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)
### MECHANICAL PROPERTIES

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>$\geq 220$</td>
<td>$\geq 11$</td>
</tr>
<tr>
<td>B (CA24)</td>
<td>241 - 280</td>
<td>$\geq 260$</td>
<td>$\geq 10$</td>
</tr>
<tr>
<td>C (CA28)</td>
<td>281 - 330</td>
<td>$\geq 305$</td>
<td>$\geq 10$</td>
</tr>
</tbody>
</table>
sapa:

Standardized tests for crash performance
3-POINT BEND TEST

Quantitative material test

- Bending punch
- Specimen
- 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
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.

Video Comparing quasistatic and dynamic tests

Quasistatic vs. Dynamic Compression Testing
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 $^3$ (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.

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<th>Yield Strength</th>
<th>Elongation^3 (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

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!
Partnering with Sapa for a lighter and stronger future!
DAVID A. LUKASAK
Director of Metallurgy

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