ALUMINUM EXTRUSION ALLOY DEVELOPMENT

FOR AUTOMOTIVE APPLICATIONS

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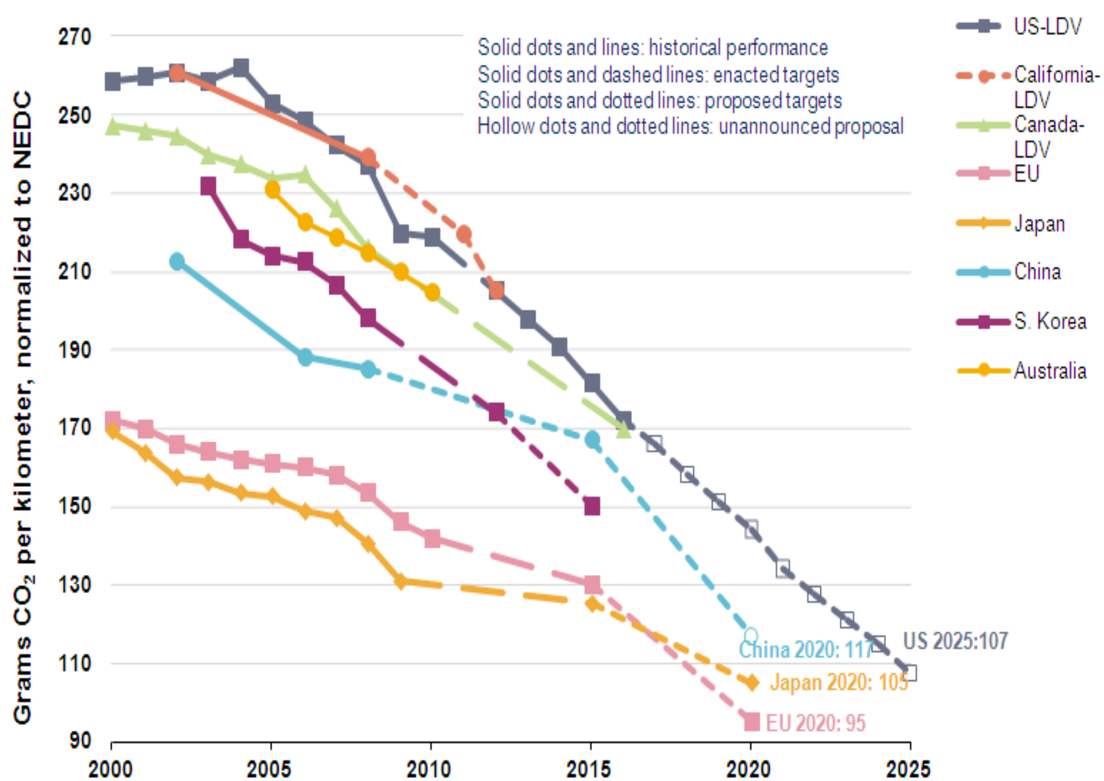
BACKGROUND

sapa:

Driving force for lightweighting

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



[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.
[2] US and Canada light-duty vehicles include light-commercial vehicles.

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

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focus points for aluminum extrusions in mass reduction strategies

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Create the **Safest** and Most **Cost-Effective** Design

1

ENERGY ABSORPTION APPLICATIONS

Which profile would you like to have in your car?

	Crush alloy (310 Mpa)	6005A (295 Mpa)	Crush alloy (225 Mpa)	6082 (330 MPa)	6060F22	6063
Water	14,27	12,95	12,36	12,23	10,91	11,18
Air					10,28	10,70

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Lightweighting across the **full range**

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Full Range - Lightweighting as intended

Optimization for **production** and **performance**

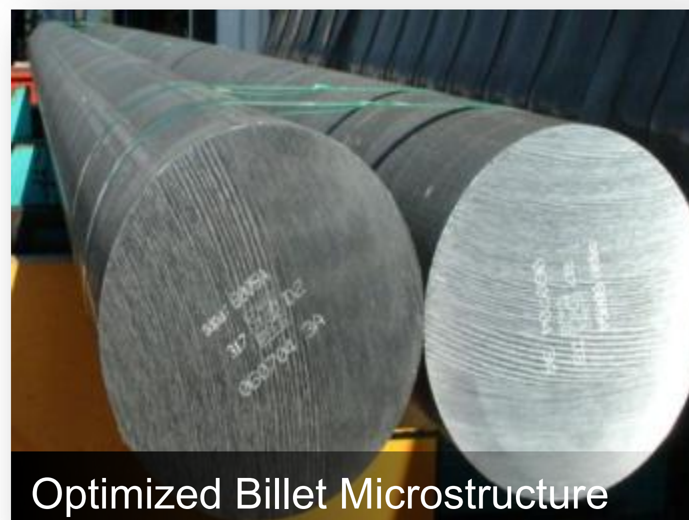
3

BILLETS

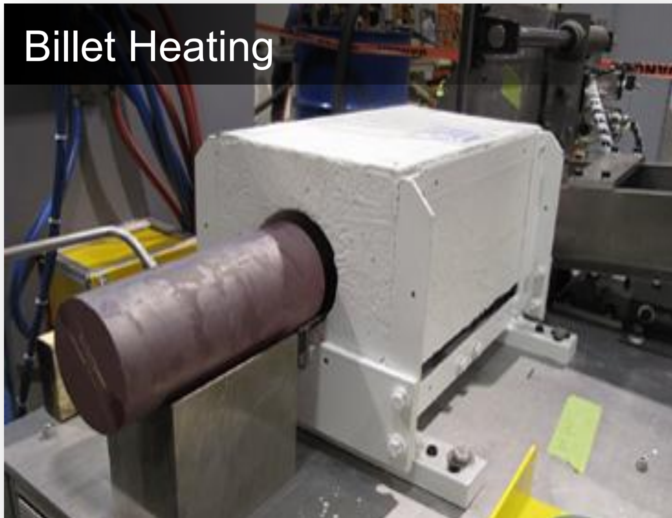
Melting


Homogenizing


Casting


Optimized Billet Microstructure

EXTRUSION


Billet Heating


Quench


Strong Presses


Optimized Extruded Microstructure

Focus on **crash** properties

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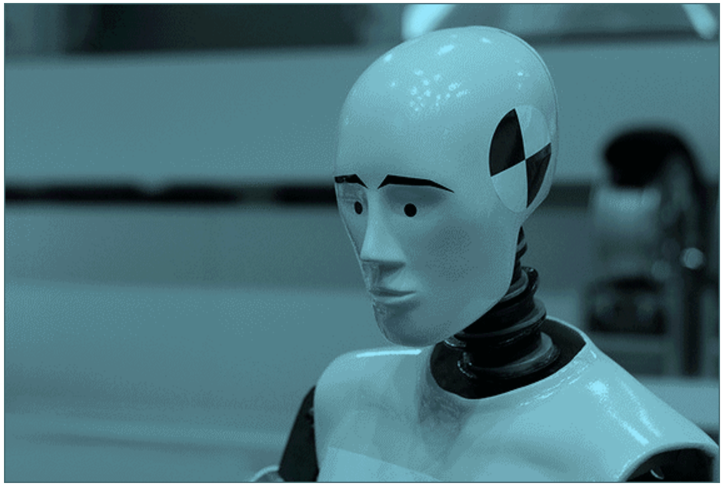
What physical property is important for aluminum energy absorption in a crash?

- Elongation/Ductility
- Strength
- Other property?



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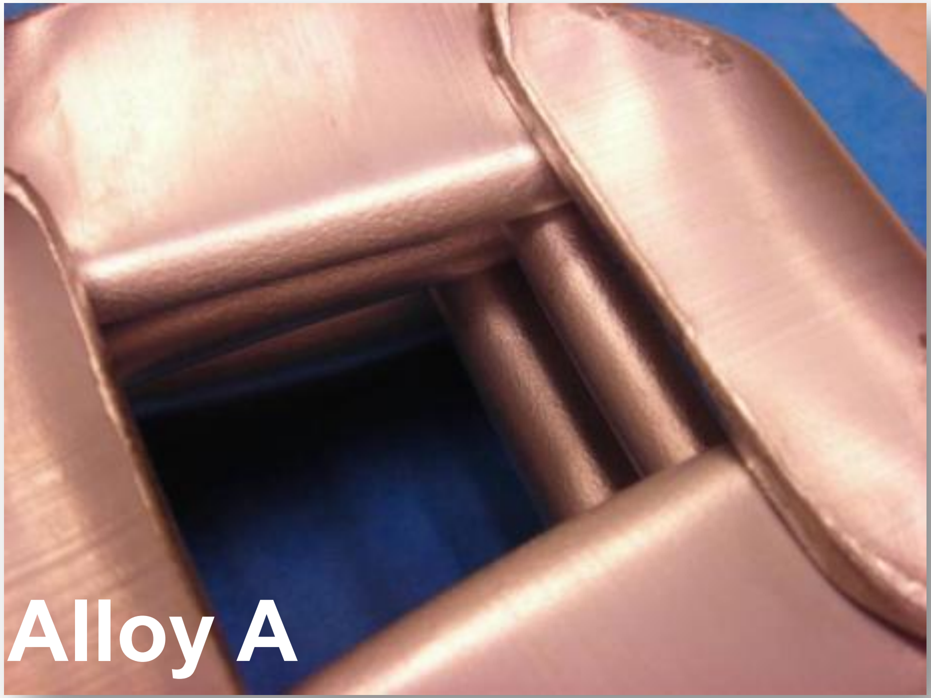
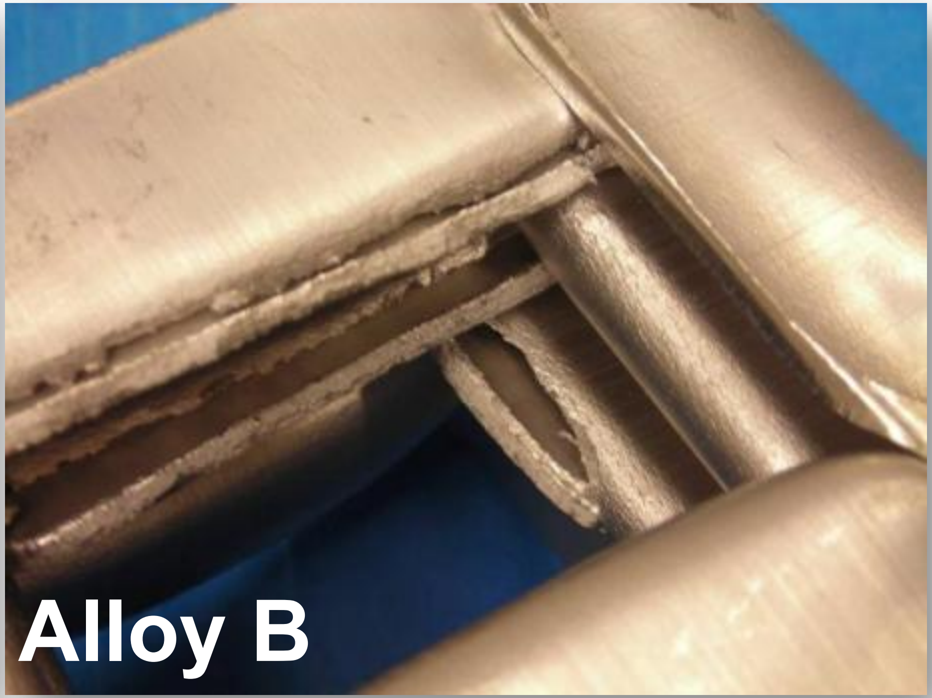
Alloy comparison – same strength and elongation

Rp0.2 / Rm / A5 / crush grade

~ 290 / 306 / 13-14 / 9 (alloy A), 3 (alloy B)

Alloy comparison – same strength and elongation





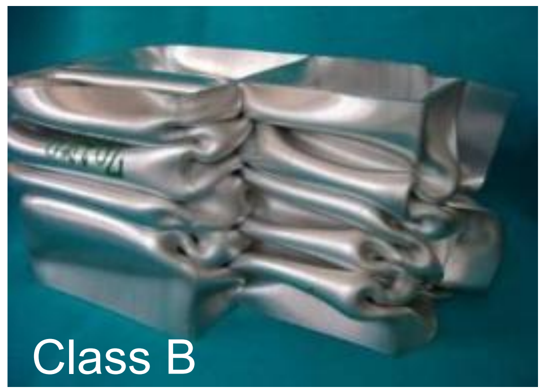
Rp0.2 / Rm / A5 / crush grade

~ 290 / 306 / 13-14 / 9 (alloy A), 3 (alloy B)

MECHANICAL PROPERTIES

3 different grades are defined

Class A



Class B

Class C

Class (Alloy)	$R_{p0.2}$ (MPa)	R_m (MPa)	A_5 (%)
A (CA20)	200 - 240	≥220	≥11
B (CA24)	241 - 280	≥260	≥10
C (CA28)	281 - 330	≥305	≥10

Standardized tests for crash **performance**

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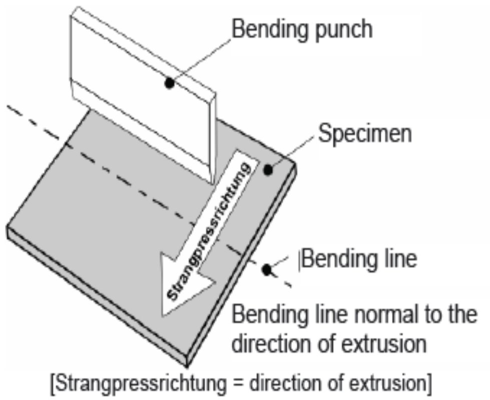
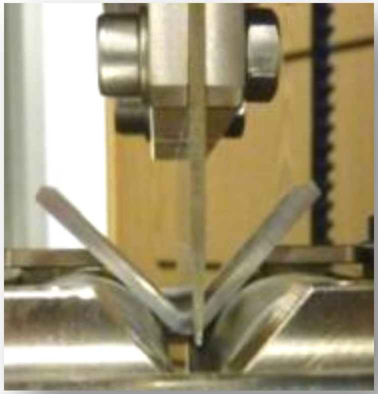
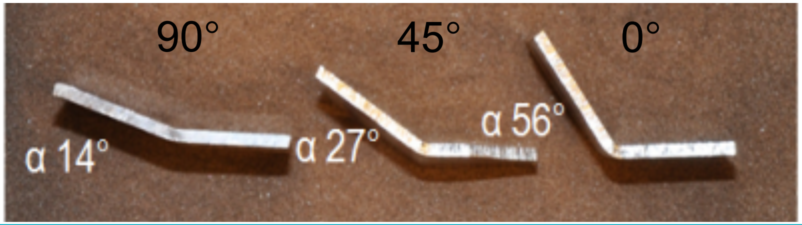
3-POINT BEND TEST

Quantitative material test

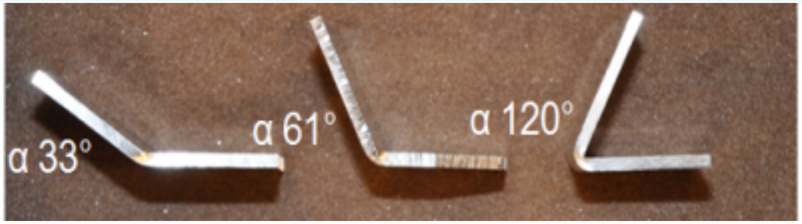




6082
(330/345/10)



Crash alloy
(310/325/11)



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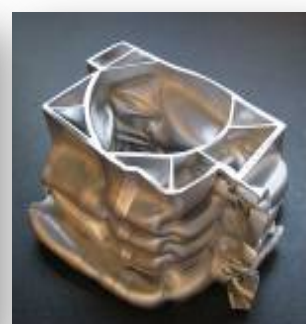
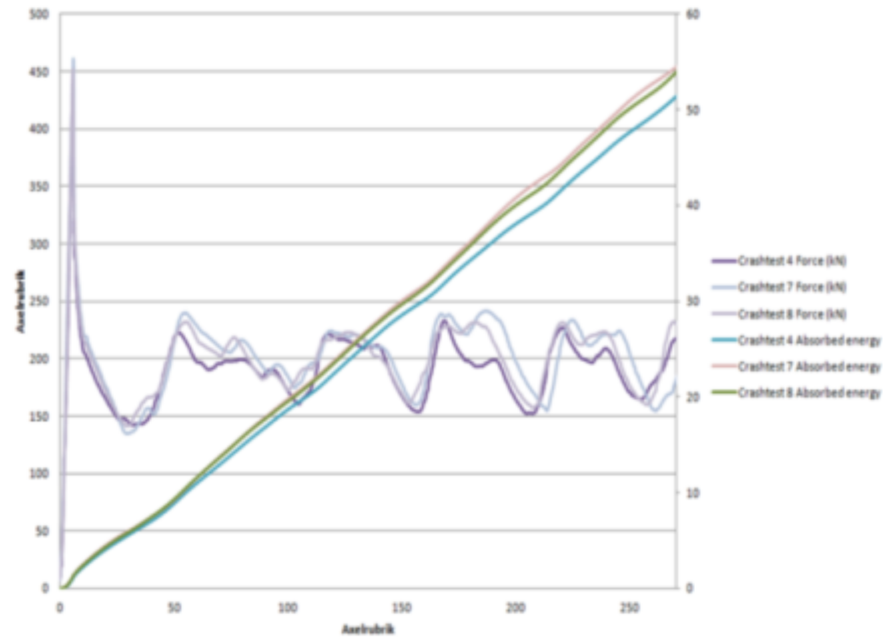
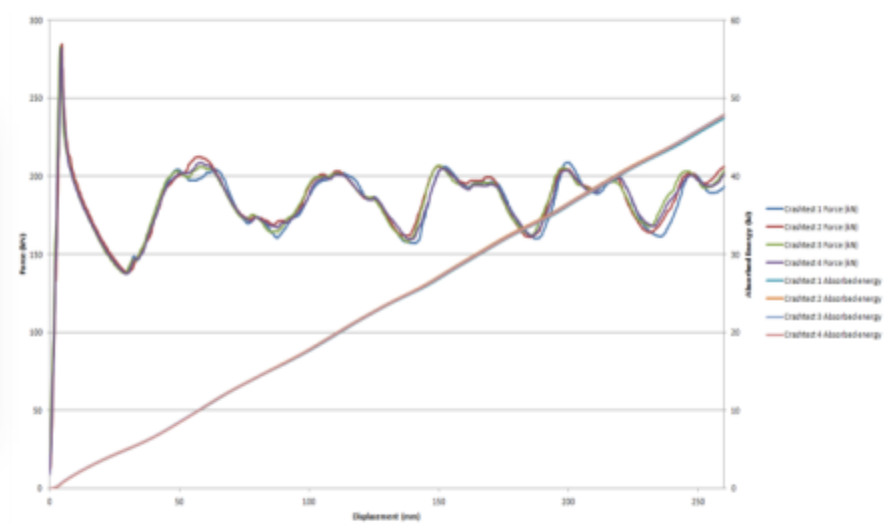
QUASISTATIC COMPRESSION

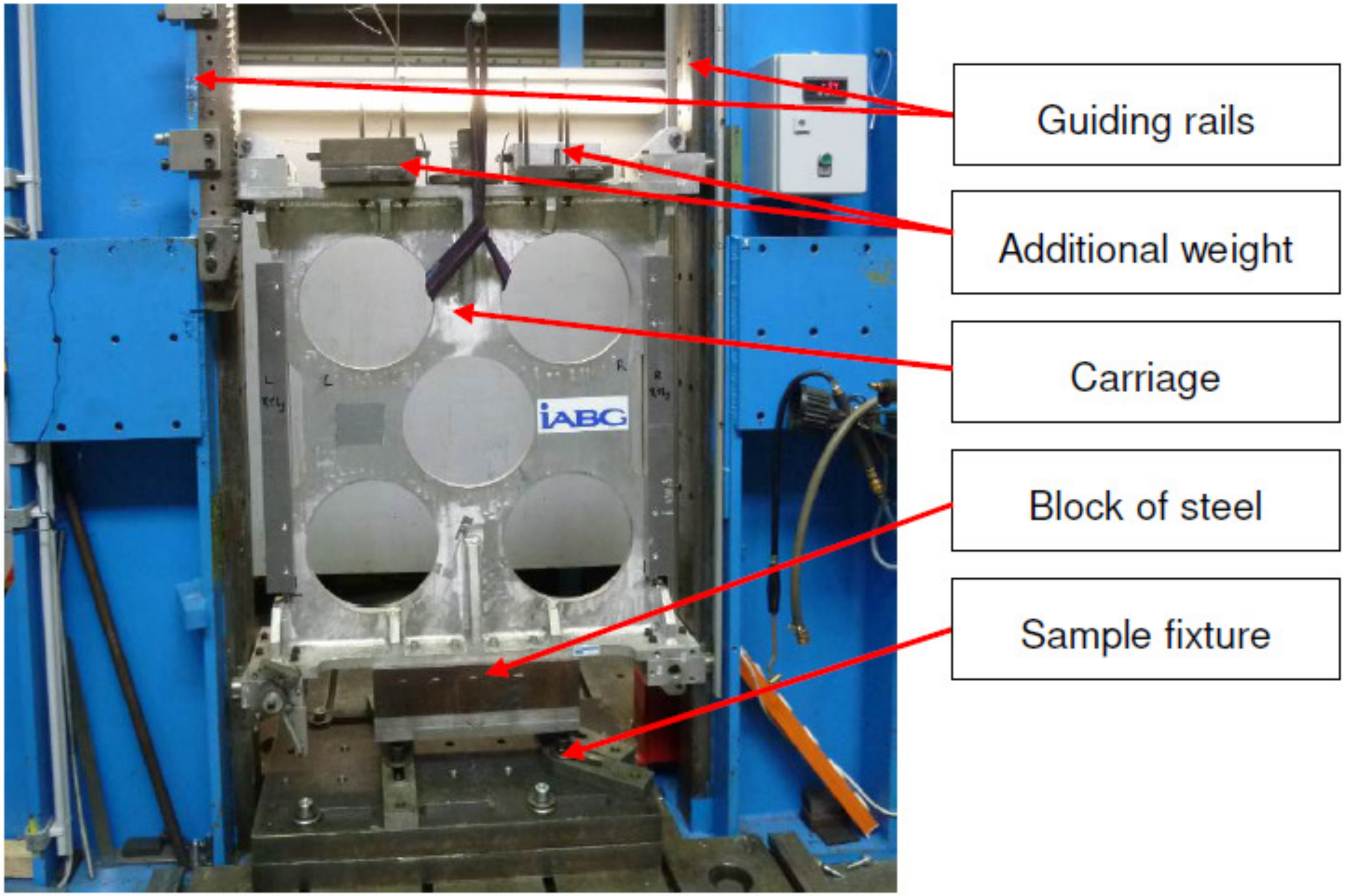
- Material and component test
- Quantitative force energy absorption
- Subjective crash grading
- Peak and average force







DYNAMIC COMPRESSION

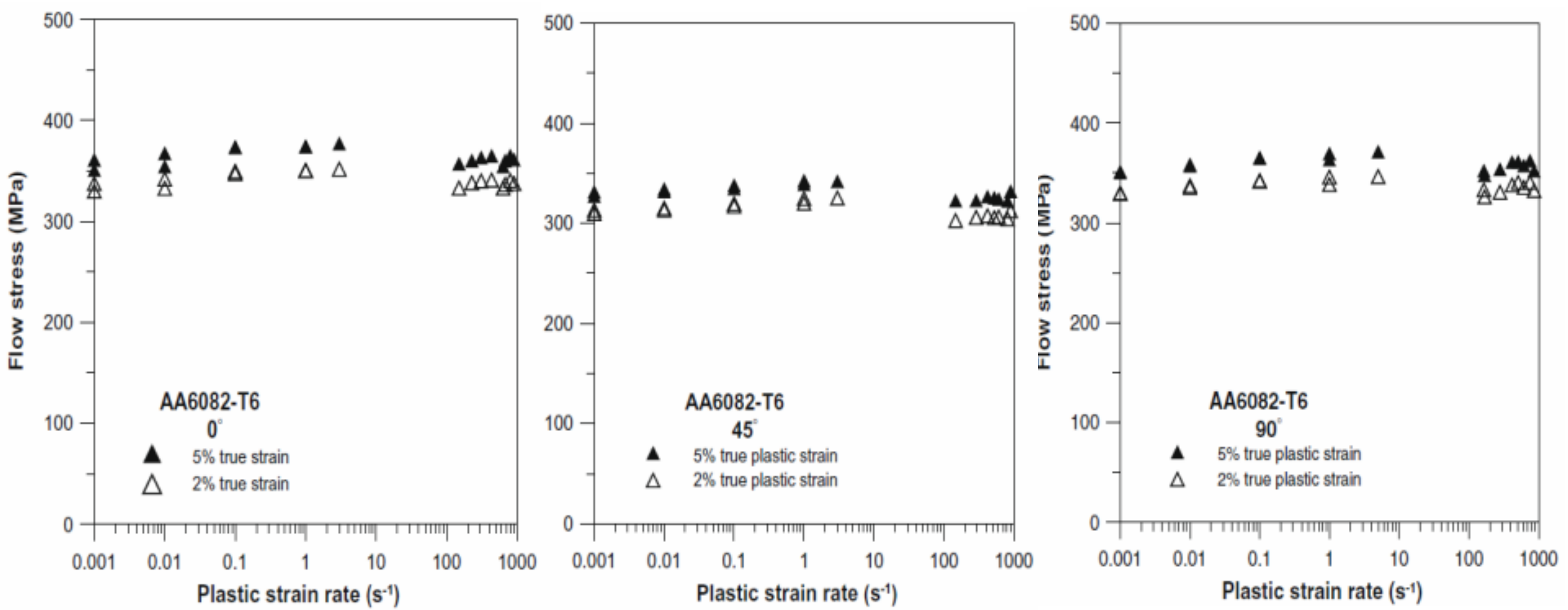


Material and component test, expensive and complicated

QUASISTATIC VS. DYNAMIC

Properties for 6xxx-alloys can be considered to be independent of strain rate

Dynamic testing and quasistatic testing should give the same results



Y. Chen, A.H. Clausen, O.S. Hopperstad and M. Langseth: *Stress-strain behavior of aluminum alloys at a wide range of strain rates. Int. J. of* Solids and Structures, Vol 46, pp. 3825-3835 (2009).

….which is our experience as well

Dynamic

Quasistatic

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Focus on **strength critical** performance

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6XXX Alloy Development – High Strength Alloys

- Sapa has developed higher strength alloys that are available

Alloy	Standard Tempers	Tensile Strength	Yield Strength	Elongation[3] (min.)
6061 AA	T6/T6511	260 MPa	240 MPa	8%
6082 AA	T6/T6511	310 MPa	260 MPa	6%
Sapa HS6X	T6/T6511	337 MPa	320 MPa	8%
Sapa 6082 (RX82)	T6/T6511	310 MPa	290 MPa	8%
Sapa 6061*	T6/T6511	285 MPa	275 MPa	8%
Sapa 340**	T6/T6511	360 MPa	340 MPa	10%

* 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.

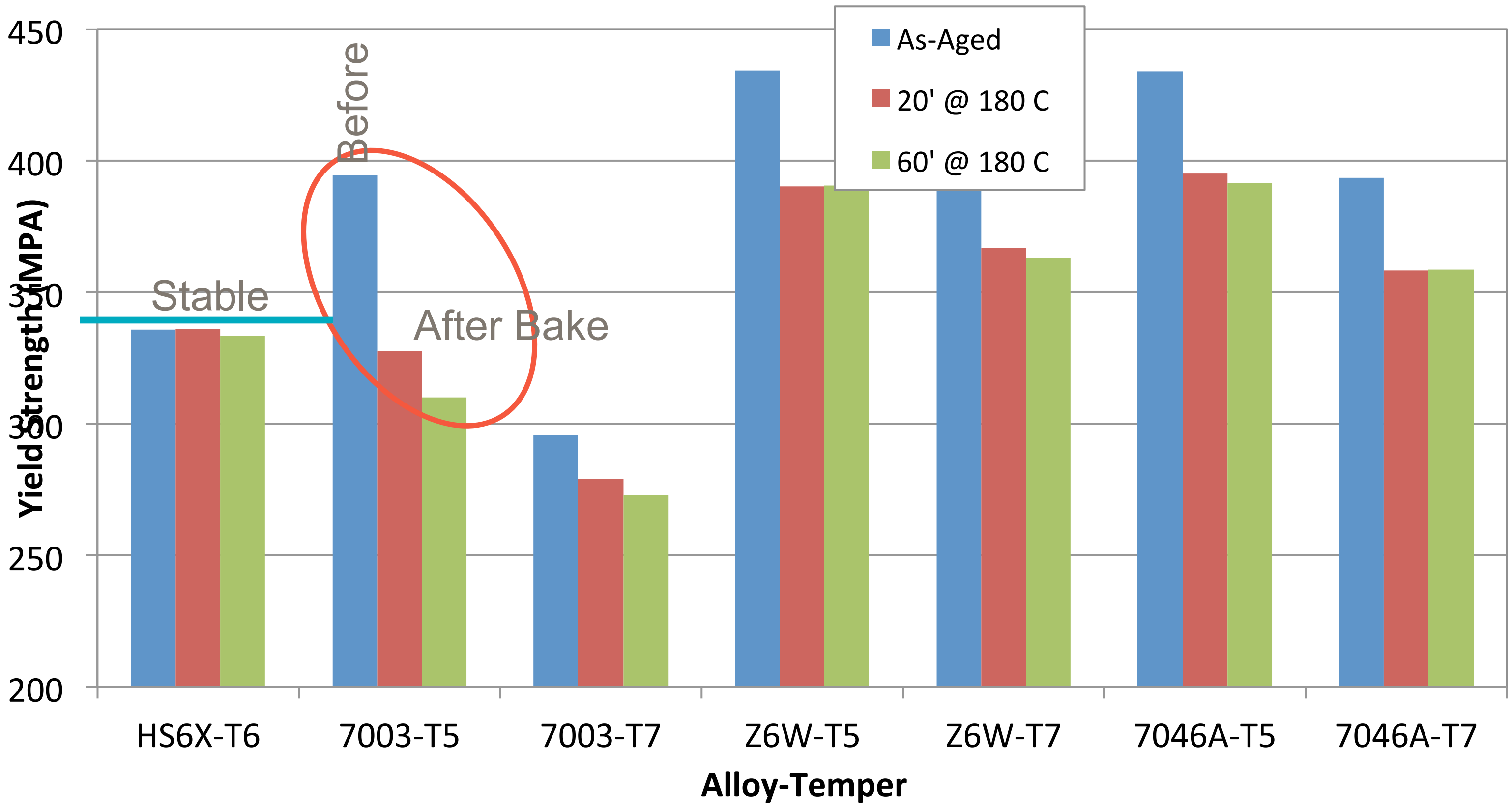
Alloy	Standard Tempers	Tensile Strength	Yield Strength	Elongation[3] (min.)
Sapa 7003	T5	375 MPa	345 MPa	10%
Sapa 7046A	T7*	410 Mpa**	370 MPa	10%
Kobe Z35B	T5	350 MPa	285 MPa	10%
Kobe Z6W	T5	410 MPa	390 MPa	10%

* 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.

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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**

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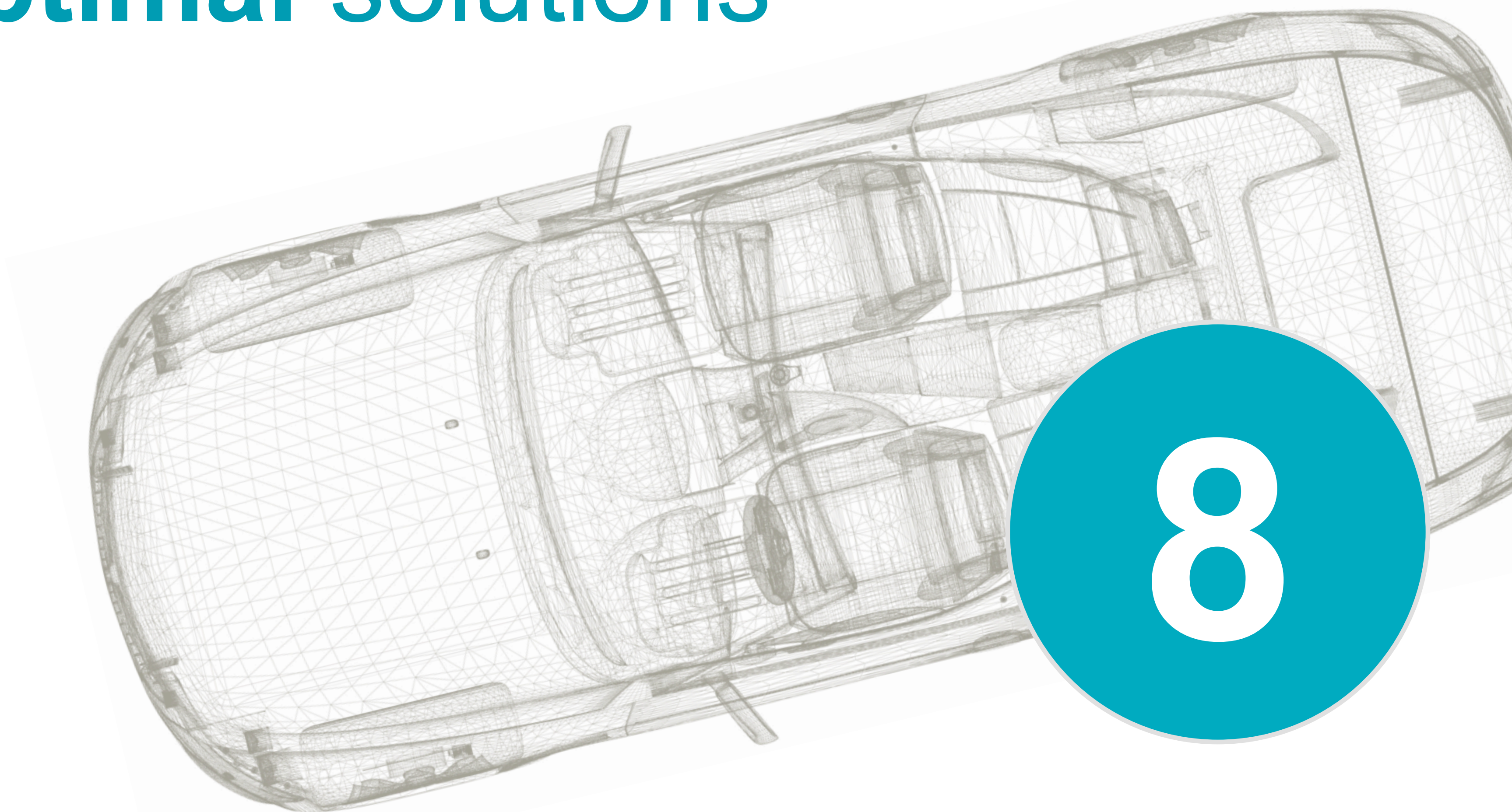
- Energy consumption for producing 1000kg prime aluminum is 30 000 kWh
- Recycling only requires 5% of the energy input
- Scrap segregation is very important
  - Keep to one alloy series...
  - ...or make sure separation is possible
  - 7XXX alloys in particular have the potential to have the biggest negative effect on recycling efforts.

Joint development for **optimal** solutions



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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!

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