High strength steels for light weighting automotive applications

Mark Rainforth
Andrew Patterson
Alfonce Chamisa
Arjan Rijkenberg (Tata Steel)
High strength steels - a success story!

High strength, low weight components for automotive applications
Increase in car curb weight in Europe

Increasing customer affluence induces more weight!

Comparison of curb weights of common B-segment vehicles over the model years

Source: Stephen M. Zoepf, Automotive Features: Mass Impact and Deployment Characterization, Massachusetts Institute of Technology (MIT) 2010
Material Classes
Comparison with state of the art compact cars

VW Polo (2009)
Audi A1 (2010)
FSV (2020) 188 kg

Polo V 2009:
- 33% HSS (HSLA, BH, IF)
- 53% AHSS (DP, TRIP, TWIP)
- 8% UHSS (CP, MS)
- 2% HF

Audi A1 2010:
- 33% HSS (HSLA, BH, IF)
- 48% AHSS (DP, TRIP, TWIP)
- 11% UHSS (CP, MS)
- 5% HF

FSV 2020:
- 33% HSS (HSLA, BH, IF)
- 43% AHSS (DP, TRIP, TWIP)
- 11% UHSS (CP, MS)
- 10% HF

Significant increasing share of AHSS, UHSS and hot forming steels

Source: Eurocarbody 2009
ATZ extra 06/2010

FSV = future steel vehicle

www.worldautosteel.org
The need to escape the ‘banana’ diagram
Designing Alloys for Resource Efficiency (DARE): A Manufacturing Approach
Design of nanoprecipitation steels to deliver strength and formability

- Designers are specifying higher strength multiphase steels to meet weight targets. This also extends to the automotive chassis system.
- However, processing and joining higher strength materials can prove challenging.
- The need is for:
  - High yield and tensile strength
  - Improved combination of hole-expansion and elongation
  - Good bendability
  - Good fatigue strength
  - Good weldability

Edge splits waste a lot of time and money: 99% of splits on chassis parts are edge splits.

Courtesy Tata Steel
To achieve high elongation and high hole expansion ratio, adopt a single-phase ferrite microstructure as the base-line.
Nano-precipitation strengthened single-phase ferrite microstructure

**MICROSTRUCTURE**

![Schematic CCT diagram](image)

- **FERRITE**
- **BAINITE**
- **PEARLITE**
- **MARTENSITE**

- Temperature range: 600-650 °C
- Temperature range: ≥900 °C
Fine ferrite grain size with either equiaxed or possibly bainitic structures
Nano precipitation steels- starting to break out of the 'banana' diagram
Nano precipitation steels—starting to break out of the ‘banana’ diagram

- 800MPa grade offers superior elongation and HEC compared with CP800 and S700
- 800MPa grade offers increased yield strength compared with CP800

Courtesy Tata Steel
Nano-precipitation strengthened steel

Balancing strength and formability

STRENGTH: Nb, V, Mo nano-precipitation

FORMABILITY: single-phase ferrite

Balance
Nanoprecipitation steels- remarkable strengths >1GPa, ductility >25\%
Nano precipitation of vanadium carbide in a ferrite matrix
17-VMo Atom Probe

Left: Carbide distribution, showing interphase precipitates

Bottom: Line scan across a carbide showing that it consists of V and Mo, with a trace of Nb
What does the future hold?
Conclusions

• There is no such thing as a traditional material—materials can evolve quickly to meet a demand

• Materials must be designed with resource efficiency in mind—both composition, manufacturing route, manufacturing waste and recyclability/re-use