The Future Revolution in Automotive High Strength Steel Usage

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Automotive Steels – From Low Carbon to Advanced High Strength

**Conventional Steels**
- Low Carbon (LC)
- Bake Hardenable (BH)
- Solid Solution Strengthened (SSS)
- High Strength Low Alloy (HSLA)

**Advanced High Strength Steels**
- Dual Phase (DP)
- Complex Phase (CP)
- Transformation Induced Plasticity (TRIP)
- Martensitic (MS)
The Types of High Strength Steels

Conventional Steels – The Medium Strength Steels

- Bake Hardenable (~180–300 MPa yield strength)
  - Transitional strengths between low carbon and high strength steels (HSS’s)
  - Excellent combination of strength and formability
  - Good mechanical property consistency
  - Gain strength after strain and bake

- Solid Solution Strengthened (~180-300 MPa yield strength)
  - Various strengthening elements
  - Good formability
  - Low cost
The Types of High Strength Steels

Conventional Steels

- HSLA Steels (~270-550 MPa yield strength)
  - Wide Availability
  - Excellent Weldability
  - Familiarity
The Types of High Strength Steels

The Advanced High Strength Steels

- Dual Phase (~ 500-1000 MPa tensile strength)
- TRIP - Transformation Induced Plasticity (~ 600–800 MPa tensile strength)
- Complex Phase (~ 800–1000 MPa tensile strength)
The Types of High Strength Steels

The Advanced High Strength Steels

- Multiphase structures
- High formability for tensile strength
- Higher energy absorption than microalloyed or solid solution strengthened steels
- Available in high and low yield to tensile ratios
- Require specific annealing cycles
- Carbon equivalents can be high
The Types of High Strength Steels

Ultra High Strength Steels

- Martensite (~900-1500 MPa tensile strength)
  - Fully martensitic structure
  - High tensile and yield strength
  - Single phase structure
  - Can exhibit excellent weldability in lower strengths
  - Low ductility
  - Best suited for roll forming
The Advanced High Strength Steels

**Definition of AHSS**

AHSS’s are multiphase steels which contain martensite, bainite, and/or retained austenite in quantities sufficient to produce unique mechanical properties (transformation hardening). AHSS’s exhibit an excellent combination of high strength and high formability resulting primarily from their high strain hardening capabilities.
Formability of High Strength Steels

- **Low Strength Steels (<270MPa)**
- **Ultra High Strength Steels (>700MPa)**
- **High Strength Steels**
  - Conventional HSS
  - AHSS
- **Steels**
  - IF
  - IF-HS
  - Mild
  - ISO
  - BH
  - TRIP
  - CMn
  - HSLA
  - DP, CP
  - MART
- **Formability of High Strength Steels**

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[www.autosteel.org](http://www.autosteel.org)
Historical Steel Usage at GM

Early 1990’s GM Vehicle

- Primarily composed of low carbon steel
- Significant HSLA steel content
- High bake hardenable steel content

* Includes Closure Applications

- Low Carbon Steel, 78%
- Bake Hardenable, 12%
- HSLA, 10%
Small Car/Small SUV Body Structure

- BH and SSS extensively used in underbody structure
- Extensive use of HSLA for load carrying members
- Very low usage of low carbon steels

Current Structures – Evolutionary Materials Composition

- Medium Strength, 66%
- Low Carbon Steel, 8%
- HSLA, 27%
Midsize Luxury Vehicle Body Structure

- First usage of martensite in welded body structure at GM
- Large HSLA content

Current Structures – Evolutionary Materials Composition

- Low Carbon Steel, 62%
- HSLA, 34%
- Martensite, 4%
**Epsilon – Chevy Malibu Body Structure**

- First GM use of DP steel in welded body structure
- Global structure with common, worldwide specifications

![Pie Chart]

- Medium Strength, 42%
- Dual Phase, 12%
- HSLA, 5%
- Low Carbon Steel, 41%
- Medium Strength, 42%
Current Structures – Evolutionary Materials Composition

CR590T/340Y Dual Phase Usage by Part

- Panel - Rocker Inner R/L: 1.60 mm
- Extension - Rocker Inner Panel Front R/L: 1.20 mm
- Reinforcement - F/Compartment Inner: 2.25 mm
- Extension – Rocker Inner Panel Rear: 1.20 mm
- Reinforcement – Floor Panel Bar #2 R/L: 1.60 mm
The Future of AHSS’s

The Need For Advanced High Strength Steels?

• Mass Avoidance
• Improved Crashworthiness
• Regulatory Requirements
  – Front Barrier
  – Front Offset Barrier
  – Side Impact
  – Roof Crush
  – Rear Impact
GM’s High Strength Steel Task Force

- Multidisciplinary AHSS Expert Team
  - Oversee AHSS development
  - Resolve issues
  - Assist in applications across vehicle lines
  - Communicate lessons learned
  - Resolve roadblocks
  - Allocate financial resources
Near Term AHSS Usage

• Apply AHSS’s in refreshed designs
  – Improve frontal crash performance
  – Improve side impact and roof crush

• Typical Applications
  – Motor compartment/longitudinal rails
  – Rocker inners
  – B Pillar reinforcements
Future Direction

New Vehicle Architectures

- AHSS’s are integrated into structural designs…..
  - Spot welding and formability needs incorporated
  - Fatigue and high strain rate properties available to CAE
  - Future development plans in place
  - Crash repair strategies being developed
  - AHSS intensive structural vehicles validated
Projected Volume of Advanced High Strength Steel (metric tons)*

Dramatically Increasing AHSS Volumes

* Excludes bumpers and door beams

Model Year

Great Designs In STEEL Seminar  w w w . a u t o s t e e l . o r g
Chevy Malibu Dual Phase Experience

• No production welding issues
• Formability has been acceptable
• No significant issues with springback
• Some edge cracking has occurred
Cadillac CTS Martensite Experience

- Roll Formed Rockers
  - Rocker inners and outers panels experienced springback and dimensional issues
  - Water quenching contributes to flatness, waviness and variations between slit coils
  - Issues minimized with optimized roll forming process

- Roll Formed Rocker Reinforcement
  - No production issues
Advanced High Strength Steels

The Benefits

• Improved energy absorption in axial crush
Advanced High Strength Steels

The Benefits

- Energy Absorption
The Coming Revolution…
GM Material Body Structure Breakdowns

The Past........
- Low Carbon, 62%
- Martensite, 4%
- HSLA, 34%

The Near Future........
- Dual Phase, 35%
- Martensite, 8%
- Low Carbon, 11%
- Medium Strength, 46%
The Coming Revolution...
GM Material Body Structure Breakdowns

And Beyond?...........

- **Dual Phase, 45%**
- **Medium Strength, 33%**
- **Low Carbon, 10%**
- **Martensite, 12%**
Conclusion

- AHSS have a bright future in automotive structural applications and are poised to revolutionize how steel is used to manage structural crash energy.
- The single greatest impact of AHSS’s will come from integrating these materials with efficient structural designs and efficient joints.
- The manufacturing challenges for implementing AHSS, such as welding, springback control and repairability can be overcome.
- AHSS’s represent the greatest opportunity to maintain steel as the primary body structure material and to provide our customers with a low cost and exceptionally safe vehicle structure.