Steel Response to Challenges of a Modern Automotive (and Mobility) Industry

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Outline

• AISI introduction
• Modern steel producing operations
• Steel grade development history
• Decarbonization and sustainability in the American steel industry
• Challenges with advanced steel materials
• Impact of vehicle electrification
AISI Introduction

Mission

The American Iron and Steel Institute’s Mission is to **influence public policy, educate and shape public opinion** in support of a strong, sustainable American steel industry committed to manufacturing products that meet society’s needs.

Vision

The vision of the Institute and its members is for a sustainable American steel industry **strategically positioned for growth and innovation** and as a leader in the global marketplace.

Producer Members

- ArcelorMittal
- Cleveland-Cliffs Inc.
- DTE Energy Resources
- Harsco Environmental
- North American Stainless
- Nucor Corporation
- Outokumpu
- SSAB Americas
- Tenaris Bay City

Associate Members

- Approximately 70 supplier and supporting companies
Steel Industry Collaboration

Automotive Applications Council

Focuses on innovation in automotive steel and advanced manufacturing, providing industry education and supporting technology transfer initiatives.

Pre-competitive Collaborative Research & Development; Leveraging joint contributions and intellectual capital providing more value and quicker results.

www.steel.org
www.autosteel.org
www.a-sp.org

Leverages the global industry to meet society’s needs for automotive and mobility related steel products in a sustainable and environmentally responsible way.
Modern Steel Producing Operations
Steelmaking Modernization in the U.S.

• Today’s American steel industry is high tech and clean, resulting from significant modernization and new technology investments.

• Globally developed improvements in the steelmaking process have been and continue to be implemented by American steelmakers.

• There has been SIGNIFICANT investment in personnel training, new mill facilities and highly capable process equipment.
Industry Consolidation and New and Announced Investments in Recent Years

- Acquisition of AK Steel
- Acquisition of ArcelorMittal USA
- Toledo, OH HBI production facility
- Silver Bay, MN upgrade
- Acquisition of Ferrous Processing and Trading

- Acquisition of Big River
- Big River Osceola, AR expansion
- Fairfield, AL EAF
- Osceola, AR EAF Plant
- Sedalia, MO EAF
- Frostproof, FL EAF
- Gallatin, KY expansion
- Brandenburg, KY EAF
- Mason County, WV EAF
- Kingman, AZ EAF
- Lexington, NC Micro Mill
- Acquisition of majority interest in CSI

Total sheet mill investment nearing $10 Billion (USD) with added capabilities for electrical steels and 3rd Gen AHSS
Honorary Member of Our Team

Equilibrium Phase Diagram

- A range of equilibrium solid solution phases can be observed in this unique alloy system.
- Non-equilibrium processing (fast heating and/or rapid cooling) can precisely modify and combine these phases to create new steel grades.
- That’s what drives innovation in steel grade design.
Steel Grade Development History
The Existing Material Paradigm

TRUE or False?

Higher-strength materials have lower ductility

TRUE

Civilization is rife with examples of the impact of heating metals to reduce strength and improve ductility (improve malleability). The paradigm of higher-strength equating with lower ductility remains.
The steel industry over the past several decades has been actively engaged in implementing state-of-the-art processes and modernizing its infrastructure.

These upgrades focused on very precise control of the thermomechanical processes to produce **NEW** steel grades with **BOTH** high strength and high ductility.

The **time** to process steel in the **temperature** range of 1300°F - 1700°F (725°C to 900°C) and the **speed** with which the steel is cooled creates different phases and content ratio of phases.

**In short ...**

**The steel industry continues to improve its product value!**

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**Steel Facts**

- BH – Bake Hardenable
- DP – Dual Phase
- MP – Multi Phase
- CP – Complex Phase
- TRIP – High Austenite content MP
- MS – Martensite
- PHS – Press Hardened Steel

**Iron-Carbon Equilibrium Phase Diagram**

**Time/Temperature/Speed manipulation to achieve steel grades with variety of properties**

*Source: Engineering Quality Solutions, Inc.*
Baseline low carbon “structural” steel grade
- Carbon limited for weldability
- Conventionally rolled, not heat treated or thermo-mechanically processed
- Typically utilized heavy thicknesses for added strength
- Used with reinforcement “patches” for door locks and strikers/hinge plates
Historical Progression of Automotive Structural Applications

• Application of High-Strength Steel grades (HSS)
  o A low carbon alloy with some substitutional alloying elements (manganese, silicon)
  o Small additions of micro-alloys (Nb, V, Ti) added to aid in precipitation hardening
  o Strength levels increased allowing some downgauging for formability and weight reduction
  o Called High-Strength Low Alloy (HSLA) as an indicator of differentiation from structural carbon steel
Historical Progression of Automotive Structural Applications

• Hot Stamped Press Hardened Steels
  o Boron additions to 1522 steels are stamped above 1500F (850 C) and then quenched in die
  o Forming in the austenite region of the Fe-C phase diagram became a relevant steel processing method developed to support complex parts at high strength levels
  o Hot Stamping (Press Hardening) required post stamping processing (descaling, trimming) but became an effective path to create complex parts at very high strength levels
Historical Progression of Automotive Structural Applications

• **Application of 2nd Gen AHSS and UHSS**
  
  - Improved steelmaking process design and facilities allow for these grades of steel
  - These are precisely alloyed with substitutional elements to increase baseline strength (Manganese, Silicon) and stabilize required Fe-C phases
  - These are continuously annealed and precisely cooled (quenched) at controlled rates to create multiple phase in the final microstructure adding strength and preserving ductility
  - The terms Dual Phase (DP) and Complex Phase (CP) are used to define the microstructure
Introduction of 3rd Gen Steel

- Recently, modern steel grades, referred to as Generation 3 steels, utilize processing techniques that improve the typical strength/ductility relationship, can be cold or hot formed and are downgauged due to increased material strength.
- They possess high strength and have sufficient ductility to be cold formed in stamping operations.
- These are the product of significant R&D on the part of the steel industry and facility upgrades to be capable of the required thermal heat treatment and rapid cooling process control.

Historical Progression of Automotive Structural Applications
Automotive Steel Processing Line (AHSS, UHSS and 3rd Gen)

3rd Gen CAL lines are very large, complex, and highly advanced in process control and automation. These lines are in production now.
Steel Processing is Modern Beyond Perception of People

Advanced process controls that support the production of “new” AHSS steels exist throughout the steelmaking and finishing operations.
Existing Paradigm is Challenged by Modern Steel Mills

TRUE or False?

Higher-strength materials have lower ductility

FALSE

Modern thermo-mechanical steel processing with precise automation and control can produce high-strength material with vastly improved ductility to allow for the cost and mass efficient use of Advanced High-Strength Steel in automotive Body in White designs.
Decarbonization and Sustainability in the American Steel Industry
Sustainability, CO₂ Emissions, GHG

• The automotive industry is a leading player in the drive to lower environmental footprint by reducing CO₂ emissions

• This will have an impact on major parts and materials suppliers to the industry
U.S. GHG Emissions and the Role of Steel

- The global steel industry contributes 8% of total global GHG emissions
- In the U.S., the steel industry emits only 1-2% of total U.S. GHG emissions

Figure 2: U.S. primary energy-related CO₂ emissions by economic sector (left pie chart) and a breakout by industrial subsector (right stacked chart) in 2020. Electricity losses allocated to end-use sectors. The CO₂ emission in million metric tons (MTCO₂) is shown, as well as the percent contribution of that sector of the whole. Data source: EIA 2021

DOE RFI on Industrial Decarbonization Priorities, DOE-FOA 0002687, 1/27/2022
American Steel is the Lowest Emitting in the World

The Sustainability of American-Made Steel

SUSTAINABILITY INITIATIVES IN US STEELMAKING
• More EAF-based steelmaking, including supplemented scrap alternatives
• Beneficiated and pelletized Iron ore, versus lower quality sintered ores in China and elsewhere
• Higher percentage of natural gas vs coal
Pictorial essay: Iron Ore to Charge Materials

“beneficiated” Iron ore pellets

DRI

HBI
Efforts to Further Enhance Sustainability

Work is underway on projects to further enhance the sustainability of American steelmaking:

• Advancements in the use of natural gas-based Direct Reduced Iron (DRI) and Hot Briquetted Iron (HBI)
• Increasing use of renewable energy in steel industry facilities
• Carbon capture and storage/use of emitted CO$_2$
• Potential use of renewable energy-based hydrogen as a reducing agent in DRI/HBI production, and in the Blast Furnace
GHG Calculation Terminology – Scope 1, 2 and 3

Scope 1 are emissions directly controlled by an organization – for example from burning fossil fuels for vehicles.

Scope 2 are emissions that a company causes indirectly from the energy it purchases and uses in production. For example, the emissions from the generation of the electricity that powers manufacturing equipment falls into this category.

Scope 3 are emissions not produced by the company itself, and not the result of activities from assets owned or controlled by the company, but by those emissions that it’s indirectly responsible for, up and down its value chain. An example of this is when we buy, use and dispose of products from suppliers. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries.

[Diagram of GHG Protocol scopes and emissions across the value chain]

SCOPE 1
- Fuel and company car gas

SCOPE 2
- Purchased power/steam

SCOPE 3
- GHG from all else bought and or used and or done.
Challenges with Advanced Steel Materials
Supplier Capability Tantamount to Success

Capable, Modern Steel Mill

Processors
Slitting, Blanking

Training/Experience

Forming Ops
Roll
Forming,
Tiered stamping

Capabilities:
- DP 980
- DP 1180
- CP
- Gen 3 DP
- PHS
- MS 1100
- MS 1500
- MS 1500

American Iron and Steel Institute
Certified Processor Training/Education

• Currently an envisioned initiative for the AISI Automotive Applications Committee

• Objective is to improve awareness and prevent problems associated with transforming coiled AHSS products into automotive parts
  o Collect information on problems/resolutions with processing AHSS
    • Survey real-world processors, stampers, roll formers, tubers
  o Automotive assembly lessons (joining, springback)
    • Assemble a fact-based exposition for causes and countermeasures
  o Create an endorsable training program, launch the training.
    • Develop a network of “Certified processors” to enhance marketability and reduce impact of incomplete awareness
Certified Processor Training/Education Concepts

- Review available tool materials for cutting inserts and/or slitting knives
- Blank and trim steel insert maintenance intervals
- Slitting gap and clearance recommendations to develop best internal practice
- Slit or trim edge conditions with steel multiphase materials, countermeasures
- Press tonnage and energy requirements and calculations for blanking or stamping
- Stamping lubricants for AHSS materials
- Die surface coatings to counter friction wear (current work, contact distribution)
- Die stiffness importance, structure requirements, locations of parallels (when used)
- Springback and countermeasures
- Blank and part design tactics to avoid excessive edge strain
- Radius to thickness ratio recommendations to prevent cracking
- Laser blanking opportunities
Current Technical Support for Challenges of AHSS

Auto/Steel Partnership


A/SP Technology Roadmap:

The A/SP agenda is based upon a technology roadmap which informs research project prioritization and resource allocation. More than 30 projects are currently underway across 8 project teams:

- AHSS Stamping
- Stamping Tooling Optimization
- Constitutive & Fracture Modeling
- Joining
- Steel Testing & Harmonization
- Repairability
- Gas Metal Arc Welding of AHSS
- AHSS Corrosion Protection

A/SP Focal Projects:

Three focal projects lead the A/SP research agenda.

- LME of 3rd Gen AHSS – Industrial Welding Solutions
- 3rd Gen AHSS Press Tonnage Predictions
- Spring Back Prediction, Control and Validation

DIE SHOP SUPPORT
- Laser Hardening
- Die Wear
- Friction
- Die Materials

WELDING TECHNOLOGY
- Stackups
- Opt schedules
- LME
- HAZ modeling

DIE DESIGN DEVELOPMENT
- Die bead options
- CM to Local Props limits
- Springback prediction

SUPPORT TO STAMPERS
- Laser welded blanks
- AHSS spring-back CMs
- Local and global properties
### Auto/Steel Partnership Web Page: Die Repair

#### Table: Crack Repair in Non-Working Surface

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#### Excel: Welding Process for CALDIE - Edge Surface No Coating

**Application:**
- Surface build up and trim edge repair/replacement or cover trim inserts which will be coated.

**Filler Metal Alloy:**
- TIG: CALDIE TIG-WELD MAXA (available from Uddeholm) or UTP 73

**Pre-Heat:**
- Heat detail to 390-410°F and maintain at this temperature during the welding process. After welding allow to cool in still air to 150°F

**Process Notes:**
- Stringer bead length should be 1.0-1.5 inches. Pack each pass. Apply beads in staggered pattern. See sketches

**Post Welding Heat Treatment (Tempering):**
- Heat detail to 390-400°F and maintain at this temperature for one (1) hour per inch of thickness. Allow to air cool in still air.

**Hardness:**
- Weld deposit should be 55-60 RC after tempering.

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**Recommended Bead Pattern:**
- Welding Cables along a Trim Edge
- Welding Cable to Build Up a Surface

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**Contents:**
- TAB 1 - CALDIE - NW Surface
- TAB 2 - CALDIE - Edge Surf. NC
- TAB 3 - CALDIE - Edge Surf. TCN
Impact of Vehicle Electrification
Vehicle Electrification Impacts

• Is a revolutionary change happening before our eyes
  o Changes to the automotive supply base will occur
  o Battery technology has potential to change material
  o The internal combustion engine (ICE) won’t go away immediately

• Up to 30% of all new U.S. car sales may be EV by 2030
  o Real constraints, now only being discussed, must be addressed
  o Critical minerals, electric supply capacity, battery energy density, range, charging stations and plugs, operating temperature range of batteries

• Automotive OEM’s may become assemblers of pcs/parts
  o GM has begun calling themselves an automotive technology company
Many Types of “EV”s

- **Mild Hybrid (MHEV)**: ICE w/electric motor & battery to provide torque assistance along with ICE. Electric motor could be belt driven or coupled with the transmission.
- **Full Hybrid (FHEV)**: Vehicle capable of driving using alternatively the electric motor or the ICE or both combined.
- **Plug In Hybrid (PHEV)**: Vehicle propelled by either the electric motor or the ICE or the combination of the two, equipped with a battery and charger to allow for plug-in capability.
- **Extended Range (EREV)**: Vehicle powered by battery and propelled by electric motor with an IC engine to add power (no capability to move the vehicle on its own power).
- **Battery Electric (BEV)**: Vehicle powered by battery and propelled by electric motor.
- **Fuel Cell (FCEV)**: Vehicle propelled by an electric motor using a hydrogen-based fuel cell.

BEV most popular, but PHEV may be most practical.
EVs Are Coming – Short Term

BEV sales are outperforming total Light Vehicles

Global LV Sales

- Global LV sales % change H1 2021 from H1 2020: +21%
- Global BEV sales % change H1 2021 from H1 2020: +172%
- YTD SAAR 84.5mn

US LV Sales

- US LV sales % change H1 2021 from H1 2020: +30%
- US BEV sales % change H1 2021 from H1 2020: +168%
- YTD SAAR 16.9mn

Source: LMC Automotive
Materials and Steel Related Battery Pack Manufacturing

- More than 200 new EV’s (BEV and PHEV) will launch thru 2029
- Battery housing designs and material choices seem to be as numerous as the number of new vehicles announced

[Diagram showing new PHEV and BEV launches from 2013 to 2029]

Google images: battery housing electric vehicle
Architectural Impact - Battery Enclosure/Protection

1. Top cover
   - CR6

2. Cross-members
   - MartInsite® 1500

3. Cladded cooling system
   - Steel panels

4. Frame
   - MartInsite® 1500

5. Brackets & Rails to BIW
   - CP800HR, MartInsite® 1500

6. Lower shield & Reinforcement
   - DPT180, MartInsite® 1500

Source: automotive.arcelormittal.com
Materials Forecast for Battery Pack Manufacturing

- Material selection for parts will get more complicated
- Range, battery volume, vehicle size, structure and COST are factors
- Advanced steel materials anticipated for battery housing variations
Thank You / For More Information

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