Recent Applications of High Strength Steels in North American Honda Production

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Honda R&D Americas, Inc.
Overview

1. Introduction of Topic Vehicle: 2007 Acura MDX
2. Market and Performance Targets
3. Role of High Strength Steel
4. Structural Areas and Material Usage
5. Summary
Honda Vehicles Made in North America

Honda ➔
Accord – Sedan and Coupe
Pilot
Odyssey
Ridgeline
Civic – Sedan and Coupe
CRV
Element

Acura ➔
Acura TL
Acura RDX
Acura MDX
2007 Acura MDX

Vehicle Background: **Exclusive N. American Model**
Developed: Honda R and D - Raymond, Ohio
Manufactured: Honda Canada Mfg - Alliston, Ontario
2007 Acura MDX

Vehicle Concept:  *Dynamic Motion*
Long and wide stance for low center of gravity.
2007 Acura MDX

Vehicle Character:  

A *Driver’s SUV*  
An SUV achieving excellent cornering, stability, and aerodynamics.
The core of the 2007 Acura MDX performance, safety, and styling is high strength steel technology.
Market Expectations

Body weight should be addressed to meet new customer fuel economy expectations and growing environmental awareness.

EX: US Regular Retail Gasoline Price (cents/gallon)
Body structure should be addressed to meet new safety requirements.

Example: 2007 Acura MDX Target, “Good” for Side Structure on IIHS SICE Test
Technical Challenge

Create 360° Safety Cage
By optimizing Materials and Design
The vehicle requirements necessitated the extensive application of high strength steel.
HSS & Aluminum Application

| HSS 340: 4.4% | HSS 780: 5.8% |
| HSS 440: 22.8% | HSS 980: 1.4% |
| HSS 590: 21.6% | AL: 3.9% |
The applied grades of high strength steel covered a wide range of properties.

- **Solid solution**
- **Precipitation**
- **Dual phase**
- **TRIP**
- **Martensitic**

**Body-in-White:**
- 7 HSS grades.

**Other peripheral applications:**
- **Bumper:** Roll form
- **Tank guard:** Hot Stamp

**Tensile strength (MPa)**
- 200
- 400
- 600
- 800
- 1000
- 1200
- 1400
- 1600

**Total elongation (%)**
- 0
- 10
- 20
- 30
- 40
- 50

*SAE Paper 2006-1-1585*

*Great Designs in STEEL Seminar*

*www.autosteel.org*
# The Role of High Strength Steel

## Steel Grades:

<table>
<thead>
<tr>
<th>Grade</th>
<th>General Type</th>
<th>Typical Key Alloy</th>
<th>MDX Application Area</th>
<th>Honda Model Introduction (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>440W</td>
<td>Solid Solution</td>
<td>C-Mn</td>
<td>Various Body Structures ex: cross members</td>
<td>01 Civic</td>
</tr>
<tr>
<td>440P</td>
<td>Solid Solution (re-phosphorized)</td>
<td>ULC-Mn-P</td>
<td>Various Body Structures ex: dashboard</td>
<td>01 Civic</td>
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<tr>
<td>590R</td>
<td>Precipitation (ferrite, bainite, carbide)</td>
<td>C-Mn-Nb</td>
<td>Various Body Structures ex: cross members</td>
<td>01 Civic</td>
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<tr>
<td>590Y</td>
<td>Dual Phase (martensite, ferrite)</td>
<td>C-Mn-Cr-Mo</td>
<td>Frame Structure</td>
<td>01 Civic</td>
</tr>
<tr>
<td>590T</td>
<td>TRIP (ferrite, bainite, ret. austenite)</td>
<td>C-Mn-Al</td>
<td>Frame Structure</td>
<td>07 MDX, 07 RDX</td>
</tr>
<tr>
<td>780T</td>
<td>TRIP (ferrite, bainite, ret. austenite)</td>
<td>C-Mn-Al</td>
<td>Side Structure</td>
<td>07 MDX, 07 CRV 07 RDX</td>
</tr>
<tr>
<td>980Y</td>
<td>Dual Phase (martensite, ferrite)</td>
<td>C-Mn-Cr-Mo</td>
<td>Side Structure</td>
<td>07 MDX</td>
</tr>
<tr>
<td>1310 (M190)</td>
<td>Martensitic</td>
<td>C-Mn</td>
<td>Bumper – Rear Bumper</td>
<td>05 Odyssey</td>
</tr>
<tr>
<td>USIBOR 1500P</td>
<td>Martensitic (aluminized coating)</td>
<td>C-Mn-B</td>
<td>Fuel Tank Guard</td>
<td>07 MDX</td>
</tr>
</tbody>
</table>
The Role of High Strength Steel

Example Microstructures:

440W  590R  590Y  590T

780T  980Y  USIBOR 1500P
The Role of High Strength Steel

Example Stress-Strain Curves:
Construction Overview

1) Side Construction
2) Frontal Construction
3) Rear Construction
4) Frame Construction
5) Fuel Tank Guard

Structural Areas and Material Usage
Structural Areas and Material Usage

Side Construction

Advanced High Strength Steel Side Intrusion Structure

Hardened Steel Door Beams

The advanced high strength steel side structure and side door beams help manage side intrusion.
Structural Areas and Material Usage

Production of Side components

980Y 1.6mm
• Transfer Press
• Form Process

780T 1.6mm
• Transfer Press
• Draw Process

980Y 1.2mm
• Transfer Press
• Draw Process
### Structural Areas and Material Usage

#### Side Impact

![Side Impact Test Image](www.safecar.gov)

<table>
<thead>
<tr>
<th></th>
<th>Driver</th>
<th>Passenger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>⭐⭐⭐⭐⭐</td>
<td>⭐⭐⭐⭐⭐</td>
</tr>
</tbody>
</table>

www.autosteel.org
Structural Areas and Material Usage

Side Impact - IIHS

www.safercar.gov
Side Impact - IIHS

Post crash survival space = 165 mm.
Advanced Compatibility Engineering™ (ACE™) Structure:
• distributes the forces of an incoming vehicle across the front structure.
• helps maintain structural integrity of cabin during a frontal crash.
Structural Areas and Material Usage

Frontal Impact

![Image of frontal impact test]

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www.safercar.gov
Rear Construction

High Strength Frame Rails

Roll Formed Martensitic Bumper Beam

Martensitic bumper beam and high strength steel rails assist in rear crash protection.
Frame Construction

- High strength steel is used extensively in floor frame construction.
- Advanced high strength steel is used in selective applications.
• The 2007 MDX is designed to have exceptional off-road capability.
• For trail usage, a guard is applied to help protect the fuel tank and fuel canister from rock impact.
• Conventional steel could not meet the impact targets and formability requirements.
## Structural Areas and Material Usage

### Fuel Tank Guard - Hot Stamp Processing

<table>
<thead>
<tr>
<th>MECHANICAL PROCESSING</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>USIBOR 1500P</td>
<td></td>
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<td></td>
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<tr>
<td>Hot Stamping</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>THERMAL PROCESSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat - Press - Time</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>STEEL TRANSFORMATION:</th>
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</thead>
<tbody>
<tr>
<td>Ferrite / Pearlite</td>
</tr>
<tr>
<td>Austenite</td>
</tr>
<tr>
<td>Austenite</td>
</tr>
<tr>
<td>Martensite</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>COATING TRANSFORMATION:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al/Si</td>
</tr>
<tr>
<td>Al/Si</td>
</tr>
<tr>
<td>Al/Si/Fe</td>
</tr>
</tbody>
</table>

- Press harden C-B steel to achieve ~1500 MPa strength.
- High temp diffusion forms protective Fe-alloyed Al coating during heat treat.
- UTS = ~550 MPa
- UTS = ~1500 MPa
- t = ~25 μm
- t = ~35 - 45 μm
Fuel Tank Guard

Hot Stamp process helped achieve cost and weight reduction.

- 7% lighter than baseline
- 40% fewer parts than baseline
- 89% less welding than baseline

2001 MDX  2007 MDX

Hot Stamp Design

Hot Stamp Tank Guard - Honda’s first application of hot stamp.
Summary

• Fuel economy expectations, environmental concerns, and safety performance continue to drive Honda and other manufacturers to research and develop new innovations utilizing high strength steel.

• The new Acura MDX is an example that multiple grades of high strength steel can be used to meet design and performance targets.

• New types of steels, such as TRIP steels, can be successfully applied to challenging parts that could not have previously been producible at high strength levels.

• New processes, such as hot stamping, are also allowing for the application of advanced high strength steel to new complex parts and designs.