Automotive Aluminum Growth and Joining Trends

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ALAW
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Discussion Outline

• Aluminum Use Forecast 2014-25 (Up-date)
• Joining Automotive Aluminum (Brief)
  Laser Welding
  Rivet-Bonding
• Experience - Production Aluminum Joining Processes
• Questions
Introduction

Aluminum Transportation Group (ATG)
Advancing Growth

2015 North American Light Vehicle Aluminum Content Study

Executive Summary

May 2014

DRIVEALUMINUM

drivealuminum.org

PRIVATE AND CONFIDENTIAL INFORMATION
Automotive Aluminum Today

Average 2013 Vehicle: 350 Lbs. (9%) Aluminum
Automotive Aluminum Growth Accelerating

Source: Ducker Worldwide 2014

Heat Exchangers

Wheels

Heads

Blocks

Bumpers

Hoods

Doors & Body-in-White

Sheet, Castings, and Extrusions

Pounds Per Vehicle


350 lbs.

500+ lbs.

300 400 500 600

Source: DriveAluminum.org
Automotive Material Distribution – 2013:2025

**2013**
- Mild Steel: 23%
- HSLA: 13%
- FR AHSS: 5%
- Other Steel: 16%
- FR Rolled Al: 1%
- Cast Al: 7%
- Other Metallics: 3%
- Copper: 1%
- Iron: 8%
- Non Metallics: 22%

**2025**
- Mild Steel: 12%
- HSLA: 7%
- AHSS: 11%
- Other Steel: 16%
- Flat Rolled Al: 5%
- Cast Str Al: 2%
- Cast Al: 9%
- Non Metallics: 25%
- Copper: 1%
- Iron: 8%

Source: Ducker
### Aluminum Content Varies by Segment

<table>
<thead>
<tr>
<th>Segment</th>
<th>Models</th>
<th>Average Aluminum Pounds</th>
<th>Share of 2015 Production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A/B Segment</strong></td>
<td>Fiat 500, Ford Fiesta</td>
<td>251.6 lb.’s</td>
<td>3% of Production</td>
</tr>
<tr>
<td><strong>C Segment</strong></td>
<td>Ford Focus, Honda Civic</td>
<td>273.9 lb.’s</td>
<td>17% of Production</td>
</tr>
<tr>
<td><strong>D Segment</strong></td>
<td>Chevy Malibu, Dodge Charger, MUSTANG</td>
<td>363.3 lb.’s</td>
<td>21% of Production</td>
</tr>
<tr>
<td><strong>E Segment</strong></td>
<td>Cadillac XTS, STING RAY</td>
<td>546.9 lb.’s</td>
<td>2% of Production</td>
</tr>
<tr>
<td><strong>MPV Segment</strong></td>
<td>Honda Odyssey, Chrysler Town &amp; Country</td>
<td>396.5 lb.’s</td>
<td>4% of Production</td>
</tr>
<tr>
<td><strong>SUV Segment</strong></td>
<td>Chevy Suburban, Jeep Grand Cherokee</td>
<td>410.3 lb.’s</td>
<td>33% of Production</td>
</tr>
<tr>
<td><strong>VAN Segment</strong></td>
<td>Dodge Sprinter, Ford Transit</td>
<td>273.2 lb.’s</td>
<td>2% of Production</td>
</tr>
<tr>
<td><strong>PUP Segment</strong></td>
<td>Ford F150, Ram 1500</td>
<td>548.9 lb.’s</td>
<td>17% of Production</td>
</tr>
</tbody>
</table>
Automotive Aluminum Wrought Products – 2012:2025 (Sheet, Extrusions)

“Aluminum body and structural components will lead growth in content”

Source: Ducker
Aluminum Extrusion Content -
Bumpers, Structures, Components

MIG Welding
Aluminum Sheet Content -
Closures

Aluminum by 2025:
- Closure Panels - 26%
- Hoods - 85%
- Gauge: 1 – 3 mm

Source: Ducker Worldwide 2014
Aluminum by 2025:

BIW - 18 %
Auto Body Architecture Alternatives

- Space Frame
- Uni-body

Production volume:
- Low
- Medium
- High

Manufacturing costs:
- Tool costs
- Material costs
- Assembly costs

Units per year:
- 20,000
- 50,000
- More

Costs trend:
- Manufacturing costs invest tool costs increase with production volume.
- Material costs and assembly costs decrease with production volume.
Aluminum Intensive Vehicles Today

- Corvette
- Jaguar XJ
- Audi A8
- Land Rover
- Tesla
- Pick-up Truck
Joining Aluminum Body Sections

BIW Joining Process – A Complex Question:

- Design advantages – stiffness, NVH, energy absorption, mass
- Durability – fatigue, corrosion
- Serviceability
- Cycle time
- Know-how
- Manufacturing cost – consumables, energy, maintenance
- Capital cost
Joining Body Structures

Industry Trends/Experience

- Significant Aluminum Growth

- Best Solution:
  Robust Design / Robust Process
  Structure Optimization
  Accommodate Characteristics of Aluminum
  Lowest cost

- Alternative processing choices:
  Spot
  MIG
  Laser
  Friction stir
  Rivet
  Weld-bonding
  Rivet-bonding

*** Aluminum is different ... not difficult ... just different
Joining Aluminum Body Sections

Welding Aluminum – Critical Success Factor

(Different ... Not Difficult)

Heat Affected Zone (HAZ)

Strength reduction
alloy depletion
annealing

Fatigue strength reduction
hot tears
hydrogen porosity
oxide contamination
general contamination

Distortion
Residual Stress relief
Thermal expansion
Laser Welding Considerations

Attributes

- Weld quality
- Reduced HAZ
- Cosmetic
- Continuous Joint - Possible
  *(Not as effective as rivet-bonding)*
- Speed / Cycle Time
- Commonly:
  - one side access
  - stamping to extrusion or casting

Issues:

- Component positioning
- Beam guidance
- Gap tolerance
- Energy (reflect, conductivity)
- Capital cost
- Maintenance Cost
Aluminum Auto Body Joining – Low Volume

Utilize Most Joining Processes

Corvette

Tesla
Aluminum Body Joining – High Volume

Rivet, Rivet-bonding, Weld-bonding
Aluminum Truck Body – Sheet, Extrusions
Aluminum Body-in-White Joining Process: Rivet, Rivet-bonding

Self Piercing Rivet
2 side access

Flow Screw, Tacks
1 side access

Attributes:
- No predrilling
- Gap tolerance
- Eliminate heat affected zone
- Continuous joint (with adhesive, surface pre-treatment)
  - Stiffness, NVH, Energy Absorption, Mass/Cost
- Eliminate crevice corrosion
- Capital cost
- Energy consumption
Significant Automotive Growth Opportunity – Aluminum Joining

Summary:

Steel and Aluminum will **Co-exist**
Important Auto Materials

**Significant Growth in Aluminum Joining**
- Structures
- Closures
- BIW

**Joining Process “Critical”**
- Vehicle design
  - Mass Optimization, Stiffness, NVH, Energy Absorption
- Cost Structure
  - Variable cost
  - Investment

**MIG, Laser Welding, Rivet-Bonding**
- Issue: laser weld-bonding sheet structures

Aluminum Joining .... Different not difficult
Thank You!

www.DriveAluminum.org
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