## DRIVING INNOVATION WITH AUTOMOTIVE ALUMINUM



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### DISCUSSION OUTLINE

- Why Automotive Aluminum?
- 50 Years of Growth
- Aluminum Materials
- Advances in Automotive Aluminu
- Corrosion
- Repair Industry Issues





# THE ALUMINUM ADVANTAGE



### ALUMINUM ADVANTAGES

### What Automotive Customers Need...

- Weight Reduction

   (Multi-Material Vehicles)
  - Fuel Economy/CO2 (CAFE)
  - Performance:

Safety, 0-60, handling, ride, NVH, braking, etc.

Payload, towing capacity

Cost Effective

- Aluminum Products
  - **Body Sheet**
  - Extrusions
  - Structural castings
- Properties
  - Strong
  - Tough
  - Energy absorbing
  - Corrosion resistant
  - Formable



### ALUMINUM AUTO BODY SHEET AND EXTRUSIONS

- 1.0 lb. of aluminum replaces
  - 1.7 lbs. of MS/HS/AHSS
    - Body: 40% mass (BIW, Closures)
    - Curb mass: -12%
    - Jaguar, F-150, Aachen, FEV/EDAG ...
- Secondary mass reductions
  - Up to 0.5 lbs.
- 10% vehicle mass reduction "achievable"
  - 6.5% FE improvement (+ 2.7 MPG)

- Cost advantage over other fuel economy technologies
  - Diesel, hybrid, electric, ...





### THE VIRTUOUS CYCLE



# **50 YEARS OF GROWTH**



### 2015 DUCKER WORLDWIDE AUTOMAKER SURVEY

- 40 year growth trend continues
- Highest growth = 2015
  - First high-volume automotive body and structures –
     F-150 pickup truck all-aluminum body
  - Sheet and extrusions body, closures
- Continued growth
  - Non-body applications: castings and extrusions



### **50 YEARS OF ALUMINUM GROWTH**



Source: Ducker

### **50 YEARS OF ALUMINUM GROWTH**



### AUTOMOTIVE MATERIAL MIX SHIFT - LIGHTER

2015

2025



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### ALUMINUM BODY COMPONENTS



### ALUMINUM-INTENSIVE VEHICLES TODAY





### ALUMINUM DRIVES CREATION OF NEW SEGMENT: ULTRA-LUXURY SUV



#### **Bentley Bentayga**



**Maserati Levante** 



#### Lamborghini Urus



#### **Rolls Royce Cullinan**

### MULTI-MATERIAL VEHICLES: THE NEW NORMAL



2016 Chevrolet Malibu



### ALUMINUM REPAIR - MARKET GROWTH





# AUTOMOTIVE ALUMINUM MATERIALS



### ALUMINUM AUTO BODY MATERIALS

- All aluminum materials are <u>NOT</u> the same
   Can not easily identify specific material in the field Repair practices varies by material
- Automotive alloy selection
  - Strength Ductility Corrosion resistance Cost (material, processing) Energy absorption



### ALUMINUM AUTO BODY MATERIALS

#### Different Automotive Aluminum Materials

**Product form** 

sheet, extrusion, casting

Alloys

composition, mechanical properties, strengthening process

**Tempers (strengthening)** 

mechanical properties, formability

Heat Treatable: Typically: body exterior, loaded structure
F, T4, T4PB,: High Formability
T6: Maximum Strength (+50% over T4 Typ.)
Non-heat treatable: Typically: under-body structure
HXX Work hardening



### ALUMINUM AUTO MATERIALS – PRE-TREATMENT

#### Pretreatment – Sheet, Extrusions

Function – alter natural oxide layer

Chemically

**Physically** 

**Purpose - enhance** 

**Adhesive bonding** 

**Paint adhesion** 

**Corrosion resistance** 

Types

Anodize Alodine

Alcoa 951





....

### ALUMINUM AUTO BODY MATERIALS

#### Exterior Body Sheet (class "A" surface)

#### **Requirements**

Stiffness, Formability, Surface Quality, Dent Resistance, Corrosion Resistance

#### **Product Attributes**

```
Alloys

6005, 6009, 6010, 6013, 6016, 6022, 6111, 6451, (7XXX)

Tempers

T4 or T4 PB Typ.

Strength

T4: 185 – 250 MPa UTS (elongation 20-25 %)

Gauge

0.8 – 1.4 mm Typ.

Forming

T4 temper

Some aged to T6 after forming
```



### ALUMINUM AUTO BODY MATERIALS

- Body Structure (non class "A" surface)
  - Sheet, Extrusions, Castings
  - Requirements

Strength, stiffness, energy absorption

Alloys

Sheet – 5182, 5454, 5754, 7XXX, ... (Cold worked in forming) Extrusion - 6005, 6061, 6063, 6082, 7003, 7043, .... (T6 Typ.) Casting – 380, 356, 357, ..... (T6 Typ.)



# ADVANCES IN AUTOMOTIVE ALUMINUM



### ADVANCED ALLOYS MEET AUTOMOTIVE NEEDS

### Continuous Product Improvement

- High Strength
- Energy Absorption
- Advanced Formability
- Value
- Sustainability





Graphic: Alcoa R&D

### HIGH STRENGTH ALUMINUM GRADES

#### "High Strength" Alloy/Temper Variants

**Applications – body structure, bumper** 

Sheet:

Variants: 6022, 6111, 6451, 7021

UTS: 400 + MPa

**Extrusions:** 

Variants: 6082, 7003, 7046

UTS: 400+ MPa



### ALUMINUM ENERGY ABSORPTION

#### "Crush Grade" Alloy/Temper Variants

**Excellent energy absorption** 

Applications – body structure, bumper, frame rails, crash cans

Sheet:

Variants: 6022, 5454, 5754

UTS: 300 + MPa

**Extrusions:** 

Variants: 6005, 6061, 6082, 7046

UTS: 300 + MPa

Aluminum: Highest energy absorption automotive material, pound for pound

Sheet:



#### **Extrusions:**







### ENHANCED FORMABILITY ALUMINUM ALLOYS

#### "Formability" Alloy/Temper Variants

- Excellent: deep draw, hydroforming, hemming
- Applications body structure, exterior panels, door inner
- **Sheet (exterior):** 
  - Variants: 6111,6022,6XXX,....
  - UTS: 250 365 MPa
- Sheet (structural)

Variants: 6022,6111,6XXX,5182,5454

UTS 250 – 575 MPa



- **Extrusions:** 
  - Variants: 6061, 6082
  - UTS 300 350 MPa

### BODY SHEET GAME CHANGER: ALCOA MICRO-MILL TECHNOLOGY



Alcoa Micromill™ Simplified auto sheet flow-path 20 minute process time Small foot-print Alcoa Micromill<sup>™</sup> Technology: 30 percent greater strength 40 percent greater formability 6xxx alloy Class A surface quality 5xxx and 6xxx alloys components

Micromill™ process description and advantages over conventional technology





### BREAKTHROUGH: GM ALUMINUM WELDING



GM's new resistance spot welding process, using a proprietary multi-ring domed electrode, will enable more use of lightweight aluminum, which can help boost fuel economy.





Source: General Motors

### COST / EFFICIENCY IMPROVEMENT





### ENVIRONMENTAL STEWARDSHIP

#### North American (U.S. Canada) Primary Aluminum Production:





### NAFTA PRIMARY ALUMINUM: LONG TERM TREND



CO2 Generation\* Coal – 20 lb./lb.Al Hydro – 5 lb./lb.Al

\* Includes: mining, refining, transportation



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# ALUMINUM AUTO BODY AND CORROSION



### AUTO ALLOYS - CORROSION RESISTANT

#### Aluminum Automotive Alloys

**Excellent Corrosion Resistance (5XXX, 6XXX)** 

**Natural Oxide Film** 

**Cosmetic Corrosion – Certain conditions** 

Galvanic corrosion Crevice corrosion

**Filiform corrosion** 

#### **Preventive Measures**

**Known and practical** 







### ALUMINUM – NATURAL CORROSION RESISTANCE

- Natural Oxide Film (The Key Attribute)
  - Forms instantaneously

increasing thickness over time

Transparent

**Tenacious** 

Hard

Chemically stable in "normal" environments (pH 4.5-8.0)

exposed raw metal does not corrode

engine, transmission, suspension

 Corrosion can Occur if Damaged

> Scratch Stone chip Mechanical abrasion Sanding, Grinding Chemical attack (Ph: <4, >8)

Corrosion Typically
 <u>Cosmetic</u>

Un-painted - White powder on surface



### **GALVANIC CORROSION - ALUMINUM**

#### Galvanic Corrosion - Conditions

**Dis-similar Metals (or Materials)** 

and

**Electrical Contact** 

and

Electrolyte (NaCl)

- Corrosion Rate typically "very slow"
- Prevention

**Protective coatings** 

fasteners – common coatings

- sheet or extrusion
- Seal interface crevice (exclude electrolyte)











### **CREVICE CORROSION - ALUMINUM**

#### Crevice Corrosion

Chemical action between surfaces

#### Required conditions

**Crevice - fraying surfaces** 

and

Electrolyte (NaCl)

#### Locations

lap joints

spot welded joints

or, surface mud accumulation

(similar to steel, less aggressive in aluminum)

#### Prevention

- **Protective coatings** 
  - sheet or extrusion

Seal interface crevice – exclude electrolyte

**Flexible sealer** 





H<sub>2</sub>O + NaCI





304 Stainless Steel Bolt (Passivated)

### FILIFORM CORROSION – ALUMINUM

#### Filiform Corrosion (Form of crevice corrosion)

Chemical attack under coatings

#### Required conditions

Damaged coating (scratches, stone chips, <u>sheet edges</u>) and

<u>Electrolyte intrusion (NaCl)</u> (similar to steel, less aggressive in aluminum)

#### Corrosion Rate

Accelerated by surface marks from grinding, sanding

Prevention (or Mitigation)

Surface - Alloy selection (mitigation) Surface conversion treatments Coating durability Edge - Seal crevices









### FILIFORM CORROSION – GRINDING, SANDING

Aluminum 6111 T4: Summary of On-Vehicle Results Steel: Average Normalized Corrosion Area (mm<sup>2</sup> 4000 Detroit 2 yrs E60 Montreal 2 yrs 3500 OH/NY 2yrs St. Johns 4 yrs 3000 Detroit 5 yrs 2500 Mill Finish Sanded CRS 2000 1500 1000 15 3 500 Laboratory Test: ASTM G85-A2 (Acidified Salt Fog) 5% NaCl Mill Finish 6111 T4: Sanded Steel: E60 CRS Ph 2.8-3.0 acetic acid 120 F. Impact: grinding, sanding, factory coatings 500 Hrs. (6 Hr. cycle) :45 - spray





2:00 – dry 3:15 - soak

# **COLLISION REPAIR**



### ALUMINUM AUTOMOTIVE BODY REPAIR

#### **Aluminum Repair Considerations**

- Shop Safety
   Dust Management (Combustion)
- Corrosion
- I-CAR / Aluminum Association Joint Studies Industry open issues / concerns Information Develop "Best Practices" Bulletins



### ALUMINUM DUST MANAGEMENT

#### Fines

- Dust or powder
- Grinding, sanding, polishing
- Can be combustible when:
  - Small particles < 500 micron</p>
  - Suspended in air
  - Concentration
  - Ignition source
  - Incidences are rare

Re: Nat Fire Protection Assoc. Std. No. 484



- Control
  - Dust collection system
  - Electrically grounded
  - Spark resistant
  - No smoking



# SUMMARY



### SUMMARY

Multi-material vehicle designs – the new norm
 Aluminum and steel – <u>Co-exist</u>, important auto materials

 Aluminum 2025 - OEM production Closures - 24 % by 2025 Body - 12 % by 2025

 Repair is similar to steel, but different Training – OEM, I-Car, ...
 Equipment Many different aluminum grades
 OEM repair procedures should be followed

✓ Keep Shops SAFE!
 <u>No</u> Dust incidences





# QUESTIONS?

