Post-Extrusion Processing

The Aluminum Transportation Group
Agenda

- Extrusion process (review)
- What is post-extrusion processing?
- Machining
- Joining
- Bending
- Coating
- Summary
Extrusion Process

- The extrusion process produces long profiles with a constant cross section (2D lineal)
- Common and proprietary alloys and tempers allow a wide variety of properties to be selected
- Profiles have been inspected and tested to meet customer requirements
- Now what?
Why Put More Work Into Extrusions?

- Most parts are 3D
  - What uses a constant cross sections at 50’ – 60’ lengths?
- Bare aluminum may not be cosmetically acceptable
- Parts need to be attached to other parts
Machining

- Machining generally means removing material
  - Drilling
  - Thread tapping
  - Punching
  - Turning
  - Sawing
  - Milling
  - De-burring
  - Shearing

- Makes a 2D profile a 3D part
- Allows tighter tolerances & precise feature location
Machinability

- Different alloys machine differently
  - Surface finish, chip formation, tool requirements
- Generally, softer alloy tempers are more difficult to machine
  - But not impossible!
- Rating is a guideline only

<table>
<thead>
<tr>
<th>Rating</th>
<th>Characteristics</th>
<th>Alloys</th>
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<tbody>
<tr>
<td>A-Rated</td>
<td>Very small chips</td>
<td>2011, 6020</td>
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<tr>
<td></td>
<td>Excellent surface finish</td>
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<tr>
<td>B-Rated</td>
<td>Curled or easily broken chips</td>
<td>2024, 6262, 6042, 7075</td>
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<td>Good to excellent finish</td>
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<tr>
<td>C-Rated</td>
<td>Continuous chips</td>
<td>6061, 6082, 6005, 6105, 6005A</td>
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<tr>
<td></td>
<td>Good surface finish</td>
<td></td>
</tr>
<tr>
<td>D-Rated</td>
<td>Continuous chips</td>
<td>6063, 6101</td>
</tr>
<tr>
<td></td>
<td>Satisfactory surface finish</td>
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Machining and Cutting
Cost Effective Machining

- 2 parts vs. 200,000 parts will require significantly different investment levels
- Utilize extrusion strengths
- Identify critical dimensional requirements and any datums
Types of Joining Methods

- Mechanical joints
- Welding
Mechanical Joints

- Mating features can be designed into extrusions
- Screw ports and snap fit assemblies can also be extruded
Mechanical Joints – Rivet Nuts

• “RivNut”, “Blind Nut”, and “Nutsert”
• Often used on hollow profiles and with thin wall profiles
• Installation can be fully automated
Mechanical Joints – Self-Piercing Rivet (SPR)

- No pre-drilling required
- Access to both sides required
- Can be fully automated and combined with other methods like adhesives
- Mixed materials can be joined with proper practices

Source: Böllhoff Group
Welding

- All “automotive” aluminum alloys are weldable
- Surface preparation and shielding gas very important
- High energy input is required (due to aluminum thermal conductivity)

- Wire fed through the welding torch
- All weld positions and a variety of joint types
- Higher welding speeds yield higher productivity
- Robotic or manual welding

- Filler metal introduced from a side of the weld torch
- All weld positions and a variety of joint types
- Often used when appearance and performance are critical at the cost of lower productivity.
Welding – Filler Materials

- Filler selection is critical for high quality welds

- 5356 (~5% Mg)
  - Not suitable for service temp. >~150 F or post weld HT

- 4043 (~5% Si)
  - Color mis-match if anodized after welding

- Many other 4xxx and 5xxx options, based on alloys being joined
Welding Zone

- The local microstructure is modified by melting, re-solidification and heat input
  - Fusion zone (weld nugget)
  - Transition zone (mushy zone)
  - Heat affected zone (HAZ)
- Properties vary within the weld zone and between the weld zone and bulk structure
- Post weld heat treatment can reduce the variation
Solid State Joining – Friction Stir Welding

- Solid state process – no melting
- Significantly smaller HAZ
- Often used for long lengths and cold plate applications
Bending

- Bending gives design flexibility and allows complex geometries
- Often a substitute for joining corners
- Cosmetic
Springback
Springback

- Springback is the return toward the original shape after plastic deformation
- The amount of springback varies with yield strength
  - Unaged vs stabilized
Bending Considerations

• Alloy-temper
  o Softer alloy-tempers are able to have more severe bends
  o Fully aged (T6, T7) material are recommended for bending without special processing

• Bend unaged/stabilized, then age to T6
  o Best combination of properties, more expensive
Bending Types

- Roll bending
- Press bending
- Rotary draw bending
- Stretch bending
- Hydroforming
- Hot gas forming
Roll Bending
Stretch Bending
Bending Examples

Radiator Beam

Charge Air Intake

Class 8 Truck Cross Member
Coatings

- Bare aluminum is suitable for many but not all applications
  - Lot to lot variation
  - Silver may not be the desired color
  - Corrosion
  - Safety
There is a variety of coating types and application methods

Coatings
- Liquid (paint, PE, lacquers)
- Powder (paint, epoxy, vinyl)
- E-coat (electrodeposition process)

Electrochemical
- Anodize (not electrically conductive)
- Conversion coatings (anti-corrosion, adhesion)
- Alodine (electrically conductive)
Coating Pretreatment

- Pretreatment is required for best coating results (longevity, adhesion, etc)

**CHROME-FREE**
1. Caustic cleaner
2. Water rinse
3. Conditioner
4. Water rinse
5. Chrome-free conversion coating

**CHROME**
1. Caustic cleaner
2. Water rinse
3. Chrome conversion coating
4. Water rinse
5. Water rinse
Coatings

• Understand the requirements & limitations of coatings
  o Longevity
  o Any further processing/assembly
  o Environment concerns
  o Profile compatibility with application method
Punching and Shearing

• Can be a very cost effective solution
  o High production rates, low cycle time
  o Repeatable, easy to automate
  o Tooling cost can be very high
  o Capabilities limited based on tolerances, equipment, and part thickness
Tooling – General Comments

• Tooling needs to be designed for aluminum
  o Steel requires different design
  o Not a drop in solution
• Feeds & speeds will also need to be changed
• The Aluminum Association has general recommendations, as do most extruders and tooling suppliers
  o If not familiar with machining aluminum, ask
Fabrication Summary

- Nearly all extrusions have multiple operations after extrusion
  - Understanding the advantages and limitations extrusions offer will help select the most cost-effective solution
  - This can include bending, machining, punching, welding, assembly and many others
  - Fabrication of extrusions is generally limited by vendors’ capabilities, not the extrusion itself
- Many extruders offer fabrication services or have close relationships with preferred outside vendors – let the extruder know what will be fabricated
  - They can help ensure success by recommending alloys tempers, packaging, etc based on their experience
  - Utilize the existing supply chain whenever possible
Questions?
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2. Visit: pollev.com/aassociation001

3. Give us feedback!