Aluminum Frame Design Considerations

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February 8, 2008
Seminar Topics

- Background
- Why Aluminum?
- Tuning Aluminum Frames
- Q&A
Mike’s Background

- Avid mountain biker
- Mechanical engineer
- Extensive CAD experience
- Passionate about bike design!

Rider: Mike Ahrens/Ahrens Bicycles
Why Aluminum?

- Racers demand performance
- Aluminum has an excellent strength-to-weight ratio
- Aluminum’s density is 1/3 that of steel (0.098 lb/in^3)
- Larger diameter, taperwall aluminum tubes can be used without weight penalty

Racer: Liz Hatch/Vanderkitten
Why Aluminum – cont

- Aluminum is easy to machine
- Aluminum is available in numerous formats (bar stock, tubing, etc)
- Aluminum has excellent corrosion resistance
- Aluminum can be used to build lightweight bicycle frames with highly-tuned stiffness characteristics
Common Bicycle Alloys

- 6061 and 7005 aluminum are the most common grades for bicycle applications
- Both grades require heat treatment after welding to achieve proper mechanical strength
- This seminar will focus on 7005 alloy
7005 Alloy

- Zinc is the major alloying element
- 7005 has good fracture toughness, easy formability and good corrosion resistance
- After welding, 7005 can be polished, painted or powdercoated
- Powdercoat temperatures must be closely monitored as to not over-age frames after heat treating
7005 Alloy – cont

- Stress Corrosion Cracking (SCC) is a known failure mode with 7000-series alloys containing copper (such as 7075)
- However, 7005 materials used for bicycle frames do not contain copper and are much less susceptible to SCC
- The key to minimizing SCC is to minimize the chance of cracks from starting in the first place
- Good manufacturing practice includes close-tolerance mitering, using correct filler rod and prompt frame alignment

Racer: Christine Vardaros/Vanderkitten
7005 Heat Treating

- 7005 tubing comes pre-heat treated; thus no solution heat treatment is required (only artificial aging after welding)
- Residual stress remains in the frame after the welding process; it’s important to relieve the majority of these stresses through a controlled heat treating process
- Proper heat treating creates precipitates within the grain structure at desired locations; ultimately improving hardness
• Precipitates serve to strengthen the material by minimizing the movement of dislocations between adjacent grain boundaries
• Artificial aging process for 7005 frames:
  6 hours @ 200°F
  4 hours @ 320°F
Tuning Aluminum Frames

- Open communication is the key to understanding the rider’s needs, their riding style and pros/cons of their current setup
- Frame designer develops a comprehensive solution that encourages proper fit in all riding scenarios
- Frame designer provides custom frame design utilizing appropriate geometry and tubing profiles for the application

Racer: Christine Vardaros/Vanderkitten
Signature Rear Triangle

- Developed over 7 years of R&D, racing and extensive rider feedback
- Wishbone rear triangle controls flex through short tube lengths and engineered frame components
- This design improves torsional compliance during descents for increased traction
- Similar to the feel of steel but with the lower weight of aluminum
Practical Design Approach

- Lower Yoke has been designed to resist bottom bracket twisting under load for increased powertrain efficiency
- Forward motion is achieved with less effort from the rider, minimizing rider fatigue
- Lower/Upper Yoke designs enhance torsional compliance on hardtail frames
- Excellent rear tire & crank arm clearance is achieved with this approach
Modularity

- Our library of 7005 frame components are modular in nature
- Modularity makes it easy to develop custom frames around popular wheel sizes (26” • 650B • 29” • 700C)
- Other frame builders can incorporate these components into their frames

Top Image: Siren Bicycles 96er
Bottom Image: Rock Lobster 29er
Frame Component Library

10mm Disc Dropouts

Sliding Dropouts

Lower Yoke

Upper Yoke
Ease of Fabrication

- Dropout ‘hoods’ are semi-circular and easily accommodate custom frame sizing
- Welding vent holes are pre-machined into dropout designs
- Yoke holes save weight and double as tooling holes for use with Anvil fixtures
- Components are precision CNC-machined and inspected to aerospace standards
Summary

- Aluminum is a viable material for developing handmade, lightweight and durable bicycle frames for numerous riding styles.
- Ahrens Bicycles has developed modular frame components which help tune ride quality and ease manufacturing.
- Surprisingly, very few custom frame builders use this versatile material.
- Consider aluminum as the material for your next custom frame!
Source List

Aluminum Tubing:

Easton Sports (7005, EA6X material)
Columbus (7005 material)

Suppliers:

Nova Cycle Supply (6061, 7005 material)
Fairing (6061, 7005 material)

Background Info:

“Fabrication Instructions for 6061 and 7005 Tube Sets” article (downloaded from www.eastonbike.com)
“Metallurgy for Cyclists” article by Scot Nicol (downloaded from www.frameforum.net)
“The Art of Bicycles” article by Gary Klein (downloaded from www.ibike.com)
“Stress Corrosion Cracking of Aluminum Alloys” article (downloaded from www.key-to-nonferrous.com)