

DEFINING THE ROCKY MOUNTAIN CYCLIST

mountainflyer

magazine



\$5.95

Number 9

www.mountainflyer.com

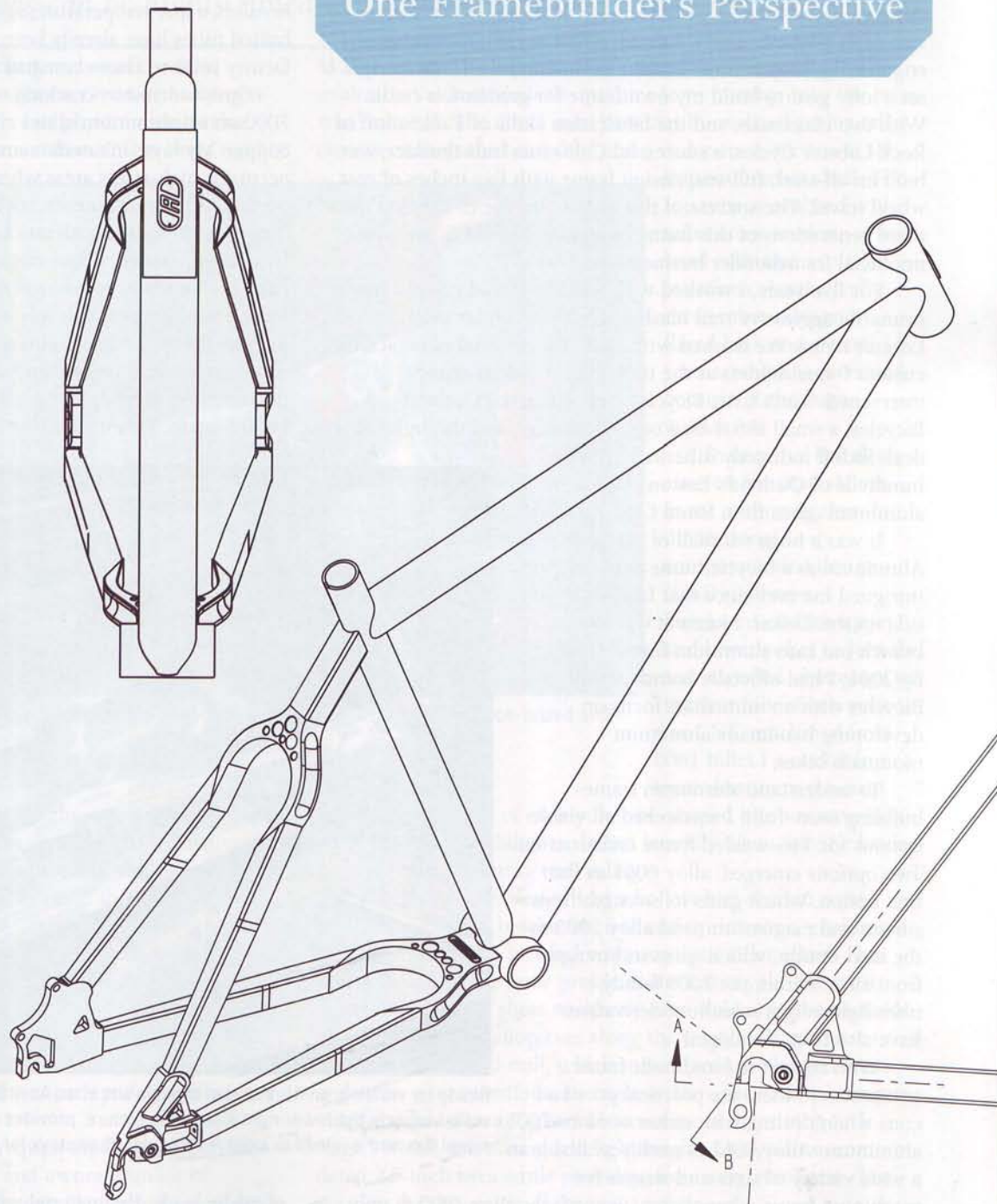


THE ROMANCE OF LA RUTA
ALUMINUM:
THE MISUNDERSTOOD METAL
FOUR ONIE'S AND ROADIE
BUILD YOUR OWN LIGHT

Understanding Aluminum

by Mike Ahrens

One Framebuilder's Perspective



SIZE	DRAWING NUMBER	REV
D	APEX-2006-MEDIUM-NODIMS	I
SCALE: 0.500	DO NOT SCALE DRAWING	SHEET 3 OF 4



In the summer I turned 21, I toured Southern Oregon and the mountain biking experience I had there inspired me to pursue my future career. Little did I know how this ride would lead me into the world of aluminum.

That day, a local trail guide loaned me his GT Zaskar. Shortly into the ride, I realized the bike rode far better than my own clunker with its mismatched components. It was more responsive, lighter and extremely rigid, making climbing a breeze.

As an engineering student at Santa Clara University, I found my young mind racing. What made this ride so well? How did this frame's geometry compare to my current bike? Did the aluminum frame offer better power transfer than steel? Could I design a better bike?

After post-ride beers, I decided that my senior mechanical engineering project must involve mountain bike frame design. I set a lofty goal to build my own frame for graduation credit. With two classmates and the fabrication skills of Paul Sadoff of Rock Lobster Cycles, a successful California framebuilder, we built an all-steel, full-suspension frame with five inches of rear wheel travel. The success of this project led me to develop three more generations of this frame design, and in 1996, my small, unofficial framebuilder business was born.

For five years, I worked with Sadoff to build custom frames, primarily aggressive trail hardtails, branded under the Rock Lobster name. We worked with steel, the material of choice for custom framebuilders at the time, until random chance intervened. Santa Cruz Bicycles had purchased Outland Bicycles, a small U.S.-based one-hit wonder, and through the deal, Sadoff indirectly inherited literally hundreds of Outland's Easton 7005 aluminum tubes from Santa Cruz Bicycles.

It was a huge windfall of materials. Aluminum as a bicycle frame material had intrigued me ever since that fateful Oregon ride on the Zaskar. I knew it was time to branch out into aluminum framebuilding. By 2001, I had officially launched Ahrens Bicycles with an immediate focus on developing handmade aluminum mountain bikes.

To understand aluminum framebuilding more fully, I researched all viable options for TIG-welded frame construction. Two options emerged: alloy 6061 as the first option, which gains its strength from silicon and magnesium; and alloy 7005 as the next option, which gains its strength from zinc. Within the 7005 family, ultra-lightweight scandium derivatives have also been developed.

With respect to handmade frame construction, there are practical pros and cons when dealing with either 6061 or 7005 aluminum. Alloy 6061 is readily available in a wide variety of sizes and shapes for machining frame components. Conversely, alloy 7005 is only offered in limited useful sizes. Both alloys are malleable and easily machined by conventional methods.

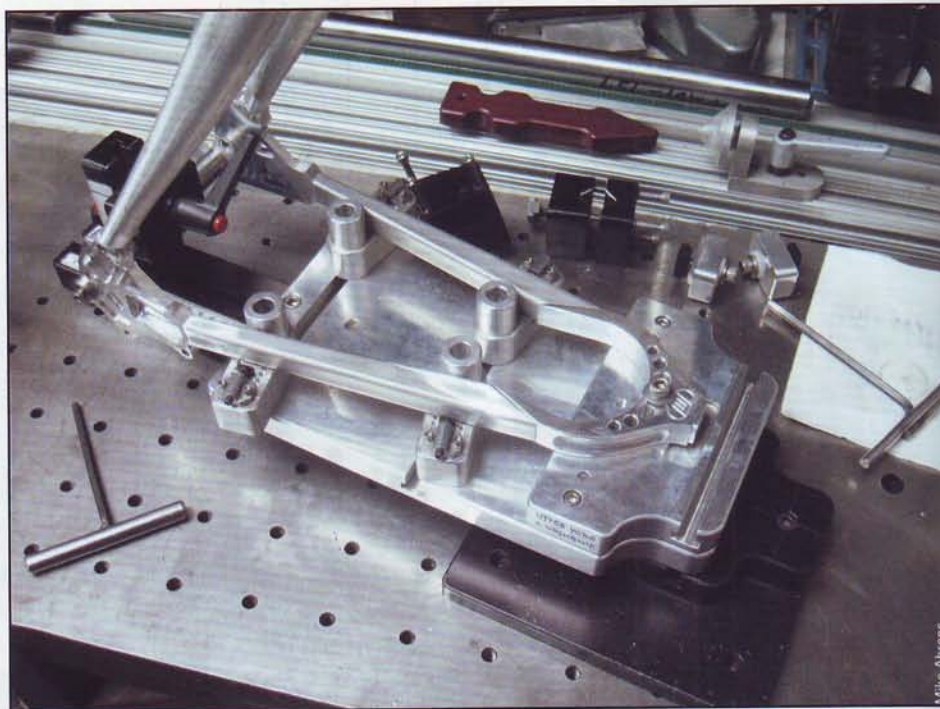
I'm not a metallurgist or material scientist, but I've gained

some practical knowledge over the years in aluminum framebuilding. Heat-treating 6061 after welding requires a high-temperature quenching and age-hardening process that must be tightly controlled for optimal results. During quenching, the material's alloying elements are trapped in solution, which results in a soft metal. During the impurity phase of the aging process, the alloying elements form fine particles that impede the movement of dislocations (defects in the metal's lattice structure) and ultimately harden the material. Aging will occur naturally over time or the process can be accelerated at elevated temperatures (artificial aging).

Heat-treating 7005 after welding is straightforward and involves a low-temperature, age-hardening process. The 7005 butted tubes have already been quenched and aged at the factory prior to frame construction and welding.

Stress corrosion cracking is a known failure mode with 7000-series aluminum alloys containing high amounts of copper. My layman's understanding is that this failure mode occurs at high-stress areas where crack propagation is likely to occur. Corrosive elements, such as water, travel into crack initiation sites and accelerate crack growth, which can lead to failure. In practice, I have not seen a 7005 aluminum frame failure from stress corrosion cracking, possibly because 7005 bicycle tubing has low levels of copper, and proven framebuilding and design practices aim to minimize stress at critical joints.

Aluminum frame failures due to fatigue are well documented, although I have not directly experienced this failure mode. This means that at some point, after some amount



Ready for welding, an Ahrens rear triangle sits in an Anvil fixture. The custom machined lower yoke, visible in the lower right side of the picture, provides ample tire clearance and subtle torsional flex and is joined to stout rectangular chainstays for great acceleration.

of cyclic loads, the material will fail when it reaches its endurance limit. In the bicycle world, this usually translates into many years of riding on the same frame without failure. Some of my earliest aluminum frames are still being ridden, and one

frame has even been raced for seven consecutive seasons. Yet I always advise riders to inspect their bikes frequently for any signs of increased stress that could lead to material failure.

One of the long-standing myths regarding aluminum says that every frame built from this material has a harsh ride quality. This may be true when oversized, straight-gauge tubing is used since the tubes have little chance to deflect under load.

Early adopters of aluminum framebuilding, with no access to butted tubing, which is thicker at the ends than in the center,

had been riding one of my steel slalom frames since 1999, but the rear tire clearance was too limited and the lateral stiffness of steel couldn't stand up to the power demands of dual slalom racing.

For Dave's 2001 race season, I sourced Easton Elite butted 6061 tubing for the front triangle. I chose 6061 because I was familiar with its properties, especially the ease of machining, from my day job as an aerospace manufacturing engineer. I soon discovered that front triangle fabrication wasn't as cut and dried

Through extensive R&D, I've discovered that aluminum frames can be highly tuned in a fashion similar to steel frames.

had no choice but to use straight-gauge tubes of the 6061 variety, and the myth of rigidity was born. Oversized tubing is required to achieve proper strength; but physics dictates that larger diameter tubes will yield extra stiffness. This extra rigidity is definitely undesirable.

To refine the ride quality of this material, early adopters pushed the envelope by experimenting with new tubing shapes and thinner walls, ultimately bringing butted tubing into the marketplace.

In its main advantage, the wall thickness of butted tubing changes along the length of the tube, placing more material in high-stress areas and less material in low-stress regions. Steel tubing suppliers had been doing this for decades, but aluminum butted tubing wasn't widely available for mountain bikes until the 1990s. The net result of this approach yields tubing that is strong, light and more forgiving.

Handmade aluminum frames have a ride quality distinct from other popular materials. Under power, aluminum frames launch forward with no perceptible flex and the pedaling efficiency is superb.

By the time I started using aluminum for handmade mountain bike frames, tubing designs from Easton were well-established and widely accepted across the industry. My new engineering challenge was to fashion these materials into mountain bike frame designs aimed at reducing any harsh characteristics while maintaining the superb pedaling efficiency of the material.

One of my first customers to request an aluminum frame was Dave Verrecchia, a local racer and owner/founder of women's apparel company Vanderkitten. He needed a new dual slalom race frame and wanted aluminum for its increased stiffness over steel. This would not be the first time Dave challenged me to develop new frames for racing purposes. Dave

as I assumed. The top and down tubes required manual ovalization at both ends to optimize joint overlap once the tubes were mitered. The down tube becomes bi-ovalized with a taller cross-section at the head tube and a wider cross-section at the

bottom bracket shell. The top tube is ovalized with taller cross-sections at both head tube and seat tube junctions. Aesthetically these tubes take on a flared look and overall joint strength is increased because of the larger weld areas.

To improve tire clearance on the dual slalom frame and using three-dimensional computer-aided design (CAD) software, I developed custom upper and lower yokes to join the seatstays and chainstays to the seat tube. Each yoke was CNC-machined from 6061 billet I sourced from a local aluminum remnant

vendor. The profile of each yoke was shaped like a tuning fork with the inherent ability to deflect laterally when specific loads are encountered during trail riding.

The lower yoke design had a hollow box-section right behind the bottom bracket shell to stiffen this zone, enabling the frame to launch forward with very little rider effort. The upper yoke had the same profile as the lower yoke except it tapered to accept a short wishbone tube welded to the backside of the seat tube. Scallop cuts along the outside length were created with a ball end-mill, which minimizes any sharp corners and stress concentrations. In cross-section, the scallop cuts provided the basis for a C-channel structure of the tuning fork "legs," which was strong and lightweight. The yokes accommodated 2.5-inch tires while providing necessary crankarm clearance on the drive-side of the rear triangle.

To address the lateral stiffness issue, I created custom 12 mm thru-axle dropouts also machined from 6061 aluminum. I opted to use rectangular BMX chainstays for the entire rear tri-



Beautiful but tough, the Ahrens Vanderkitten team frames are race-tested and race-proven.

Mike Ahrens

angle for a distinctive aesthetic and rigid ride quality. My feeling was that the rectangular tubes would add the needed stiffness to launch this bike forward through the numerous transitions common to dual slalom courses.

These various design ideas came together to create a one-off prototype slalom frame that was TIG welded by Sadoff. The prototype slalom frame had a compliant front triangle from the butted tubing and a rear triangle optimized for lateral stiffness, efficient pedaling and immediate power transfer. This frame garnered a lot of attention at its Sea Otter debut that year and its features served as the basis for many future frame designs.

I'm not sure how Dave finished that season but he loved the snappiness, crisp handling traits and responsiveness of the bike. Since then I've designed many frames for Dave and the Vanderkitten racing team. With technical feedback from elite female racers on Team Vanderkitten, I've continued to optimize key aspects of each frame design.

After building two small batches of 6061 frames based on the dual slalom prototype, I realized the supply of 6061 tubing was limited, so I decided to transition to 7005 aluminum to take



An Ahrens 7005 aluminum front triangle rests in a fixture. The 7005 series aluminum is becoming scarce for small frame builders, but it's easier to work with than 6061 series aluminum. When coupled with good frame design, the material provides some very attractive properties for a race bike.

IGLEHEART
CUSTOM FRAMES & FORKS

steel
SUPERIOR FRAME MATERIAL

PHOTO: JURYIN CRAIG BETH

keep
pedaling,
you'll
get there.

CHRISTOPHER IGLEHEART

978.626.1193
www.iglebike.com

IGLEHEART
custom frames & forks

9 WALNUT ROAD
WENHAM, MASSACHUSETTS 01984

HANDMADE
Titanium and Stainless Steel
Waterbottle Cages

KING CAGE

Hangs on tight
Keeps it clean

The best bottle cages you can buy
KingCage.com



LENZ Sport
www.LENZsport.com

Made in Colorado, Specializing in 29" wheel bikes with 4 suspension models to choose from, building suspension MTB frames now for 10 years. - Devin Lenz

LENZsport, 3302 WCR 27, Ft. Lupton, CO 80621 • (303) 857-9151

advantage of the tubing supply that Sadoff had acquired from the Outland sale.

Frame components such as dropouts, cable stops and bottom bracket shells were readily available from a local distributor, and I assumed that moving to this new alloy would be painless. That was a bad assumption. The off-the-shelf frame components were poorly designed and quality was moderate at best. These parts had to be reworked by hand to achieve a decent aesthetic. I was clearly disappointed with the available frame components and new versions of these parts were required for my handmade frames.

I encountered a new challenge when I found that any weldable frame component had to be machined from 7005 alloy using bar stock offered only in a 1-inch by 4-inch format. This bar stock size is not ideal and has limited design creativity since each frame component must fit within this pre-defined outline.

What if I wanted to design a chainstay yoke that was 1.5-inch thick and 4.25-inch wide? These ideas were not possible because the largest 7005 aluminum blank size was too small. And my dropout designs were less than 1-inch thick, meaning extra material was wasted during CNC machining. Overall the transition to 7005 had a steep learning curve.

Tuning stiffness characteristics for each rider is one of my primary motivations when building handmade aluminum frames. Through extensive R&D, I've discovered that aluminum frames can be highly tuned in a fashion similar to steel frames. In the front triangle, different styles of tubing can be combined to provide the desired stiffness level, from race-specific applications to everyday trail riding.

For example, changing the down tube's outside diameter and butting profile has an immediate effect on ride quality. In addition, tube-end ovalization can be further tweaked by hand to achieve different stiffness levels.

The most advanced tuning of my aluminum frames happens in the rear triangle by combining the custom-machined yokes I've developed with select tubing shapes. Riders can perceive the aluminum frame's torsional compliance during trail riding. This means that the rear triangle "gives"



photography by Scott Clark



Go custom, you deserve it.
GROGNARD BICYCLE COMPANY

CITRUS HEIGHTS, CA WWW.GROGNARDBIKECO.COM

similar to steel frames when under dynamic load. Long-term testing and rider feedback indicates this design strategy improves wheel traction, high-speed cornering stability and climbing capability.

Over the years, I've learned that aluminum is a viable frame material with unique ride characteristics. Understanding the nuances of this material has enabled me to offer a variety of frame styles that are lightweight, responsive and highly tunable.

Moving forward I plan to build an aluminum dual-suspension trail bike with a customizable front triangle where the rider can select 26-inch, 650B or 29-inch front wheel size. Rear wheel size is currently fixed at 26 inches and I'm analyzing the suspension effects with larger rear wheels. This frame concept will utilize a 7005 front triangle and 6061 rear triangle; splitting materials in this way offers the most design flexibility for this application.

While conceptualizing these designs, I've spent many hours sourcing 7005 aluminum raw materials since the domestic tubing supply is dwindling. Sourcing 7005 alloy involves seeking out domestic and overseas suppliers that don't cater to small companies like mine. Domestic aluminum factories such as Easton and Worth have moved their production overseas while increasing the minimum order quantities. Small builders specializing in aluminum are working to pool resources to meet the minimums required by large corporations.

Handmade aluminum frames offer riding characteristics unlike other materials. Stiff but not too harsh, this material is an excellent choice for both racers and weight-conscious enthusiasts. Since aluminum is capable of being tuned to meet the demands of modern mountain bikers, I'll do whatever it takes to continue building with this unique material.

Mike Ahrens owns and operates Ahrens Bicycles in San Jose, Calif. He has been designing custom frames since 1996 with an emphasis on aluminum and is currently working in cooperation with Jason Grove of El Camino Fabrication in Emeryville, Calif., and Paul Sadoff of Rock Lobster Cycles in Santa Cruz, Calif., for handmade frame production. 📍



Custom Titanium

StevePottsBicycles.com

Signature road, cyclocross and mountain frames



KENTERIKSEN

BUILDING
CUSTOM
BIKES
FOR OVER
25 YEARS

Andy Hampsten's 69er

29er

kenteriksen.com
970/879.8484

call for
prices and
more
information

the first and last name in titanium bikes | made in steamboat springs colorado