INTO THE RIDE #41

Steel and Aluminum

Bicycle Frames

by Randy Schlitter

With the right tube size, shape an alloy, a welded aluminum bike frame can be an excellent choice over steel, and save a pound or two to boot. But if aluminum is so good, why not use if for everything?

Aluminum in general is a third as light and half as strong as steel, or the inverse, steel is twice as strong but three times as heavy. It is also softer and more prone to fail over less deflection cycles than steel. When used in a bike frame designed to be of equal or near strength of a steel frame, it will save 34% in weight. In a typical 6 pound recumbent frame that comes out to an easy 2 pounds, all things being equal. But they rarely are, because pure theory and general assumptions have a way of falling short with such easy hip shot calculations. No doubt aluminum bikes are lighter than steel, but if aluminum is good weight-saving material, why not use it everywhere, like say even the bolts and chain? We'll get back to that in a minute.

Riding an aluminum bike seems to be stiffer. But aluminum is softer and less strong in tension and compression. So why are steel bikes perceived to ride softer over aluminum? Steel bikes are generally more limber-feeling due to tube sizes used compared to aluminum. Because aluminum is softer and less strong, larger tubes are used to add stiffness, otherwise the alloy frame would flex more than steel. Greater flex means more deflection; excessive deflection will kill any frame no matter the material. Cracks will result followed by catastrophic failure. Larger tubes get stiff no matter the material, an ideal trait for making bike frames. Controlling tube size controls stiffness, so dialing in the ride within acceptable deflections should be the goal.

Can a steel bike be made as light as aluminum? Steel frames have come close in matching weights of aluminum. Ultra thin wall steel tubes with single and double butting can shave many grams. The weight savings is admirable and the production ease of steel retained. Typical wall thickness of our frames of steel is .032 down to .028. Ultra thin tubes are .012 to .016. These require single or double

butting in order to make a lasting joint. That is nearly half the wall with the correspondent weight savings. But by using the same methods aluminum tubes can be ultra thin and single or double butted too. Both materials in this form present production considerations in the handling, machining and welding. Ultra thin tubes are easy to damage not only in the production stage but also in application. Steel or aluminum tubes could be so thin that you could crush them with your hand, yet strong enough for the sole purpose of being structural in the frame.

The concern over a harsh ride requires a keen balance between stiffness and compliance to arrive at a long lasting frame. Unfortunately some recumbent designs may not be good candidates for aluminum if saving weight is the primary goal. Designs that have little depth to the truss or no truss see the least benefit. One saving grace of recumbent design, which seems to allow forgiveness in material choices, is how the loads are transmitted into the frame. A typical upright bike frame is more point loaded because the bulk of the rider's weight is nearly vertical between seat and crank. The recumbent's seated position distributes the load along the frame length. Torsion applied by a rider twisting against the handle bar on a DF is hardly present on a bent.

A good question is: why are the main tubes the same size on the aluminum Formula, as the steel framed V2? Glad you asked. The truth is the steel version of the V2 is way overbuilt. But it proves the point about up-sized tubes. Riders report little difference to possibly a softer ride on the Formula. Just a trivial note, the V2 started life with a 1.5" main tube.

Three decades ago aluminum bike frames used to be an oddity, until Cannondale helped change that, but not after a learning curve that was not without failed frames. Aluminum is now very common. A trip to Wal-Mart will reveal many aluminum bikes. The trend is a marketing ploy, the public believes if it is aluminum is must be lighter. The average made-in-China alloy bike from Wal-Mart is made from extruded tubing, with typical walls of .100". The tubes are huge ovals further adding weight, the simple round tube steel bike in this case may have been the lighter and a stronger option.

More efficient aluminum tubes are produced by first extruding then drawn over dies to thin the wall while maintaining the outer diameter. This process greatly increases the strength of the material by further work hardening and compressing the alloy. If a shape other than round is needed the tubes are then hydro formed. In this process a mold made specific to the shape is created. But even the simple extruded tube can be effective in weight reduction when replacing steel tube counterpart. In the case of our V2 becoming the aluminum Formula the 2"x .035" steel tube was replaced with 2" x .060" winning a 50% or more weight loss in that tube alone.

Corrosion still occurs with aluminum, it just looks less nasty. Aluminum's "rust" forms as a white chalky oxide. To keep aluminum from corroding is about on par with steel, until one considers anodizing. To anodize aluminum is fairly cost effective and has less environmental impact. Chrome plating steel, which is really about the only equal to anodizing raises the EPA eyebrow quite high, and is getting more difficult and costly (at least in the USA). A polished aluminum frame will impress but also requires constant upkeep. A lasting finish is polished or burnished with a clear coat. This is the finish on the Formula.

Aluminum turns out to be great for frames, is easy as steel to protect from corrosion, yet why don't we see it used to save weight on bolts, or chains? Using the simple rule of thumb that steel is 2x stronger and 3x's heavier it becomes apparent how efficient steel is for such items. A .25" steel bolt replaced by an aluminum bolt would have to be .375 in diameter just to match the sheer strength, but still in not equal in bearing. To use an aluminum bolt requires special consideration for what it is bolted to. For example: an aluminum bolt in thin steel sheet is like placing the bolt in a pair of scissors. Steel is hard stuff, and good for the high point load. A chain of aluminum would be a particularly bad idea, since it is highly point loaded and flexed. Besides it would be huge at least 1.5 times larger. Cranks are a

natural for aluminum, where the extra bulk adds stiffness and no extra weight. To save a few grams by trading steel for aluminum bolts, all the fittings on a full suspension mountain bike would weigh 50% more to be large enough to handle the upsized bolts. It turns out to be weight additive.

Style plays a big part in typical bikes, what is in style today will most certainly fall from favor in the foreseeable future. Bikes in just the last 30 odd years have gone from the small diameter steel tube diamond frames, popular in the 70's, to aluminum fat tube mountain climbers with large tubes in configurations and shapes far from the basic diamond frame.

Recumbents however have drawn new lines in the sand. They have explored many materials and configurations for the frame. Equally profound is the range of rider positions. These subtle to very radical changes have advanced bents in a condensed chunk of time to the point the average consumer has an excellent choice of machines. And aluminum and steel continue to battle for the spot as best frame material until we have the technology to knit them together, which I am certain will be something possible in the near future. Until then, stay into the ride and ride safe!

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