INTO THE RIDE #104

Design Considerations for High-Racer Recumbents

by Randy Schlitter

Over the years RANS has introduced a plethora of frame configurations. I thought it would be fun to look into some of the design considerations we made to arrive at our current high-racer platform.

Primary mission: to create a bike with low aero drag and minimum weight, with handling similar to conventional bikes, using conventional road bike components as much as possible.

Space frame or single tube: The first F-5's were a triangulated frame. I boldly stated in ITR# 13 that this was the proper way to build a bike, if you consider strength to weight. The frames were light, but tough to build. The main reason we shied away from mono-tube frame design was the joint where the wheel stays met the main tube. After some testing we found by making this joint extra beefy you could have a sound design with a single tube. We accomplished this by enlarging the tube-to-tube contact area. This super strong joint tuned out the soft spot in the frame, meaning a longer life frame. The idea for a massive joint was the turning point for us to go to a single tube frame -- had we not been able to make a joint of greater strength than the main tube itself, the F-5 would have remained a space frame. This is a critical joint on all high-racer frames made with a single tube. Other high-racer makers have followed suit. This is a good thing, because failure at this point on the frame would in any case be a tough break (pun intended).

ORIGINAL F5

The Main Tube… To Bend or not to Bend: Seat height has to be a frustrating issue for those not blessed with long legs. Smaller frames barely help, since the relationship between bottom of the headset and wheel does not change with a shorter wheel base. We looked closely at bending the main frame tube into either a gentle "S" curve or doing a bend at the head tube, then a straight boom off the front. Bending the tube looked sexy, but it was not as efficient as keeping it straight. When you bend the main tube on a high-racer, you add weight, but even worse, you create a greater moment to the torsion mode. Now remember the driving reason for bending the tube or segmenting the frame vs. using a single straight tube was to lower the seat height. After drafting several concepts, the average difference between a straight frame or bent was about an inch at best. We then looked at the seat clamp itself, and found it could be another half inch lower. We could also make a seat that minimizes interference with the legs (the Hoagie seat and Sling Mesh seat are two good examples of this). The latest Hoagie seats feature a lower mounting. Also even the straight tube frame could be tweaked to be lower, so the decision was made to stay with the straight tube concept. The end result of using a straight tube over bending was acceptable seat heights, less wind up (torsion losses), and better chain line.

Torsion, Stiffness in Beam, and Tube Shape and Material: Torsional rigidity in conventional bike design is easy because of the greater depth of structure (the "diamond frame"). In recumbents you have much less structure -- often, a single tube is asked to do the work of a space frame. The shape, size, wall thickness, and material this tube is made of all contributes to the torsional properties. Tube shape is a funny thing. In many mass-produced bikes there are shapes that simply do not make sense from an engineering perspective. I guess either access to the technology to make funny tube shapes or marketing whims are why so many bikes sport everything but a round; there are few shapes better than the round tube. In fact in our testing we found this descending order of shape to torsional rigidity:

- Round
- Slight Oval
- Flat Oval
- Slight Pear Shape
- Soft Triangle
- Soft Diamond
- Sharp Square
- Rectangle
- Clover Shape

Most single tube frames, no matter the material, lack in torsion stiffness. We built a couple of carbon F-5's and I was shocked at how much wind-up the frames had. I checked out other carbon stick bikes and was even more surprised; none had near the stiffness in wind-up that steel frames exhibit. Our robust aluminum test bikes, using large diameter tubes, showed the least amount of wind-up and were competitive in weight to carbon. One of the aluminum F-5's in testing weighs in at less than 19 pounds, and has both great beam and boom stiffness with less wind-up than the carbon bikes. In the end which material the F-5 evolves to is still up in the air, but from a cost vs. benefit, metal frames are winners.

Chain line: The more deflection in the chain line, the more possible energy loss, noise, weight, and wear due to idlers. In a high-racer, we place the crossover idler as high as possible to reduce loading on the idler, and thus in theory, less energy loss.

Climbing: The ability to climb is affected by seat angle, frame stiffness, power transfer, chain line, and overall weight. Following are things that reduce climbing power in a high-racer: seat angles too laid back, soft seat frames, and a bike frame that is not rigid in side load and boom stiffness. When the boom is a cantilevered structure, stiffness is tough to create -- our high-racers use 2" steel tubes, and the boom extension is kept as short as possible. Ideally, a larger diameter tube would be better, but weight increases substantially, unless going to aluminum or carbon. Again we have seen good results with large diameter aluminum tubes.

Handlebars: There are two popular hand/arm positions: "tweener" is with hands outboard of the knees and "hamster" is hands inboard, usually behind the knees. Both are good choices, but many think the hamster position may offer the best aerodynamics, since the arms are tucked inside the main width of the torso. This supposed advantage has been hard to define in roll-down tests, so choosing a handlebar that feels natural to the rider and has good steering control is more important. The tweener vs hamster choice also affects tiller, of course – but the good news is most high-racers can be fitted with many styles and sizes of handlebars.

Other: Of course a bike has to have some style points, and this is done in a number of ways -- the paint scheme, color choices, graphics, material, and the name itself all play a part in creating the buzz about the product.

Challenges

As we moved into building high-racers we came across some challenges. Our initial thinking was "We have made short wheel base bikes before, so this is well within our sights." What we actually encountered looked something like this:

1. Rides stiff, lots of road shock coming through the sprint braces.
   a. Tried different locations on seat stays, not much help
   b. Tried headrest...seems to help
   c. Larger tires, lower pressure....ah better, but speed is not so impressive

2. Need custom seat, our standard mesh seat and M-5 seat not a perfect match

3. Reaching the ground is interesting

4. High speed stability sensitive to headset bearing pre-load

5. Chain management not as uneventful as desired

6. Space frame design has some softness in latitude.

Most all these challenges have been overcome. The only real bother to me is road shock. I have yet to ride any brand of non-suspended high-racer that reduces this to a level I would find acceptable. Maybe I am spoiled by my Stratus XP Ti? But the extra road shock can be worth it. The F-5 PRO with the 700 wheels is fast. It slices and dices the headwinds into manageable chunks. It is amazing how fast you can ride this bike into the wind. The aerodynamics pay off handsomely, especially in the windy state of Kansas.

Developing and exploring the high-racer configuration has benefited other bikes in our line up. One great spin-off has been the Xstream. As mentioned earlier, it is a great climber, fast average speed, low drag, and light. Maybe in a future ITR we can explore the thought process behind this bike in even more depth than we have before. Thanks for stopping by, and until next time, ride safe and stay into the ride!

Into the Ride