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TRUING BY TENSION

Part 3 of the Wheel Building Series Makes the Hardest Part Easy

By Eric Hjertberg

Don't be fooled by perfect trueness, apprentice Wheel Wizards. That's how you want your wheels to turn out, of course, but it isn't the whole story. Not by a long shot. Uniformly tensioned spokes, which ensure that your wheels *stay* perfectly true, are even more important.

In the January issue we selected our wheel components. In February, we laced the spokes into the hub and rim. Now it's time to tighten those spokes in a way that produces a wheel that's not only round and straight (i.e., true), but strong and reliable. I promise that it won't take a trip to Oz to pull this one off.

Uniform spoke tension is a wheel's most important asset. Even the best rims and spokes can't make up for incorrect tension, and trueness without uniform tension is short-lived. Traditional building methods emphasize spoke corrections based upon visual straightness, with tension occupying a mysterious background role. At Wheelsmith, our long-standing interest in spoke tension has developed a building method that monitors and balances tension as it produces straightness.

It may sound like this must take a lot of extra time, but it doesn't. Rather than prolonging construction, my method creates wheels that are easier and quicker to finish, and they're more likely to stay true. They are also more resistant to spoke breakage because the load is shared more evenly among the spokes.

These are the 4 steps of what I call the tension method:

1. Start by creating "ground zero." This is a perfectly true, low-tension state that serves as a foundation for further tightening.
2. Add tension in small, equal "layers" (1/4 or 1/2 turn per nipple each time around the wheel).
3. Following each layer of tension increase, correct roundness and side-to-side errors with tension balancing and visual evaluation.
4. Avoid overstressing the finished wheel with any sort of physical force.

Ground Zero

Mount your loosely laced wheel in a truing stand. Starting from the valve hole (as you should for all appropriate procedures so you know when you've finished one complete trip around the rim), put a drop of light oil where each nipple comes through the rim. This helps nipples turn with uniform friction as spoke tension mounts.

Tighten the nipples until 2 threads on each spoke are visible. The spokes should still feel relaxed when you squeeze pairs together.

Next, tighten each nipple one more half-turn. If the spokes are still relaxed, do another round of half turns. After several half-turn advances, spokes will start to feel snug. Then stop tightening. In this lowest tension condition, truing is easier than at any other time.

Most good rims do not need adjustments at the joint (seam), but occasionally one will. If you merely see a gap at the joint, ignore it. As the forces generated by tightening spokes increase, the rim will probably be drawn together. If the seam is disjointed, try gently squeezing it in a smooth-jawed vise. By all means do not overcorrect -- a joint area that's narrower than the rim means interrupted, weak braking. If the rim is out of round in the joint area, it may be helpful to bend it gently over a 2-by-4, holding the rim on either side. Only experience can help you determine which joints to lever and how much force to use. If you are uncertain, continue truing and perhaps spoke tension will make the correction.

Before adding any more tension, the wheel must be as true as you want the finished wheel. This is the principle of ground zero. By providing a perfectly true base, the wheel will be ready for the tension to come. New, undamaged rims should allow spokes to be uniformly tight. Such equality is the basis of an excellent wheel. (And this is why used, bent rims make such poor candidates for rebuilding; in order to be in true at ground zero, spoke tension must be unequal.) Another factor in favor of the ground zero approach is that a wheel is much more easily manipulated at low spoke tension than high spoke tension.

Attack side-to-side play first. Imagine that the uppermost section of the rim is a helium-filled balloon restrained by guy wires (the spokes). Its position can be precisely adjusted by changing the lengths of the wires. If the rim is too far to the right, then slacken the spokes from the right and tighten those from the left. Work in 1/4 turns and try to make equal changes to right and left spokes. If you add and subtract the same number of tensioning turns, you will bring the wheel into side-to-side true without disturbing its up-and-down true (roundness).

Hold each spoke lightly so you can feel if it twists as you turn the nipple. If it does twist, turn the nipple slightly past the desired point and then back to it, so the spoke is no longer twisted. Always work on the largest error first. After each correction, spin the wheel to find which error is still largest. Sometimes you will return to the same error; other times your attention will be directed to another section.

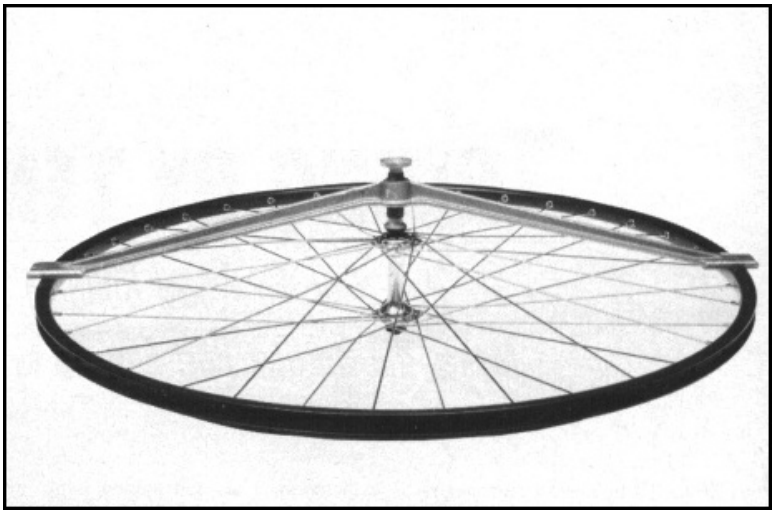
Continue making 1/4-turn corrections. Aim at the center of each error. If the wobble spans 4 spokes, the middle 2 are the ones to adjust. Eventually, the rim will spin straighter.

Once the side-to-side trueness is within 1/8 inch all the way around, try improving roundness. A section of rim can be moved down toward the hub or away from it by tightening or loosening the spokes that go to that section.

Spin the wheel slowly and watch for the largest high spot. Tighten the left and right spokes at the center of the high spot 1/2 turn each. If the high spot is long, go to the next two spokes in each direction and tighten them 1/4 turn. Spin the wheel and find the high spot again. (It might be in the same place.) Make another set of half-turn and/or 1/4-turn corrections, balancing right and left changes so as not to spoil side-to-side trueness. When you encounter a significant low spot, use the same technique but *loosen* the spokes. Never loosen to the point where they become slack.

If loose spokes do occur, check those from the same flange on either side of the slack pair. They may be so tight that the others don't have to be tensioned to keep the rim round. Remember, any given spot on the rim is affected by many spokes. Spokes that have too little or too much tension need to share their load with their neighbors.

Once roundness is within 1/16 inch or so, go back to trueness. After trueness is improved, switch back to roundness. Keep alternating to bring the wheel to the straightness you desire.



When both ends and the middle of the dishing gauge touch evenly on each side of the wheel, the rim is correctly centered.

Now check the wheel's dish. The rim must be centered between the hub axle locknuts. This means the rim will be centered between the hub flanges of a front wheel, but will be offset toward the freewheel-side flange of a rear wheel. You can check for proper dish by mounting the wheel in your bike. It should center in the frame and between the brake pads. But a much more precise way is to use a dishing gauge. Apply it to one side of the wheel so the adjustable center piece contacts the axle locknut and the arms rest on the rim. (See photo.) Then put the gauge on the opposite side of the wheel. If it fits the same way, the wheel is in perfect dish. If not, you must make a correction.

Draw the rim to the right or left by uniformly tightening *all* the spokes on the corresponding side. Most errors are best approached with 1/4 turns.

Rear wheels are a bit more complicated than fronts because the rim is offset or "dished" toward the freewheel side. As mentioned last issue, dishing can be accomplished by using shorter spokes on the freewheel side, or by using a uniform length but tightening those on the freewheel side several additional turns. Once the dishing gauge tells you the rim is centered between the axle

locknuts, be careful -- further work on the spokes, if done equally to both sides, will put the wheel out of dish. The reason is that spokes from the freewheel-side flange approach the rim at a more vertical angle. Tightening (or loosening) them won't move the rim laterally as much as the same number of turns to the other side.

Most builders approach the situation by applying extra turns on the freewheel side during ground zero work. This overdishes the wheel so that during the next step, tension layering, equal turns around the wheel will bring it back into correct dish.

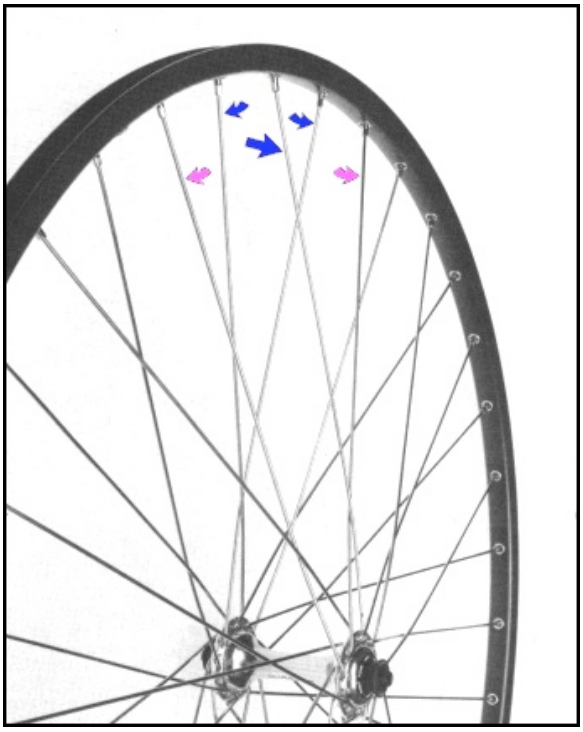
Once trueness, roundness and dishing are correct, you've accomplished ground zero and are 80 percent finished. Any extra time spent achieving this state, especially when you are learning, is well worth it.

Tension Layering

Now you must add tension to the wheel. Depending on your experience, the increase each time around may be as small as 1/2 turn per nipple or as much as 2 turns. In general, smaller increases are easier to monitor and more appropriate for lighter rims. Inspect for roundness; a lightweight rim's roundness is a good indicator of spoke tightness. When the rim is round, tension is more even and side-to-side adjustments are quicker and less likely to spoil roundness.

Keep adding tension and checking trueness, roundness, and dishing.

For rear wheels, add tension to only one side of the wheel at a time, trying to maintain a little overdish. This means more turns on the freewheel side than the left side. As tension builds, it becomes almost impossible to pull the rim to the right by increasing tension on the already tight, vertical freewheel-side spokes, but it's easy to pull the rim to the left. Finish tensioning, truing, and dishing mainly with left-side spokes.



An example of tension balancing: If this right-side spoke needs to pull the rim to the right, but it's already too tight and creating a "low" spot, loosen the spoke and its 2 neighbors from the left side (blue arrows) and tighten the 2 nearest spokes on the right side (red arrows).

Tension Balancing

Side-to-side corrections are more effective when they complement the tension level that already exists in the spokes in question. For example, suppose you observe a wobble in a 4-spoke region. Before making changes, pluck each of the 4 spokes to see which is tightest (highest note) and which is loosest (lowest note). Try to improve the trueness by loosening the tightest spoke(s) or tightening the loosest spoke(s). Observe rim wobble to find the spot for correction, but let tension (by plucking) help determine which spokes to adjust.

Try to visualize how adjustments for side-to-side trueness can affect roundness. Toward the end of the truing process, it's often possible to tighten or loosen a single spoke to move everything in the right direction.

What if you reach a contradictory situation? Suppose there's a spoke that needs to be tensioned for trueness but loosened for roundness. Unless the rim is defective, spoke tension in the immediate vicinity is unbalanced. Pluck at least 6 spokes to either side of the one in question. Mark those that are too tight or too loose. You'll probably see a pattern of imbalance that can be corrected without making the wheel go out of true.

Truing a wheel by tone is a strange idea to many builders, who depend primarily on visual cues and let tension distribution take its own course. Learning to balance tension is like opening a new set of eyes. Given practice, wheels become easier and faster to true.

After each straightening and balancing sequence, add more tension. Since you started from a solid ground zero, roundness should become increasingly stable as tension mounts. Continue adding small layers of tension and patient corrections until the wheel feels as tight as a known good wheel of similar design. If suddenly the wheel starts becoming less true or round, or it's difficult to tighten spokes without rounding off the corners of the nipples, stop! You're venturing beyond maximum desirable tension. Loosen each spoke a full turn or so before trying to finish the wheel. Also, keep an eye on the rim, not just spokes, to spot overtensioning. Some rims give distinct signs, such as puckering at the nipple, to indicate maximum tension.

Do not try to make too many corrections at full tension. (You shouldn't have to if you've done the job right.) A fully tightened wheel resists change, which is why it is so durable on the road.

Avoid Overstressing

A tension-balanced wheel is remarkably stable. It does not need the prestressing or overstressing often applied to lesser-built wheels. Stressing tries to prevent 2 types of problems. One is the stretching of parts during building and use, which changes the trueness of the wheel. The second is spoke windup created during tightening, which produces an artificially correct tension level. When wound-up spokes untwist and release their extra tension, they ping the first time the wheel is ridden. In effect, that's the sound of the wheel going out of true.

Windup can be minimized by lubricating the spoke threads and by compensating with the spoke wrench. (See above.) You can also mark one side of each spoke with a felt-tip pen to see when it turns. Some builders grip the spokes with smooth-jawed pliers.

If spokes are prevented from winding up, potentially dangerous methods of releasing stress are unnecessary. These include bouncing the wheel on the floor, or laying it on its side, grabbing the rim at 3 and 9 o'clock, and vigorously pushing down. This is a popular technique, but it's best reserved for straightening bent rims, not building new ones. Surviving a massive side load might be a sign of strength, but it might also weaken or ruin a wheel.

Final Check

Now that your wheel is straight, centered, fully tensioned and free of hidden stresses, you might be inclined to slap on tires and hit the road. *Stop!* Before putting your safety on the line, seek the advice of an experienced builder. This may be a local shop mechanic or a bike club member. If you have followed my procedures carefully, your wheels are probably as safe as those built by any professional. But your learning curve will be enhanced and your safety improved by double checking your work.

It probably took you between 2 and 3 hours to build each wheel. After gaining the experience of another 6 pairs for yourself and your friends, you should find that time cut in half. The professional develops speed from repetition and familiarity with his or her favorite components. On a good day the pro may take only 30 minutes to fashion an outstanding wheel, although 45 to 60 minutes is the norm.

So now you know -- wheel building is not a form of magic as some would have you believe. As usual in cycling, the real magic is in the riding itself, when your hand-built wheels help the miles roll by.

Next month I'll conclude this series with some tips and procedures for wheel maintenance and repair.