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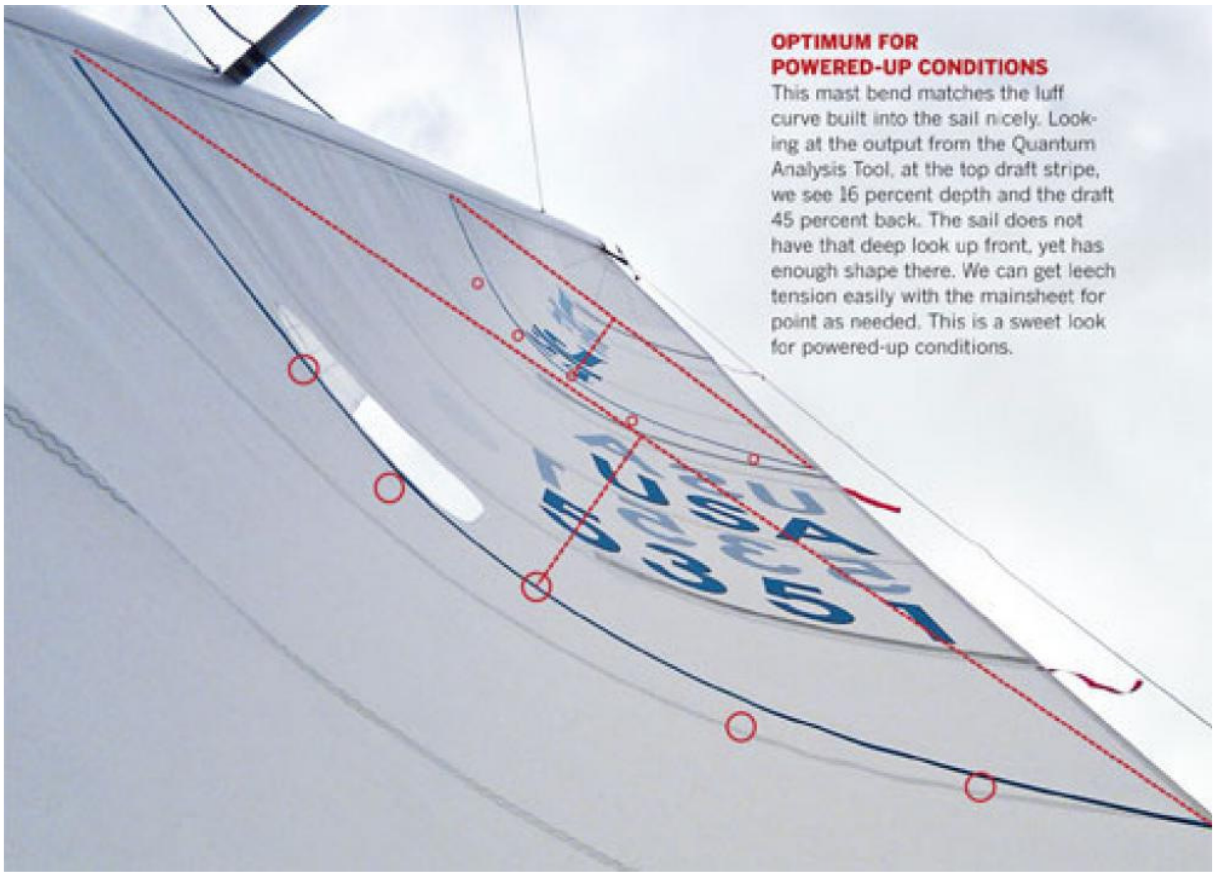
Bend for Speed

Knowing how to control mast bend is key to getting the most out of your mainsail. From the Experts "Boatspeed" from our October 2012 issue.

By Mike Ingham

I recently had a conversation with a club racer who was excited because he had been able to, on his own, diagnose and fix a speed problem during a race. He had remembered some of the fundamentals of mast bend from a series of seminars we put on and was able to recognize his mast was too straight. He simply induced more bend and has been fast ever since.

Understanding how and when to control mast bend is probably the most important tool you have to set up your boat and change gears. In general, a straight mast makes for a powerful sail. We bend the mast to depower. But it's never that simple. By first exploring how sails are designed and cut, we can hone in on how to control mast bend to get the most speed.



OPTIMUM FOR POWERED-UP CONDITIONS
This mast bend matches the luff curve built into the sail nicely. Looking at the output from the Quantum Analysis Tool, at the top draft stripe, we see 16 percent depth and the draft 45 percent back. The sail does not have that deep look up front, yet has enough shape there. We can get leech tension easily with the mainsheet for point as needed. This is a sweet look for powered-up conditions.

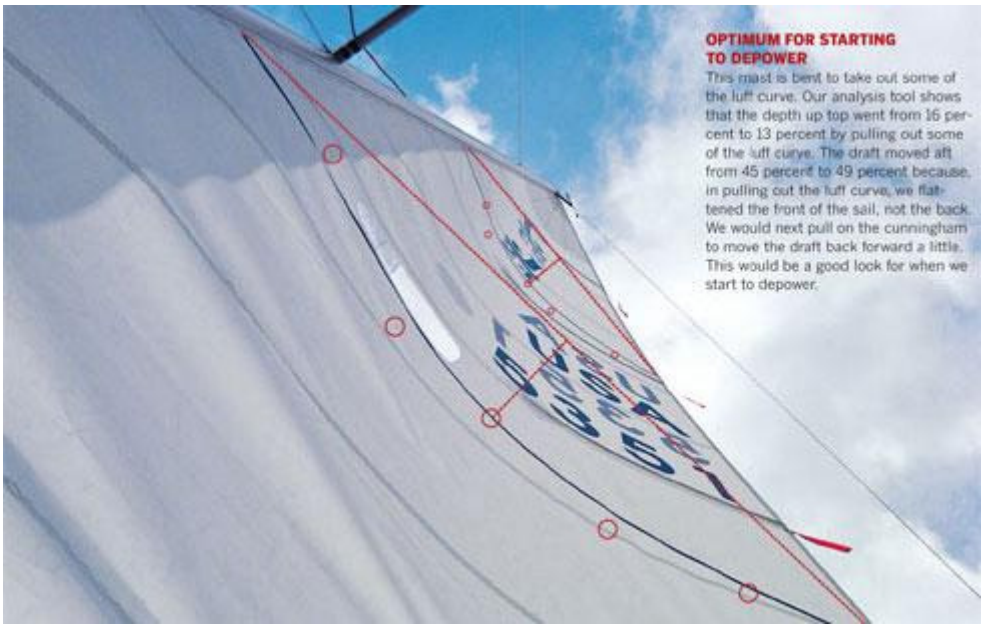
Before diving into how to set up your mast, let's review the tradeoffs in designing a sail. Wherever cloth is seamed together in a sail, shape can be created by varying the overlap. This is called broad seam and is permanent; you cannot change it with your rig or controls.

Luff curve is the arc cut along the luff where boltrope is attached. Luff curve acts the same way as broad seam, it pushes material into the sail along the mast.

Together, the two create the three-dimensional shape of a sail, and this is where the sail designer must address the tradeoffs of each. The advantage of broad seam shape is that it affects the entire sail, whereas luff curve mostly affects shape in the front of the sail. Luff curve allows depth to be controlled by mast bend, and since there is not much we can do with broad seam, we will explore how to take advantage of luff curve to both set up your rig and change gears.

Matching the mast to the sail is a good way to understand the range of mast bend available to play with. For example, if you laid your sail on the floor and ran a line from the boltrope at the head all the way to the tack, you might find 3 inches of extra material in the middle of the sail, measured from that line to the boltrope. This sail has 3 inches of luff curve. When sailing, you know that if your mast has 3 inches of bend, then all the shape you see in the sail is from broad seam. Straighten the mast so there's no bend, and you will see much more depth, mostly in the front of the sail. Bend the mast beyond 3 inches, and you will see overbend wrinkles.

In this example, you might have from 1.5 inches to slightly more than 3 inches of mast bend to work with; that might not sound like much, but you will see dramatic sail shape changes through that range. If your sail is built mostly with luff curve, you may see a radical difference in shape from almost completely flat when the mast is bent to match the luff curve, to powered up when the mast is straighter. If your sail is built mostly with broad seam, you will still see a difference, but not as much, and you will find you can only bend the mast a little before seeing those overbend wrinkles.



OPTIMUM FOR STARTING TO DEPOWER
This mast is bent to take out some of the luff curve. Our analysis tool shows that the depth up top went from 16 percent to 13 percent by pulling out some of the luff curve. The draft moved aft from 45 percent to 49 percent because, in pulling out the luff curve, we flattened the front of the sail, not the back. We would next pull on the cunningham to move the draft back forward a little. This would be a good look for when we start to depower.

Most tuning guides will recommend a certain amount of pre-bend. Pre-bend is measured on shore, with the rig in place. Usually this pre-bend is somewhere around half of the luff curve and is the straightest your sail is designed for. In our 3-inch luff curve example, the sailmaker may recommend 1.5 inches of pre-bend. This is measured by taking the main halyard all the way to the gooseneck (making sure the halyard is tight enough and the wind light so that it does not blow your halyard around and skew your measurement). You will find the deepest part is usually halfway up the mast; that is the pre-bend measurement. This measurement is

taken with the shrouds set at “base,” an arbitrary starting place your sailmaker uses so your measurement is consistent.

On our J/24, we shoot for 2.25 inches of pre-bend at base (20/15 measured with a LOOS Gauge). If you do not have the recommended pre-bend, adjust something: On our J/24, we move the mast butt (and re-adjust the shrouds to 20/15). For other boats, it might be spreader rake, mast chocks, or shims.

Once you have the desired pre-bend at base, you’re pretty close and ready to go try it out. Knowing what to look for is more of an art. We look at the mainsail, and if it looks as though the draft is too far forward, what we call “knuckle forward,” we consider that a sign that the mast is too straight. Some symptoms of this would be you stall too easily, and tend to go high and slow. If the sail looks as though the entry is really flat, and you’re having trouble pointing, you would try straightening the mast. Pre-bend is very subtle, so don’t change it radically. If our target is 2.25 inches of pre-bend, and I was high but slow, I would experiment with 2.5 inches.

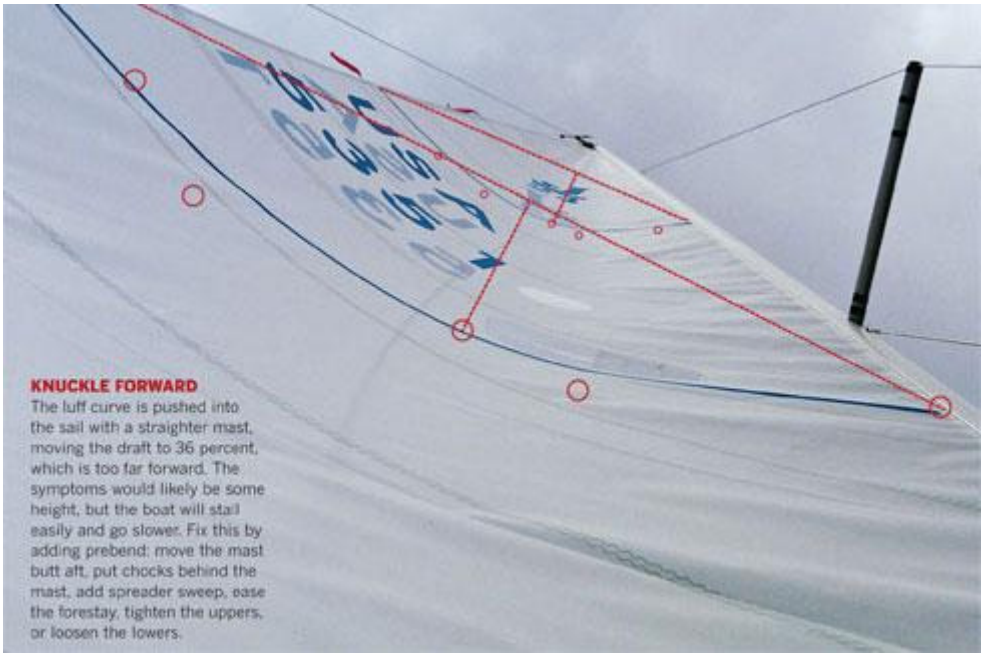
Your mainsail leech is another place to look for confirmation your pre-bend is right. When you straighten a mast, the leech tightens, and when you bend it, it opens up. If I have too much hook at the top of the main, I see that as another clue that the mast is too straight. Conversely, if I have trouble getting enough leech tension and have to pull the main harder than I think I should, I consider straightening the mast. There are no concrete rules, so have an open mind and take photographs (and mental notes) of the sail when you feel something is either right or wrong.

Once I’ve experimented and settled on a pre-bend, I make sure I’m at base so I know where to start. Then, as it gets windier, I tighten the rig. In general, loosening the rig powers up the sails and tightening depowers them, but the uppers and lowers do different things.

The uppers control how much the mast bends, side to side. For example, on the J/22, we always set the uppers such that the mast remains centered. We sail upwind and feel the upper leeward shroud: If it’s flopping around, we tighten. If it’s tight, we loosen. The idea is to keep the mast centered, but just barely keep tension on the leeward upper. We look at it differently on a J/24, however. The J/24 has a huge genoa, and using the uppers to control forestay sag is much more important. As it gets windier, we want less forestay sag so we put the uppers on tighter. Most boats use the uppers for a combination of keeping the mast straight and controlling forestay sag.

The lowers control the middle of the mast bend. This is the key to matching the luff curve to the mast. Loose lowers allow more mast bend, which in turn flattens the sail. Tighter lowers straighten the mast. One might think that tightening the lowers as it gets windier would straighten the mast, but as we tighten the uppers as the breeze builds, we need to keep up with the lowers as well, or the mast will bend too much. So we tighten both uppers and lowers.

The lowers also affect how much the mast bends sideways. In our J/22, we almost exclusively tune the lowers by watching for slight mast sag. The J/22 is deck-stepped so the center of the mast can easily fall to leeward. Mast sag powers up a sail because there is a component of side bend that affects luff curve, and because it makes the sail more like a big scoop. The J/24 is stepped to the bottom of the boat. We cannot induce side bend because the mast is stiff and levered at the partners, so we concern ourselves mostly with fore-and-aft bend. Every boat has a different protocol for controlling the rig, but the basics are the same: The lowers control the power of the main, and the uppers center the mast and control the power of the headsail.



KNUCKLE FORWARD
The luff curve is pushed into the sail with a straighter mast, moving the draft to 36 percent, which is too far forward. The symptoms would likely be some height, but the boat will stall easily and go slower. Fix this by adding prebend: move the mast butt aft, put chocks behind the mast, add spreader sweep, ease the forestay, tighten the uppers, or loosen the lowers.

Once the rig is set, we can change gears with the controls. Besides mainsheet, the control with the most influence on mainsail shape is the backstay. The backstay pulls the mast back at the tip and bends it all the way along the luff. This pulls out shape by matching the mast bend to the luff curve. This is a great tool for depowering for puffs, or adding power in lulls or waves. Note, however, that adjusting the backstay significantly changes how much hook is in the main, and it's easy to stall with the leech too tight after easing the backstay.

The boom vang has a surprising amount of control on the amount of mast bend down low. You will notice that pulling it on not only tightens the leech of the main but also pushes the boom into the mast at the gooseneck. Even the most stubborn thick masts, such as the one on the J/24, will bend down low with a lot of vang, so pull that on, too. Some boats, such as catamarans, use a very powerful cunningham, a top main halyard lock, and a no-stretch bolt rope to compression bend the mast and depower. It is surprisingly effective.

When overpowered, there is always a tradeoff on how much to flatten the sail with mast bend and how much to ease the mainsheet. In our J/24, we have the choice of pulling on the backstay or easing the mainsheet to keep the boat at the correct heel. In flatter water, we typically like to pull the backstay tight, drop the traveler, and sheet hard. We can feather up and depower with nice height. As it gets lumpy, we need to put the bow down, so we ease the mainsheet more and have a slightly looser backstay. We don't drop the traveler as much, and we play the mainsheet to steer through waves and react to pressure changes quickly without compromising heel. As a rule of thumb, the flatter the water is, the more we bend the mast to depower.

We like the dynamics of mast bend control. When we need power, we straighten the mast by easing backstay and mainsheet. Once we're up to speed, we sheet in and adjust the controls to flatten the main for a higher speed shape. We use mast bend tactically as well, bending the mast for speed to foot, or straightening it to power up and hold a high lane.

No matter what the specifics of your boat are, experiment and get comfortable with your mast bend controls. Strive to match your mast bend to your luff curve, and then adjust it to add power or take power from your main.

Pro Tip
It's important to understand that all sails are made with both luff curve and broad seam. No matter the ratio, mast bend is critical. If the sail is made with more broad seam than luff curve, you will have less control. If the sail is made with more luff curve than broad seam, you will find you have a wider range of control. Each sail design is unique and each boat has a magic combination of settings and controls that work best for it. Your job is to recognize how much luff curve your sail has and then understand the tools you have to control the mast bend relative to your luff curve.