

Moore on Mainsails - Shore Sails LTD RI

Moore on Mainsails - by Geoff Moore

When you consider that we have been riding around on sailboats longer than we have been riding around on wheels is hard to believe that sailboats still offer us a challenge. Just peer into any modern yacht designers office and you will quickly discover that the workings of sailboats are anything but simple. By comparison, aircraft designers have it easy, although their failures are a little more catastrophic. Sailboats have to work in two different fluids with different viscosity's, and they have to float on a bumpy surface. Aircraft only have to fly through air. However, both modes of transport are bounded by the basic forces of lift, thrust, and drag. These similarities have been a great advantage to sailboats. An incredible volume of sailing innovations can be traced to the aerospace industry.

So with all this high technology entering our sport how can we mortals hope to keep up? The answer of course is that we don't need to know everything about sailboat physics to successfully race a sailboat. So lets explore what information you really need. More specifically lets focus on the mainsail because mainsails are a good place to discover some fundamentals about how sailboats work.

But first we have to have a little knowledge about masts. Masts come in all shapes and sizes. They can be carbon, fiberglass, aluminum, or wood. They can have spreaders, in-line , swept back, or adjustable. They can have jumpers, diamonds, diagonals, runners, checks and permanents. Whatever contraption of tubes and wires, masts do two things. They hold the sails up, and when they bend, they affect the shape of the sails attached to them. Controlling mast bend is the first step towards controlling the mainsail, and controlling the mainsail allows us to fine tune the delicate balance between sails and keels.

In general masts bend too much in heavy air, and they stand up too straight in light air. So by control we usually talk of restricting, or inducing mast bend. There are so many ways to induce or restrict mast bend that it would be absurd to try to mention them all here. Instead, lets try to understand what the great mainsail trimmers are looking for, regardless of how they achieve it.

Most sailors understand that bending a mast flattens the mainsail. But, how do you know when the mainsail has exactly the right amount of depth? There are two steps. First you have to find out what the best depth is, then you have to have some way of duplicating it.

Determining the best mainsail depth for your boat is a trial and error process. At some point your yacht designer tried to place the sail plan (center of effort) directly over the keel (lateral resistance). But that is where the yacht designer's job ended and the crew took over. Since it is virtually impossible to get the mast and the keel in exactly the right place for all conditions there will be some inherent design flaws. Good crews will always find these minor flaws, and then optimize the sail trim to compensate for them.

For example lets imagine you win the lottery, and you decide to build a custom 45 footer. New sails were ordered and the boat launched. Over the course of the season we might notice that our mainsail trimmer has gravitated toward setting the traveler much lower than usual. We might also discover that the boat performs better if the sheet is eased and the upper leech is "opened". Using this information I could make a fairly educated guess that the keel is too far forward, or the mast is too far aft. We could not utilize all the power available in our mainsail because when the main was trimmer for MAX power the boat became unbalanced. (too much sail power in the back of the boat). So the boat just sails better with some power twisted out of the mainsail.

So the following season you might ask how you could improve performance. One option might be to move the keel aft. Another might be to move your mast forward. Moving the mast means all the sails would have to be

recut. So a more reasonable solution would be to lengthen the headstay a little and then recut the mainsail to be a little flatter. A flatter main can be trimmed much harder and will therefore be more efficient.

My point is that there is no magical sail shape that works perfectly on every boat in every condition. At least not in the real world. The only reasonable method of proving what works is by experimentation. The difference between a great mainsail trimmer and mediocre one is the time it takes discover the best trim.

Since sails are three dimensional objects it is difficult for the human eye to consistently evaluate sail shape. So many mainsail trimmers are absolutely obsessive about things like draft stripes, tell tails, and number sizes, colors, and positions. They want to make sure that their carefully trained eye is looking at exactly the same things.

Luckily for us mortals there are a few more obvious clues. Mainsail luffs are cut with a curve that has to approximate the mast bend. When a mast bends about 30-40% more than the designed mainsail luff curve the sail will start to develop diagonal wrinkles. These "overbend wrinkles" are a very consistent and visible indicator of how much depth the mainsail has at that point. They serve as a reference point. Any further bend will only increase the unfairness of the mainsail and performance will start to drop. At the point where we start to see overbend wrinkles all the "external shape" has been pulled out of the sail. What we are left with is "internal shape". Internal shaping, or broad seaming, is the shape built into your sail by putting together curved edges of flat panels. Some sailmaking companies advertise that they are accomplishing internal shaping through large three dimensional molds, but this is misleading. Mylar film, the foundation of all laminate sails, is only available in flat sheets. So all laminate sails must have broad seaming seams, whether they are difficult to see or not.

The other end of the spectrum is a mast that is too straight for the luff curve. (or a main that is too curvy for a mast). In this case the indicator is more subtle. The sail will look too deep and too draft forward. When this happens the sail has too much external shape. There is only so much external shape you can jam into the front of a sail before you end up with a gutter just aft of the mast.

So the area in between these extremes is the working mast bend. Every mainsail will have a MAX power shape and a MAX depower shape. During most sailboat racing the mains will be in one of these two settings. When you find yourself in between these settings then angle of heel, and rudder pressure are the best indicators of how to trim the main. Constant tinkering with the mainsail controls can pay huge dividends in this condition especially if the wind pressure is erratic.

Once the overall depth of the mainsail is set there are still plenty of adjustments. Cunningham tension pulls the draft forward. As the mast bends, more cunningham is needed to keep the MAX draft in place. When the mast is straightened the cunningham needs to be eased to elevate that knuckle forward shape. Remember the overall depth of a sail is always more important than precise draft placement. However, correct draft placement will help reduce drag and also help balance the boat. As sails age they need more cunningham tension because the draft migrates aft as the sail material becomes more elastic.

Outhaul tension controls the lower mainsail, and therefore the lower batten exit angle. The best place to view the lower batten exit angle is from the windward side of the mast looking straight aft. From there you can make fair assessments about the lower leech versus the center line of the boat. The most common mistake is to have the lower leech stalled in light air, but it is just as devastating to have the lower leech too open when the traveler is down.

That brings us to the traveler and mainsheet system. These two controls allow us to adjust the upper leech or "twist" in the main. It is important to note that a foil with no twist is more efficient than a twisted foil. You will never see a keel, or an airplane wing with twist. Twist works in lumpy conditions because we are trying to reduce pitching by lowering the center of effort in our sail plan. In heavy air, efficiency is not what we are after.

We already have all the power we need. The challenge in heavy air is to reduce drag. A twisted mainsail is actually less drag than reefed mainsail.

In light air a straight mast, and the weight of the boom both serve to eliminate all twist so that the upper leech stalls completely. In this case the traveler should be pulled to windward and the sheet eased until the top batten tell tail starts to fly. Keeping the boom on centerline up to the point where power needs to be shed is usually a good plan.

Many boats have booms strong enough to utilize the boom vang instead of the traveler in heavy air. This technique is called vang sheeting. Vang sheeting works best when the traveler system is either too short or too difficult to control. In very puffy conditions there just is not enough time to play the traveler and the sheet. So the vang roughly sets the twist and the mainsheet is used to keep the boat balanced. One benefit to vang sheeting is that the extreme vang pressure forces the boom forward and adds lower mast bend. This helps to depower the lower mainsail, and opens the slot. Excessive vang pressure can damage the mast or boom. The risk can be reduced by easing the vang before rounding the windward mark. Masts are built to take a lot of fore and aft load, but they definitely do not like to be severely side loaded. Another important consideration is that traveler sheeting allows you to place considerable more tension on the mainsheet. This pressure is transferred up the leech of the mainsail and eventually helps to pull the sag out of the headstay thereby flattening the headsail. With all these contradicting forces how do you know when to vang sheet or traveler sheet?

Traveler sheeting allows you to be much more precise, but it slows down the reaction time. Vang sheeting is very quick, but it is a crude way to adjust your twist. Make your decision based on which priority the conditions warrant. Often, a combination of both methods works well.

Mainsails are just one component of a modern sailboat. So it is unwise to trim a mainsail without some consideration as to how the headsail interacts with it. The most obvious interaction is "backwind". As wind flows between the main and genoa it gets compressed slightly. The Genoa also bends the wind forward. The effect is that the mainsail is always sailing around in a slight header relative to the genoa. As more air gets compressed through this so called "slot" the back wind increases. Back wind is not desirable. The sail plan would be much more efficient without overlapping sails, but without huge bow sprits there is only so much length to pile on sail area. So some interference has to be tolerated.

When we start looking for ways to shed power the first obstacle we hit is that the main can't be eased because too much back wind results. Eventually there will be so much back wind that the mainsail will become difficult to fly. Stiffer battens help keep the leech stable under these conditions, but once the mainsail starts flogging performance will drop quickly for two reasons. One, flogging mainsails generate a lot of drag. And two, the genoa will drag the bow down and the whole boat will become unbalanced. Balance is the overriding goal. If the main has too much backwind then the balance shifts too far forward in the boat. So you have to open the slot. Usually this means easing or twisting off the headsail, but flattening the main also helps. As conditions get windier a smaller headsail will become desirable because a genoa will have to be eased too far.

On well sailed boats there is an intimate relationship between the helmsperson and the main trimmer. One reason is that the mainsail trimmer operates the safety relief valve. When a crash happens all eyes fall on the helmsperson, but in ducking situations it is really the mainsail trimmer who controls the boat. Another reason is that a good helmsperson is constantly testing the balance of the boat, and it is the mainsail that fine tunes that balance.

Unlike jibs and genoas mainsails are kept up when we turn down wind. This deserves some consideration. Swept back spreader rigs have a special problem because the boom can not be let all the way out, and the spreaders poke into the leeward side of the main. Sometimes the vang can be eased slightly so that at least the top part of the main can go out all the way. However, many of the newer breed of race boats never sail with the apparent wind aft of the quarter. These light, powerful boats drag the apparent wind far enough forward to sail

reasonable gibe angles. In their case they get flow across the mainsail. The important difference in these boats is that the mainsail has to be trimmed much more aggressively. The goal is to keep the mainsail at MAX power, or just before it stalls. For the rest of us the goal to sailing dead down wind is to create the maximum amount of drag. The boat with the most drag mushes fastest. Many boats switch between both these methods depending on wind and sea conditions, but that is a topic for a different article.

Good Luck, and remember, practice, patience, and perseverance wins races.

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