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High Speed Sails

WHAT IS DIFFERENT ABOUT SAILS FOR PLANING DINGHIES, CATAMARANS, AND TRIMARANS?

HIGH SPEED SAILS! A better understanding of high-speed sails can aid in the design of other sails.

Everyone who owns a catamaran or a trimaran knows that there are important difference between his sails and those of a neighbor with a displacement sailboat. But what are they? How do high-speed sails differ from “normal” ones?

It is the design of the sails that distinguishes them. These design differences are very important, but they are differences of degree rather than kind. Indeed, the discussion below should be useful even for those who never intend to build catamaran or trimaran sails, since it will point the way for those who need a bit more speed from the sails that they are using. By discussing the extreme, it should be possible to elucidate the middle ground.

There are three places to look for differences: in the two-dimensional shape of the sails, in the design of their draft or fullness, and in the manner in which they are rigged. We will take up each one in turn.

HIGH ASPECT RATIO

High-speed sails benefit from a very high aspect ratio. In part this is because high aspect ratio is most effective when going to windward and high speeds tend to move the apparent wind forward to the point where almost every point of sail is a beat. When wind is flowing over a sail from front to back, air circulates over the top and under the bottom of the sail. This circulating air both reduces the efficiency of the foil and creates induced drag. If sail area is distributed over a high and narrow foil, the relative importance of this bypass flow will be greatly reduced. Thus, any given area is more efficient when it is distributed over a long leading edge, so long as air flows over the foil rather than “around” it.

A high aspect ratio benefits a high-speed sailboat in another important respect: the potential speed generated by the foil will be higher. The velocity of the air moving over the foil will be greater along its leading edge. At this point the friction drag of the sail has not slowed the flow of air or rendered it turbulent. As a result, thrust can be generated into a higher range.

Note that I am not suggesting that total force will be higher; the force generated by a foil of given size is a constant, assuming all other variables are constant, but the same force can be generated by a small volume of air at high speed as by a large volume of air at a slower speed. High aspect ratio sails characteristically work with smaller volumes of air but at a higher speed than sails with low aspect ratios. *

High aspect ratio is not enough to make a sail efficient on a high-speed boat. The three-dimensional shape of the foil must also be appropriate. Obviously the sail must be relatively flat. Flat sails generate less power than full ones but can be used effectively at lower angles of incidence to the wind and operate effectively at higher speeds than fuller sails.

The appropriate depth for any given sail is not easily determined apart from experience. The weight of the boat, the size of its rig, the shape of the hull(s), the water and wind conditions on a given day, even the helming technique of the skipper--all of these play an important role In determining the proper fullness for the sails. As a general rule, however, it can be assumed that light, fast boats will be best served by sails of from 1:14 to 1:17 draft ratio, that is, for every inch of depth in the sails, they will be from 14 to 17 inches in chord.

There is a second aspect of three-dimensional shape. The depth of the sails must be in the proper place. High-speed sails always benefit from draft farther forward than “normal.” This forward draft can be conceived as working with air that is moving at speeds close to those in the free stream. Chances are that air will also still be moving smoothly in a boundary layer flow. Aft draft may result in the sail affecting more gross volume of air, but it is accomplished only by slowing and disturbing the air flow to such a point that potential speed to be derived from the sail is much reduced. Unfortunately, just as in all mechanical devices, an increase in power requires a decrease in potential speed. So, the faster the boat, the farther forward draft should be moved.

The entry curve for high-speed sails should also be very rounded. A rounded entry curve or leading edge tends to reduce stalling tendencies. This does not directly lead to increased speed potential, it is nevertheless necessary with high-speed boats since they are generally very light. As a result, they are hard to maintain on a constant course. In addition their rapid acceleration or deceleration leads to rapid change in the apparent wind directions. All of this requires a sharply rounded leading edge in their sails.

CAT RIG AND BATTENS

Finally, consider the rig appropriate for these high-speed boats. You will have noticed that most high performance catamarans have a cat rig. This follows from our discussion of aspect ratios. The sloop rig tends to spread sail area out, in effect, decreasing aspect ratio. That sloop rig will make possible more power, but it will cut down the potential speed of the boat. If the boat is so easily driven that this power is not required in order to get it moving, it is best to place all sail area in a single, tall sail.

One more thing: high-speed sails should have full-length battens. These battens are tied into the sail with enough compressive force to bend them into the desired shape. As a result, the sail becomes so rigid that the sail must be “popped” from one side to the other when the boat is tacked. This rigidity holds the sail in shape in spite of rapid acceleration and deceleration and in spite of the abrupt apparent wind shifts, which accompany those changes in speed.

The rigidity imparted by the battens also lets the sail operate at higher angles of incidence than would otherwise be possible (see Marchaj’s Sailing Theory and Practice, page 70). Once again, this can be very useful on a boat that moves the apparent wind well forward just because its own speed is so high. The power developed by such a sail will be relatively low, but its potential speed will be very high.

There are, in conclusion, no secrets in the building of high-speed sails. They are simply the result of extending the same lessons we have learned with “normal” sail design.

*This discussion is somewhat simplified. If you are interested in more detail, see C. A. Marchaj, Sailing Theory and Practice (N.Y.: Dodd, Mead & Co., 1964).

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