Finn sail and mast dynamics

Photo: François Richard

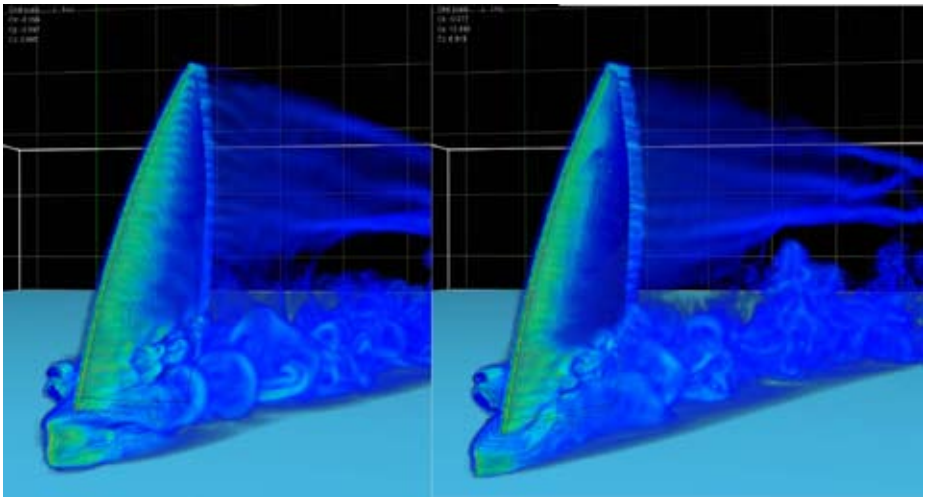
When discussing the dynamics of the sailboat rig, the metaphor of a car can be useful. If the sail is the engine of your boat, the rig is the suspension. The mast controls the leach tension, and the leach is your shock absorber in gusty winds and choppy seas. On a bumpy road you want soft suspension, while on a smooth road you can use a stiffer one. You adjust the stiffness of the suspension through mast rake.

Basic dynamics

Let's study the basic dynamics of sailing in waves, in a straight line, if you do nothing with body kinetics or steering to help the boat to pass over the waves more easily. We will limit ourselves to sailing upwind.

When passing a wave, the bow is suddenly lifted up. The mast top swings back, but due to the inertia of the mast, there is a little lag. This straightens up the mast and closes the leach of the sail. As the mast is swinging back the apparent wind is swinging to the side and decreasing. With the closing of the leach there's also a risk of stalling the sail. The sail is out of phase with the movements of the boat; you would want the leach open, not closed when the mast swings back.

After the bow passes the wave crest and plunges down, the mast top swings forward, but again at a lag due to inertia. The inertia bends the mast backwards and the leach opens. At the same time, due to the angular motion forward of the mast top, the apparent wind swings forward and increases. Again, the sail is out of phase with the dynamics; with the wind turning on the nose, you would want the leach to close, not to open, in order to prevent the sail from backwinding in the top.



To summarise, the motion of the boat when passing waves causes the apparent wind speed and direction to vary along the height of the sail, especially in the top part where the motion is larger. This is detrimental to performance if nothing is done.

But the Finn sailor is more clever than that. To get the sail better into phase with the changing apparent wind sailors have learnt to give a powerful 'jerk' with the thighs and legs just as the bow of the boat starts rising. Alternatively the 'jerk' is accomplished with body movement, but you must be careful not to infringe rule 42. The force transmitted by the sailor's lower body to the deck travels up the mast and opens up the leach of the sail, just as the bow is starting to lift up. Now the sail is in phase with the apparent wind moving to the side.

When the bow is heading down after the wave crest, the sail leach is coming back and closing, again better in phase than if the sailor did nothing. All this happens in a very short period of time of 1-2 seconds, the typical wave encounter period for a Finn. And it needs to be repeated at the passage of every wave, intuitively timed so that the leach of the sail will be in phase with the pitching of the boat. The phasing

Turbulence: Simulating the turbulence around the pitching boat and sail. The motion of the boat in the waves has a big influence on the aerodynamics, for instance robbing 10% of the drive of the sail on average. Recent advances in computer simulation has made it possible to look at dynamic effects on the sail and the boat.

Above: Daniel Birgmark - sometimes big waves call for severe steering

Below: Jonathan Lobert uses the momentum of whole his body to apply pressure to the hull at every wave that passes. He leans aft when the bow plunges down the wave and forward as the bow hits the bottom. The GoPro camera distorts the boat weirdly. Excellent in video, courtesy Lionel Cottin/FFV.

is not perfect though, as there tends to be a second flick in the sail, which can disturb the flow when bowing down.

Often, the helmsman combines some steering into the body kinetics, to follow even better the changes in apparent wind due to the motions of the boat. Steering also helps prevent slamming the bow into the bottom of the wave and balancing the heel of the boat. However, steering is more of a keelboat technique. When the boat is heeled, the rudder has an additional function to steering the course sailed. When you head up, the heeled rudder pushes the stern down, and when you bear away, the rudder lifts the stern, pushing the bow down. The keelboat helmsman uses this effectively by pushing the tiller away when the wave crest is approaching, lifting the bow on top of it. As the bow passes the crest, he pulls the tiller forcing the bow to follow the wave contour instead of slamming into it violently. The same technique does apply in the Finn, in severe conditions, but to a lesser extent due to heeling much less than keelboats.

In choppy conditions, and unstable wind conditions, a softer mast, especially sideways in the top, usually performs better than a stiff one. It allows more body kinetics to be transmitted into the sail than a stiffer mast. Fore-aft, soft very low down (a large tip number) can also be fast in waves. On the other hand, in flat water the stiff mast will allow you point better. As we mentioned at the beginning, you use the mast rake adjustment to control the tension of the leach. In choppy conditions you want a softer, more responsive leach, hence more aft rake in the mast.

Text and diagrams provided by Mikko Brummer/WB Sails. For more information go to www.wb-sails.fi

Mast dynamics while pitching in waves: As the bow goes up, the mast head swings aft, but at a little lag due to inertia. The inertia straightens up the mast closing the leach, just the opposite of what you would want to happen. To alleviate the problem, you want a mast as light as possible. The sail does not escape inertia effects either, so you want a light material and light battens.