Blog written by
BRIAN HANCOCK
brian@greatcirclesails.com

MAXIMUM SAIL POWER

CHAPTER 5
MOLDED SAILS - Part 1

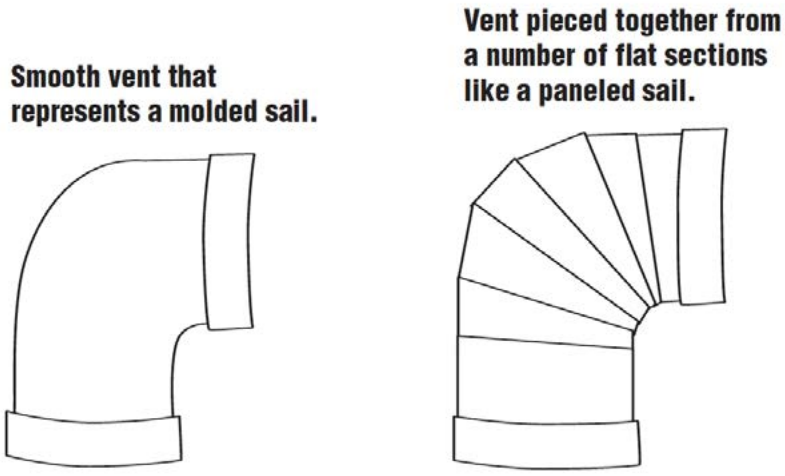
In this chapter we will look at molded sails. Placing individual fibers precisely along the anticipated load paths in a sail has revolutionized sailmaking. But it has not been all smooth sailing. We will look at the very beginnings of molded sails to get some perspective on how far we have come.

Molded Sails

The changes in the sailmaking industry have been nothing short of astounding since the invention and implementation of molded sail technology in the early 1990s. Before that time, although fibers and fabrics had developed to a point where laminated sails in particular were light, strong, and held their shape

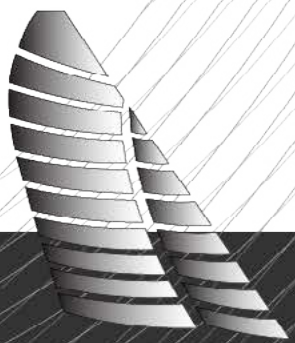
extremely well, the process of orienting panels around a load catenary was still somewhat unwieldy. The reason for this was that in order to take advantage of the low-stretch properties of today's exotic yarns, the yarns had to be continuous and precisely follow the load lines in the sail. When these yarns and fibers are incorporated into rolls of fabric, however, the fibers are laid in straight lines so that the only place where their direction can be changed is at the seams between separate panels of sailcloth. The result is a series of straight lines making abrupt changes at each seam, which is both an inexact and time-consuming way to design and engineer sails.

Molded sails are specifically designed to allow the yarns to follow an exact, curved catenary, thereby increasing the efficiency of each individual fiber. This can be illustrated by two different plumbing elbows. The aluminium vent on the right represents the paneled sail with a curved form being made up from a number of flat sections joined together. The molded elbow on the left is a smooth compound curve without any of the sharp angles, and it represents a molded sail. This is slightly exaggerated, but the difference is striking.



What are molded sails?

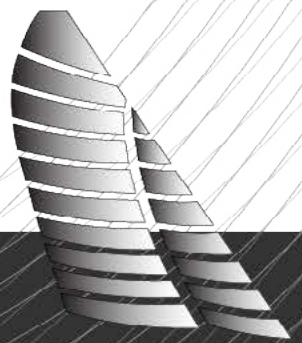
At their most basic, molded sails are sails created in whole sections over a curved mold rather than pieced together from panels of flat sailcloth, as is the case with cross-cut or radial sails. Molded



sails are a kind of laminated sail in that they are made up of layers of fibers, taffetas, films, and other substances. But in contrast to conventional paneled sails — either radial or cross-cut — the load-bearing yarns are laid down to follow the precise load paths that will be incurred by the sail, as opposed to straight lines in the form of a weave or scrim. Note that while in the case of North Sails' now famous 3DL process where the entire sail is made in one piece on a single mold, there are other companies that build their sails in separate sections that are then joined together to produce the final product. North, however, is the only company that can claim that their sails are truly molded. To illustrate this point, if you cut out a section of a North 3DL sail you will not be able to lay it flat. Every square inch of the sail has some molded shape to it. While the other sail- makers will argue that their sails are also molded, in fact what they are referring to are the computer programs they use that design the shape and engineering of the sail as if the sail was molded, but in fact shape is added through more conventional means, i.e., at each seam. The basic idea, however, of having load-bearing yarns or fibers follow an exact catenary remains the same. Despite the gee-whiz nature of the 3DL process, the other techniques are also worth a close look. In fact, they have plenty of advantages and backers among racing and cruising sailors alike.

An uncertain beginning

The technology that forms the basis of molded sails was first developed and patented by Peter Conrad, head of Sobstad Sailmakers, using a process he called Airframe. This concept, according to a legal brief drafted to defend it against patent infringements, "employed the principal of addressing the catenary-shaped load patterns in the sail by using vertical and transverse straps in close configuration where heavy loads were located." Conrad was certainly a visionary and his technique made the most of modern technology and the latest fibers to build sails that were substantially better than their paneled counterparts. Conrad named his creation, appropriately, Genesis.



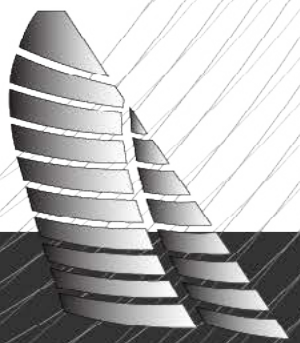
Unfortunately, the good news for sailors was soon overshadowed by a lawsuit that developed when arch competitor North Sails created its own sail-molding system in apparent violation of the Sobstad patent. The lawsuit, initiated by Sobstad, dragged through the courts for years before it was finally settled in Sobstad's favor. At times it threatened to shut down one of North's most lucrative facilities, the plant in Minden, Nevada, where molded sails are manufactured. Fortunately, cooler heads prevailed and North effectively ended up buying the patents from Sobstad, and Conrad, once a starving sailmaker, walked away a man of means.

The patent that Sobstad once held has now run out and most sailmakers have their own way to make molded sails from North 3DL and 3Di to various forms of Tape Drive and string sails that are molded sails but not made on a mold. In Part 2 of this chapter we will look at the various methods and discuss the strengths and drawbacks of each but before we get to that let's take a look at what Genesis sails were all about if only to get a perspective on how far we have come with membrane sails.

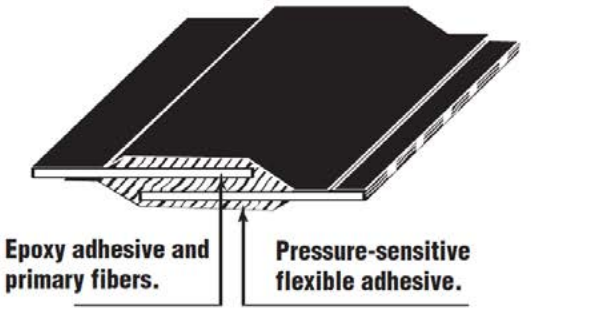
Genesis

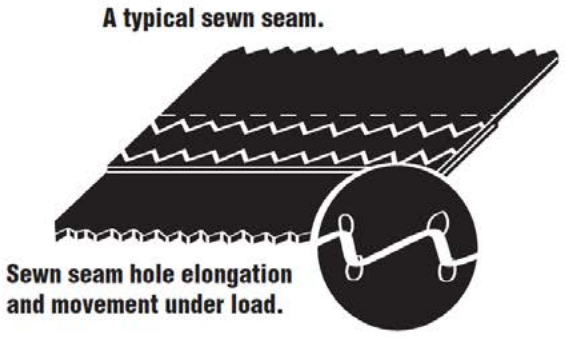
Sobstad first marketed Airframe sails in 1985, and the sails were used to win the America's Cup in 1987. Those early sails were a far cry from the sophisticated, highly engineered products that are now being manufactured, but they were a breakthrough for their time. The problems associated with paneled sails, namely bias stretch and hard angles in the catenary path were overcome by the Genesis method, which orientated individual yarns directly along specific load paths. The process starts by creating complex stress maps that analyze the various loads in sails and then reproduces the resulting two-dimensional stress map as a three-dimensional sail.

Strictly speaking, Genesis sails are not created on a mold, but manufactured in large panels, which are then pieced together to create the finished sail. In fact, in the case of Genesis sails, the



seams where the panels come together are used to create the shape of the sail just as broadseaming is employed in paneled sails. Still, any sail that is designed and built using a three-dimensional design program can be referred to as a molded sail, and is certainly considered to be such by the U.S. court system. As part of its process, Sobstad has developed an interesting seam construction that allows two panels to be joined together without the need for sewing. This is important since in contrast to paneled sails where the various scrims and weaves provide plenty of yarns for the stitches to bite into, the Genesis panels have fewer yarns and the result is a seam that is much harder to sew. During the assembly process the Genesis seam is heat-sealed at 120 degrees Fahrenheit, while pressures on the order of 25 pounds per square inch are brought to bear on the seam. This heat, combined with pressure and the latest epoxy adhesives, results in a seam that does not need stitching, yet is still extremely strong.





As is the case with laminated fabrics, molded sails would not be possible without the sophisticated adhesives that have been developed in recent years. And it's important to remember that a large part of the success of the laminating process stems not only from the adhesive, but also from the amount of pressure that is applied to the surfaces being laminated. When rolls of sailcloth are laminated, for example, the pressure is exerted over a relatively narrow surface area. As soon as the surface area to be laminated

is increased, say on a large mold, it is not that easy to get the intense pressure needed for a secure bond and more reliance is placed on the adhesive. In fact, there is an ongoing debate among sailmakers who produce paneled sails versus those that produce sails on a mold. The paneled sail- makers claim that their sails are actually lighter than molded sails because they are able to bring more pressure to bear on the fabric and therefore use less adhesive. It's an interesting debate that likely has no resolution since sails are complex pieces of engineering with too many variables to compare one technique directly against the other. It does, however, give the salesmen some interesting material for bringing in customers, and the difference in weight, if indeed there is one, will likely diminish as the technique for molding sails becomes more sophisticated.

In terms of the specific production process, the construction of Genesis sails begins with the application of thread to a film substrate, which is accomplished by a thread-laying machine that is programmed with each sail's design information. The machine plots precisely the right density and type of yarn to create what Sobstad calls the "primary carrier film." Once this is done a second layer of fiber on film is created with the yarns orientated to accept all the secondary loads to which the sail might be subjected. Then the two layers are bonded together to produce a strong panel ready for shaping and joining with the rest of the panels to finish the sail.

As noted above, the individual yarns do not run the full length of the sail, since they are severed at each seam. But the design program lays them onto the film so that the seams from different panels will meet head-on creating a "virtually" continuous fiber running from head to clew. With no seam slippage and a myriad of yarns precisely oriented to accept the loads, the result is a sail designed to hold its shape once the forces of the wind come into play.

It's also important to note that with this kind of construction there is less need for the corner reinforcement usually found on paneled sails since the individual yarns radiating from the corners along the load paths efficiently take up the extra burden placed on the corners of the sail. On some Genesis sails I have sailed with this area was vulnerable to delamination because of the number of fibers laying on top of each other. But this is an issue that over time has been addressed and improved upon.

In Part 2 of this chapter we will spend some time looking at the whole 3DL and 3Di process since North Sails have dominated sailmaking with this technology.

I hope that you enjoyed this blog. There are many more at my website www.greatcirclesails.com. If you need new sails for your boat just click this box and I will send you a no obligation quote.

BRIAN HANCOCK
Owner Great Circle Sails