Refinishing two carbon fiber masts

Originally re-finishing the masts was going to be Meps' project instead of mine, but it got out of hand. Let me start with a disclaimer:

You would all probably like reading this more if it had stayed Meps' project, as she does a much better job of writing and doesn't find the technical stuff nearly as interesting as I do! If descriptions of composite construction and fiberglass work make your eyes glaze over you may wish to stop reading very soon. (And fellow engineers can sit back and enjoy the ride!)

Our masts were built by TPI in 1981, and they are constructed with a thin inside spiral wrap of unidirectional glass fiber tape, (the filaments all go in a circle around the mast), then fairly thick vertical carbon fiber, then another wrap of unidirectional glass fiber, then a thick layer of fairing mud, then paint, and finally some epoxy painted on by the prior boat owner.

When we bought the boat, the masts had circumferential cracks, which is fairly common on older Freedom masts like ours. It turns out that the outside layer of glass fibers will separate when the mast flexes, and then the mud and paint will crack. I know that painting over old cracked paint just results in new cracked paint, and I do not want a "distressed" finish on my masts. The recommended solution we got at the time was to grind off the mud, and then add a wrap of bidirectional tape which will resist cracking, then re-fair and re-paint. We were planning to do something like this.

We had been planning to do this for a while, but in the back of my head, I knew it was gonna be a really, really big project, so I resisted starting it until we were in-between other big projects. Meps didn't appreciate me holding her back from her big project, and finally I let her get at it. One day I was talking to Alex, who is the fiberglass and paint subcontractor at the yard, and is quite helpful with advise on projects like this. Meps rides over on her bike in excitement and says "I've got it! We can get a giant condom for the mast!" She had found a product on the internet we could use for the replacement fiberglass layer. It is a giant knitted

tube of synthetic fabric that we could pull onto the mast, and unlike a spiral wrap, it doesn't leave ridges that need to be sanded and filled to make a smooth surface. When we got to using it, she claimed it was more like putting pantyhose on than putting a condom on. Given how seldom I wear pantyhose, I didn't argue.

The first things we did were work at the masthead and mast foot.

I spent a lot of time trying to get old fittings and bolts off the masthead. If you have ever tried to remove stainless steel fasteners from aluminum after many years, you know what I was going through. If not, I'll spare you the description. We also had to do some repairs to the mast foot. There are bolts that go through the foot of the mast and prevent it from spinning. They had done a little damage to the mast over the years, so I made big aluminum backing plates and Meps epoxied them in where the pins go, with a little fiberglass cloth to repair the damage.

I spent a little time making mast rollers--when we moved out of our house, I couldn't bear to throw away some used skateboard wheels, and now I knew why. I mounted a pair on each of two sawhorses, and then put two scraps of plywood with a hole in it on another sawhorse. There is a big bolt sticking up in the middle of the masthead fitting that fits through the hole and allows that end to spin, without even covering anything I want to paint.

The next project was rigging some shade over the masts. Sure, we could tough it out and work in direct sun, even though we wouldn't like it. But the epoxy and paint would dry too fast or get more air-bubbles, and make more effort for us. So we spent some time rigging our shade-cloth over the side of the boat, with a 10-foot length of conduit, lots of ropes, and the roof-rack on the

van. And every time we went into town, we had to un-tether the van (we only almost forgot once!) and then re-assemble upon our return.

Then the main event began. We had seen two men rounding a wooden spar by wrapping a strip of sandpaper around it and each grabbing an end and going back and forth like a two-man saw. This seemed like a great way to sand our masts down....until we tried it. It was taking forever, although the results looked good. The sandpaper was ripping too. (Cloth sandpaper would work much better here, I'm sure)

Take two. Meps got the random orbit sander and tried that way. It was taking almost forever, but also looking pretty good. This wasn't gonna get the masts done before we left the state in two weeks either.

Then I capitulated. I had never wanted to use the 7-inch angle grinder--It is a big heavy tool, and I've never had much upper body strength, so I figured it would turn my shoulders to jelly. I was able to borrow one, and fortunately, for this job I was able to rest it on the masts instead of holding it up onto a vertical or upside down surface. But it was working. I would sand about the top third of the mast from one end to the other, and then I would rotate it and move on to the next section. 20 disks of 40-grit paper and a few hours later I was done with one mast. My shoulders, arms, and back were done for the day too.

Unfortunately I was leaving slight high and low ridges, so Meps went behind me with the random orbit sander to smooth them out--lighter work, but it took a bit longer. I felt I had to finish that mast in one day as I probably wouldn't be able to lift the grinder the next day. Well I waited until mid-day for Meps to catch up, and took a three ibuprofens, and between us we managed to get two masts sanded in three days.

After all the sanding comes washing the masts to clean off all the dust.

Yes, it was a LOT of dust. And a lot of sanding discs too.

Finally we pulled the sock onto one mast. Then much effort to get the ends tied off, and cut it off. Gee, that doesn't look like very much left, does it....and sure enough, it only covered the top third of the other mast. Oh well, pull it tight, tie it at both ends, and we'll do what we can. We did a few quick calculations, and Meps jumped off to order another 50 feet of sock overnighted to the boatyard, so we could continue work during the holiday weekend.

We decided to start on the short section at the top of the mizzen mast, since it would be a smaller problem to finish once we got started. I was mixing epoxy and Meps was wetting out the sock. Behind her, I was wrapping the peel-ply around the mast tight, then squeegeeing the excess epoxy off. It does not have selvedged edges, so it started to make long fraying fibers from each side. I was trying real hard to keep them on the outside of the peel-ply where they wouldn't add texture to the sock. I don't remember who was turning the mast so we could make sure we wetted the whole thing out well. We finished it a little late for lunch.

Having figured out that peel-ply frays were a real pain, I decided to re-roll the leftover peel-ply taking the loose threads off the edges. It was tedious but easy work, and then we started on the next mast. We

made it go a litle more smoothly by dividing the labor up differently with Meps doing both the wetting out with epoxy in front and the squeegee work behind me. This went pretty well, until I ran out of peel-ply. I did some quick work to tape it down at the end, and then we shifted to just wetting the fabric out for the rest of the mast. The weave wasn't completely filled in on this section yet, and we could see that without the peel-ply we needed more epoxy. So as the epoxy started to get tacky we painted another coat on, and when that one got tacky, we put on a third coat.

Next, we ripped off the peel-ply and discovered that it had been a pretty bad idea in this context, and would cost us an extra day or two to fix the messes it had made. First off, the weave

wasn't filled in completely underneath the peel-ply. Second, it seemed to create a few more little air bubbles in the weave pattern, and third (and worst for us) we discovered that it left a messy high spiral at the edge where it overlapped. This was either bits of the fabric that stuck instead of peeling off, or epoxy that had pooled around the fabric. It ended up taking another day or two to scrape the worst off with a razor and sand it flush with a detail sander.

At least ripping the peel-ply off was satisfying. And I figured out that ripping all but a strip with the last half-inch off went real easy. Then the last skinny strip could be carefully removed without leaving much of a spiral to sand off. The second section we removed went a little better.

Once we finished sanding, there was a lot of dust in the open weave, and wiping or washing it wasn't doing to clean it out. So I went and borrowed a small compressor and tried to use compressed air to blow it out. I probably should have borrowed a big compressor, as we spent a lot of time waiting for the compressor to catch up with us.

Then our new sock came in, and by this time, we had figured out that the peel-ply was a mistake, and the trick was to paint it as fully and completely with epoxy as possible. Otherwise we would need to sand it again before putting more epoxy on, and sanding the masts wasn't a quick process. We now had a new division of labor for epoxy: One person painted epoxy on with a paint roller and a tub, pouring a line of

epoxy on the top, then painting it in with the roller. The other person mixed tubs of epoxy and turned the mast. Paint a couple feet. Rotate and paint the same couple feet. Rotate and paint the same couple feet a last time. Repeat for 39 feet.

By this time, we were trying to fill the open weave for the entire masts, with different sections at different starting points. The mizzen mast bottom was just started at this time, with just fabric and epoxy. The top of the mizzen had previously been wrapped in peel-ply and was just getting filled in. The main mast top had never had peel ply, and already had a couple extra coats of epoxy. The main mast bottom also had been wrapped in peel-ply and needed to be completely filled in with epoxy. We were painting one section after another, until we had about three extra coats of epoxy on everything. The day was done, and we really couldn't have done any more even if we had the energy to do it.

We also asked Amy to take some pictures during this layup, which made it more fun. We would have liked pictures of the peel-ply fiasco, but we just couldn't take them ourselves, and didn't have anybody spectating that day.

Now we had (almost) all the epoxy we were going to paint on the masts.

The next day we started sanding the masts with 120 grit paper and the random orbit sander, getting them ready to paint. At least we thought so. This when I started wishing we had put a fourth coat of epoxy on. Instead we were finding that the fabric was fuzzing through in places and shallow in places. So I was sanding and circling low spots with a sharpie as I went along. This was going fairly slowly, and Meps couldn't do much besides watch. Fortunately, Oscar was taking a break from his boat projects and wandered by to chat. Meps asked if he had another sander like I was using, and it turned out he did. Pretty soon we were sanding from opposite ends of the mast toward eachother until we bumped butts or ran our sanders almost into eachother like bumpercars. Then we would turn the mast and go do it again. And another turn, then on to the next mast.

The next morning we could see that there were a lot of places we needed to re-paint with epoxy again. So we started out washing all the dust and residue off, and painted the bad spots with epoxy. Even though it was with fast hardener, we had started early, it was a little cool, so it was taking too long. I kept trying to sand, and deciding "Nope, it isn't ready yet...keeps gumming up the sandpaper." Finally we got out the two sanders and started sanding toward eachother again. This time we only had to sand parts of the mast, probably about 1/3 of the total job. There were still a few spots that had some fuzz from the sock showing through, but we were leaving tomorrow, and there was no looking back now.

So back to washing the masts with soap and water and rinsing them well. And washing a trouble spot, then rinsing, rinsing, and rinsing. Finally they were dry, so time to paint them. By now, we had the drill down pretty well. Mix the paint, one person rolling it on, and one person rotating the mast. Oops, this is using a lot of paint....what coverage was it supposed to have anyhow? Oh well, we got one coat on everything, and put a second coat on a few other spots to use up the can.

The next day we just had to pack everything up either inside the boat, inside the van, in storage, or into our luggage for the trip to Seattle. I think we had about 15 minutes extra to say goodbye to all our friends in the boatyard, and then we left for the airport.

Lessons learned along the way:
- The easyglas sock was fantastic to work with.
- Peel-ply was a loser in this application.
- I wish we had done the whole mast by just wetting out the easyglas sock and then as soon as it got tacky, painting another coat of clear epoxy on it....I would probably do four coats.
- The 7" angle grinder with a soft pad was the right tool for removing the bulk of the old paint and mud
- The random orbit sander worked well for cleanup and sanding prior to later epoxy or paint coats
- Somebody showed me (later) a picture of a drum with a handle on one end chucked in a drill on the other end. It was turing an inside-out sanding belt to make a mast round. This doesn't look too hard to make, and I may try to fabricate one of these for sanding any fairing filler, later coats of primer, or between coats of paint. It is hard to say whether it will be better than the random orbit sander or not.