



CRYOBOO

An experiment using cryogenics in the construction of a bamboo fly rod



Cryoboo rod on right, comparison rod on left

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Introduction

Cryogenics is defined as, “The science of extremely low temperatures applied to an object and the resultant changes in properties of the object as a result of that application”.

A few years ago, an article on the web caught my eye. The Japanese were cryogenically treating bamboo in order to enhance its strength in construction projects. I wondered if cryogenics might enhance the performance of a bamboo rod.

Here at Metallurgical Solutions, Inc., we use cryogenics regularly to enhance the performance of high speed and tool steel cutting and forming tools, (things like milling cutters, taps and dies, punches and other metal working tools). With this type of tool the cryogenic treatment (after heat treatment) will increase the toughness of the tool, making cutting edges last longer, etc. (There are other benefits to tools much too detailed to go into in this particular report.)

As we receive the tools the metal in the tools is in the ferritic state. This refers to the crystalline structure within the part. As we harden (austenitize) the tool the ferritic structure converts to an austenitic structure. Upon quench cooling to room temperature, the austenite transforms to un-tempered martensite, a very hard and brittle structure. We then temper the part and change it again, forming tempered martensite; a much tougher structure, with very little sacrifice in hardness. Typically, approximately 95% of the austenite converts to martensite in tempering the part. This is where the cryogenics comes into play. Cryo helps that last little bit of austenite to kick over to martensite.

The point is, these changes are sub-microscopic. They are taking place at the molecular level.

For years we've known that cryogenics enhances the performance of golf balls, tennis balls, and nylon stockings etc. But those are all synthetic objects.

What if such a dramatic difference could be imparted to a natural product, like a bamboo rod!

Pretest

Just to determine if cryogenics had any effect at all on a piece of bamboo, a 12" length of bamboo was planed to the equilateral triangle cross section we plane our strips to when making a rod (0.172" on a side). This piece was heat treated as if it were a rod section. Then it was anchored in the lower section of a planing form and a 0.818 lb weight hung off the end. The deflection was measured and recorded. The strip was then cryogenically treated. It was then mounted again in the planing form with the same overhang, and the same weight applied. It was obvious the cryogenics increased the stiffness of the bamboo piece. When a 9% less deflection as a result of cryogenics was measured, it was apparent this project was worth a little more investigation.

Bear in mind, so far this is just a static load. We still have to find out what happens in the dynamic test. (See photo)



Static load of 0.818 lb

Procedure

In order to evaluate the effects of cryo on a bamboo rod, what was needed was two identical rods, one cryogenically treated, and one not. I chose to work with the Paul Young Midge Taper, 6'4" for a 4-weight, a taper I've built several times before.

Just as with building any nodeless rod, the entire culm was lightly flamed, then the nodes were cut out, and all of the sections were clearly identified with various colored magic markers (before splitting and heat treating them). While my wife was at the market, I used her oven to heat treat all the nodal sections together at 300 F for twenty minutes.

Masking tape was used to keep the various rod sections identified until the guides were applied. Then the color of the thread wraps accomplished that.



Next the heat treated culm sections were each split in half. Half were to be further processed with the cryogenic treatment, two hours at 150 degrees F below zero. A white line was also painted around the half sections of culm prior to cryogenically treating them. When split, each piece had a white dash reminiscent of frost on the enamel.



A couple of tubes were made to hold the splits separated and clearly identified as the rod sections were assembled. One set of tubes was painted blue, (a cool color like cryo), and the other set of tubes orange, (a warm color as in oven). At this point, the half of the strips which were to be cryogenically treated were tied in bundles with shoestrings and cryogenically treated. From this point on, it was just like building any other rod, except that it was very important to make two identical rods.



As an example, in making the strips for the two butt sections two (glued up) strips cryo'd and two strips not cryo'd (times 3) for each butt were needed. For this test only, great care had to be taken to assure that each respective nodal strip of each of the six glued up sections had to be taken from the same respective section from the culm, half of them cryo'd and half not. Joints were staggered as with any nodeless rod. Finally, the glued-up, and planed strips were arranged around the rod for each, the cryo'd and not, with the same order of glued up sections. This one step may be negated by finding the spine, but it was done anyway.



This photo illustrates the fact that strips from the same nodal sections were used in the same respective locations in the various sections of the rod. Shown here are the 4 tips.

Double all this for the four tip sections, two cryo'd and two not. Phewwww!

Spining of all six rod sections was done using the vibration method.
(www.rodbuildingforum.com, finding the spine in bamboo rods)

Supporting Data

These measurements were made to determine if the two rods were identical as intended.

Weight of non-cryo rod
 Butt = 0.166 lb
 Tip #1 = 0.036 lb
 Tip #2 = 0.034 lb
 Tip 2 & Butt = 0.200lb

Weight of cryo rod
 Butt = 0.166 lb
 Tip #1 = 0.034 lb
 Tip #2 = 0.034 lb
 Tip #2 & Butt = 0.200 lb

Using a micrometer, measurements were made at 3 places on all 6 rod parts across the flats of the six sided rod sections. On the butts they were just below the ferrule, mid point and just above the grip, (all in inches). On the tips measurements were made just below the tip top, mid point, and just above the ferrule.

Non cryo butt	Avg	Cryo Butt	Avg
Just below the ferrule	.210, .206, .208	.208	.208, .207, .206
Mid point	.222, .220, .224	.222	.223, .219, .222
Just above the grip	.262, .248, .252	.254	.255, .257, .260
Non cryo tip 1	Avg	Cryo tip 1	Avg
Just below tip top	.085, .085, .086	.0853	.085, .081, .084
Mid point	.139, .138, .139	.1386	.136, .137, .137
Just above ferrule	.198, .201, .199	.1993	.193, .196, .196
Non cryo tip 2	Avg	Cryo tip 2	Avg
Just below tip top	.085, .084, .083	.084	.081, .080, .079
Mid point	.137, .136, .138	.137	.138, .136, .135
Just above ferrule	.197, .195, .193	.195	.197, .195, .198

Testimonials

Two identical reels, (Bass Pro Shops White River Reels) were purchased and fitted with Cortland 444 weight-forward floating lines, one 4-weight and the other 5-weight. Then four friends offered to help put both rods through their paces.

7-6-13 Gerry Charpentier, an excellent caster, and the best roll caster I've ever seen tested both rods. A good part of Gerry's fishing is on local ponds and lakes from shore, so distance in casting is important to him. It didn't take very long before Gerry confirmed the non-cryogenically treated rod was a #4-weight rod, (which is what it was intended to be). Then he tried the Cryoboo rod with the same #4-weight line he had just tested. Then we applied a #5-weight line to the cryo treated rod. It didn't take very long before he decided this rod really performed much better using a #5-weight line. He consistently got more distance with the cryo treated rod and the #5-weight line, and in addition he felt the Cryoboo was almost effortless and smoother in casting, and consistently more accurate when casting to a target. Gerry felt that in the non-cryo treated rod the strength of the rod was concentrated in the tip of the rod, whereas with the Cryoboo rod the strength was evenly distributed across the mid section of the rod.

7-12-13 Bob Greco, one of the foremost casters and fishermen in RI tested the two rods. Most of Bob's casting is done in small streams, so distance is not as important to him as accuracy. Bob was impressed with the ease with which the Cryoboo rod performed. He commented that it almost cast itself, took a lot less effort, and was very accurate. He felt that the power in the non-treated rod was concentrated in the tip section, whereas the power was evenly distributed across the entire midsection of the Cryoboo rod. Bob felt that with the Cryoboo rod, one could cast slowly, thereby developing large loops as a beginner might, or cast faster developing very tight loops as an experienced caster would.

7-18-13 Ed Lombardo, Rhode Island's foremost casting instructor tried both rods. He loved them both. After getting familiar with both, Ed commented that whatever heat treatment was done on the Cryoboo rod made it more powerful, stronger and faster. He cast 60 ft with the non-cryo treated rod and 70 ft easily with the Cryoboo rod consistently. He felt no vibration in either rod tip as he put them both through their paces doing things like a "Mending Cast", "Parachute Drop", and a "Serpentine Drop." Ed felt he had to slow down his technique to fully load the non cryo rod, whereas with Cryoboo, it was nice and fast and powerful. He commented that with the 5-wgt line on the non cryo rod, he had to be careful not to overload the rod. That was not the case with the Cryoboo rod. The 5-wgt line is a good fit with the Cryoboo rod.

7-19-13 Steve Balme, a fellow rod builder and excellent caster, likes to fish salt water from shore, so distance is important to him. Steve cast both rods using the 4-weight and 5-weight lines on each. He tried them again, 4-weight and then the 5-weight lines on both rods. His conclusion was that either rod could cast either line if need be, but the non-cryo'd rod was definitely a 4-weight rod, and the Cryoboo rod fit the 5-weight line perfectly. With the Cryoboo rod and the 5-weight line, Steve consistently got 10 to 15 feet more distance with greater ease.

Determining the stiffness ratio

Using the procedure described on the web site <http://suite101.com/how-to-determine-the-weight-of-a-fly-rod> produced some very interesting results. Both rods were processed separately, and the loads identified as non-cryo'd and cryo'd. Surprisingly, when measured on a very accurate scale, the weights were identical, (18.0 grams). Even more surprising, the weights indicated that both rods were #7-weight rods.

Both rods were then mounted on the bench side by side, tips lined up, and the same weights applied. Then came the biggest surprise of all. The tips lined up with the weights applied. However, the profile of the rods was quite different.

The first picture was taken with no load and the tips lined up, and yes, there are two rods there. Look closely at the tips.



The second photo shows the mid section of both rods with the 18.0 gram loads applied. Notice the more pronounced bow to the non-cryo'd rod in the background compared to the Cryoboo rod in the foreground.



The third photo shows that the tips are in alignment with the weights applied.



Conclusions

These last three photos show graphically what was said by the people who tested the rods.

“The strength of the Cryoboo rod is concentrated across the mid section of the rod.” It appears the Cryoboo rod is a stronger, more powerful rod as a result of the cryogenic treatment.

Why would the cryogenic treatment so affect the mid section of the rod and apparently have so little effect on the tip section - possibly because there is less meat in the tip section. Further testing will have to be done, but we will probably find that the power fibers are about as strong as they are ever going to be. However, deeper into the fibers there is a lot of room for improvement with the help of cryogenic processing.

If cryogenics will allow us to make any taper more powerful, or faster, perhaps we can build lighter weight rods to give us the feel of a rod one weight higher.

There is a lot of work to be done here. Today’s rod builders have come a long way with their techniques and workmanship, but cryogenics opens a whole new area for exploration.

Questions Raised

Why did we use -150F for the test? That is a temperature we use regularly in treating metals. It is the beginning of the accepted range of Cryogenics (-120F to -320F) used by much of industry. Our freezer uses liquid nitrogen, so we could go lower if needed.

Industrial mechanical type freezers can operate down to -120F, which should be entirely adequate for any rod builders who would like to do a little independent research. Contact your local heat treater.

An interested rod builder might try packing his rod sections in dry ice, (approx -109F). But be careful. It can burn you as badly as boiling water. Wear gloves.

Would my home freezer work? Most home freezers struggle to get down to -10F. Would that be enough to improve your next rod? It’s doubtful, but try it. It couldn’t hurt.

What would happen if we treated bamboo at a temperature lower than -150F?

What would be the results if we did it twice at -150F?

Will the glue and epoxy stand up to cryogenics? We don't know. Whether treating a steel cutter or bamboo culm sections, the piece is homogeneous. The Titebond II joints in a glued-up strip, or the epoxied joints may expand and contract at rates different than the bamboo around it, thereby weakening the joints. We'll have to test it further.

Does cryogenics alter the color of the rod? The answer is "NO". Notice the picture on the cover of this report.

Appendix

It should be pointed out here that none of these gentlemen who helped in testing these rods was aware that there was any difference between the two rods except the thread wraps until each was well into the evaluation. With the exception of Steve, none of these gentlemen had ever built a bamboo rod and had no familiarity with the heat treating of a bamboo rod. I'd like to thank each of them for their assistance in this project.

Since there will be further work done in this area, I would like to ask that anyone who feels he has anything to offer by way of suggestions or solutions, please let me know. My email address is jack@met-sol.com, (work), or drdeerhair@verizon.net. (home) This report is available for download at our company web page www.met-sol.com. On the home page click on the blue banner labeled "The Industry".



Mechanical
properties of bamboo

<http://www.cartercryo.com/cryogenic-golfclubs.html>

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