Introduction to Drawing Nickel-Silver Tubing for Ferrules

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The NS tubing along with precision carbide drawing dies and mandrel sets give rodmakers the basic tools necessary to draw their own NS tubing to make ferrules. Having these tools is the beginning of the journey rather the end. Depending on the method chosen, either draw bench or pushing with an arbor press, the rodmakers can fine-tune their dies and mandrels to make precision custom ferrules--the hallmark of custom rodmakers.

To get to the point where we are today has been a long journey. First, we had to find the information about drawing NS tubing and how to build a prototype draw bench and dies. The more we did, the more we learned. The second, the hardest part, was to find sources that are willing to deal with small orders. Most suppliers just laughed at the small numbers we wanted. Eventually, we did find several sources, and the effort progressed nicely. By having a group purchase, we were able to have a large enough order to obtain reasonable prices.

Additionally, you receive the benefit of a lot of lessons learned. The die and mandrel sizes provided were developed after a number of trial pulls to determine exactly how the dies and mandrels perform. We standardized the specifications of the dies and mandrels to ensure all the resulting tubing would be complementary. You can refine the specifications based on the methods you develop for drawing as you get familiar with the processes and do a number of trial pulls to determine exactly how the tube reacts to your methods. Changes in methods can result in slightly different tubing sizes.

The cold draw process for tubing is recognized as a value-added process. It results in tubing that is more exact in size and dimension than commercially drawn tubing. You will notice that the fit of the male ferrules into the females feels much smoother, because the inside of the females are smoother and rounder. This could only be achieved earlier by lapping commercial ferrules.

Throughout the history of rodmaking in the U.S., the availability of NS tubing suitable for making ferrules has been problematic. The expense of having all the sizes required made the cost very prohibitive. The major classic premium rodmaking companies, such as Leonard and Payne, as well as all the others, had to deal with the NS tubing availability issues. It led Lyle Dickerson to make his own dies and draw bench to get the tubing sizes he required. Leonard and Payne had access to thick-walled NS tubing, 032" (2/64ths) versus the required thin walled (1/64th). They developed the process to draw the thick walled NS tubing down to thin walls for their ferrules. Credit for developing these dies can be attributed to George Halstead, a master machinist and rodmaker who also designed the ferrules and reel seat hardware for Payne. Some rodmaking companies (Grainger, Divine) resorted to deep drawing ferrules from flat stock when suitable NS tubing was not available to them. This process requires additional dies and labor. Drawn ferrules were generally considered not as good as ones made from NS tubing, but we'll leave that argument to others.

The original Halstead dies, Dickerson's and even my first set from Jerry Walls were made from steel. They produced satisfactory results, but today, the preferred material for dies is tungsten carbide. Carbide dies will yield far superior results for several reasons. First, they are precision ground and polished. Having concentricity is essential to drawing NS tubing, or any tubing. The second and most important reason is at the microscopic level. Tungsten carbide is actually porous and it will hold the lubricant. Steel isn't porous so it doesn't hold lubricant. NS tubing isn't porous either, so drawing NS tube through steel dies takes a lot of effort because the two smooth surfaces dragging on each other have a lot of friction and generate heat. It takes significantly less effort to draw NS tubing through carbide dies. When you try to pull the NS tube off shiny steel mandrels, you'll feel the heat generated. Another noticeable difference is in the finish of the tubing. Steel dies leave small thin lines on the tubing surface, while carbide dies leave a much smoother finish almost free of any marks or lines.

The basis for the rodmaker's draw bench can be traced directly to Lyle Dickerson who, built his draw bench for the same reason that we are doing so today -- the prohibitive cost of buying precision drawn NS tubing in all the sizes a rodmaker may need. Stein and Schaaf documented his draw bench in the book, Dickerson – The Man and His Rods. There are several pictures of his draw bench, dies and holding mechanism in the book. When I first read it, I just assumed that someone who was an elite rodmaker and machinist like Dickerson could only become accomplished by having a draw bench.

Several years ago, as my supply of precision-drawn NS tubing diminished, my thoughts turned to ordering more tubing, but I soon discovered the current price is prohibitive. I rediscovered Dickerson's letters in the Rodmakers Guild archive on www.powerfibers.com. This article started my quest for obtaining a draw bench. My draw bench is essentially based upon Dickerson's. The only other rodmaker's draw bench that I knew of was the one Bruce Howell made based on the Dickerson draw bench. He provided valuable insight on the design. The version Jerry Walls made for me was loosely based on this bench. However, Jerry did make one significant improvement in his design of the jaws that hold and pull the NS tubing and mandrel. Instead of the scissor type jaws that Dickerson employed, he designed an innovative set of split cone jaws and holder. The beauty of this design is that it centers the mandrel for pulling. The harder you pull, the better it grasps. When you push the mandrels, the jaws release. The other nicety is their compact size compared to the scissor jaws.

Over the past 2 ½ years, I have improved my draw bench. The single biggest improvement was the switch to carbide dies and the second was using step-down mandrels for drawing. Lastly, during working with the machine shop for making additional sets of the split cone jaws, I made one last modification that allows them to grip even better, especially on smaller size mandrels. These jaws and holder are hardened and tempered to securely grip the mandrels. With a set of 4 sizes to work with, I am confident that by changing the size of the jaws it ensures that the mandrel is held dead center to provide a straight pull.

Today, my draw bench is a significant improvement over Dickerson's original bench and yields high quality precision NS tubing. Once I learned the basics of drawing and saw the results, it motivated me to tweak the machine and solve some of the lingering problems. With the dies, mandrels, and jaw sets, we have today; we have made a lot of progress in putting this technology in the hands of the average rodmaker.

Terms and Concepts

Die: a precision piece that creates the outside diameter (OD) of the NS tubing. It has an entry angle, usually a compound angle that allows the NS tube to flow while being drawn. There has to be enough entry area to accommodate the tubing as it flows. My old steel dies did not have enough area and the NS tube would grab the entry edge and rip apart. The area where the OD is formed is very short, about 30% of the die's length. It is located just before the exit and forms the final diameter. There is an exit angle on the other end of the die
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Fig 1 – Carbide Die

Springback: when you draw tubing, there will be a minor degree of what is called springback. This is the elastic recovery of the NS tubing after it leaves the die and when the mandrel is removed. This movement is usually around .001” and has to be accounted for in doing trial pulls to determine your draw bench performance.

Trial pulls: a series of pulls that are carefully measured and charted to determine the results from your draw bench when using a certain type of NS tube. I did a number of these pulls using old NS tubing from the old Zimny buy which has .017” wall thickness and with ¾ hard tubing, and with soft tubing I had with .014” wall thickness. I got different results from both types of tubing. I also did pulls with both odd and even size tubing. Part of the process is to measure the dies and mandrels and then measure the resultant OD and ID of the drawn tubing. I use a digital micrometer (a dial indicator is not accurate enough) and pin gages and record the results on paper or in a spreadsheet. For the purpose of this buy, I fully specified the dies and did a spreadsheet to make sure we had consistent steps in sizes and maintained constant wall thicknesses.

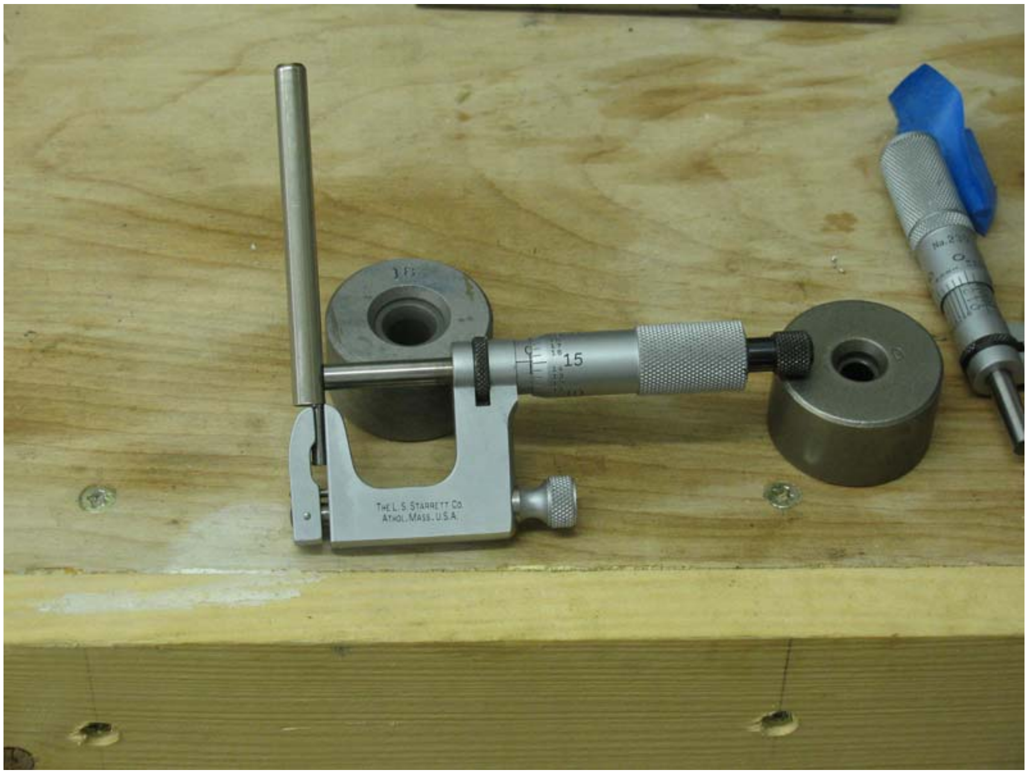

Fig 2 – Measuring Drawn NS Tube for Trial Pulls

Pin Gages: I have 3 Meyer Pin Sets; M1, M15, and M2. You should obtain the “minus” sets, which means they are .0002” under-sized, so .250" is actually .2498”. The gages are short pieces of precision-ground round steel. You fit them in the tube to determine the ID.

Fig 3 – Meyer Pin Gage Set

Hardness and work hardening: the mother tube in this buy is ½ hard. When you draw down NS tubing, you will work-harden it. This happens when both tubing surfaces are pressed between the die and mandrel, causing the tubing's molecules to become aligned. You want the tube hard for ferrules, because soft tube will wear faster. A general rule of thumb is ¼ hardening for a 20% size reduction in the tube. When drawing the tube you will feel the change in hardness. Unless you are going to draw very small size tubing, you will not have to worry about achieving too much hardness, since you want the tubing to be hard.

Sinking tube: this is the process where you draw tubing through a die, but do not employ a mandrel to iron the inside diameter. This does not significantly work-harden the NS tubing. Also, surprisingly, it does not significantly thicken the wall of the tube. You may see it get about 001”thicker when pulling down the outside 1/64th through the die. This is just how the NS tube behaves. You can always thin the wall thickness but it is difficult to thicken it. It is only when you iron the tube against the mandrel that hardening significantly occurs. The ironing stretches and aligns the molecules.

Banana-ing: this is the bane of tube drawing. The tube comes out with a curved shape, looking like a banana. The main cause is from dies that are not perfectly round, which is not an issue with our carbide dies, but did occur with the steel dies. Another cause is the misalignment of the center of the die with the gripping and pulling mechanism on the drawbench. You need to pull straight; or one side will become slightly thinner than the other side. Think of this as similar to the spine of a bamboo fly rod. We have solved one of the major uncertainties by using step-down mandrels instead of swaging the end of the NS tube and imperfectly gripping the crimped tube with the draw bench jaws. By rolling the tubing over the mandrel step-down, you can grip the round mandrel, which helps immensely in eliminating this problem.

Rolling over the tube: this is the process where you use a round-over bit to burnish over the end of the tube to grip the step-down milled in the mandrels. This can be accomplished on the lathe by using a rounded-over bit that easily burnishes the tube.

Fig 4 – Rolling over the NS Tube end in a lathe

Mandrels: the steel rods that form the inside diameter of the tubing. The mandrels should be precision ground for both size and roundness. As I will mention again, shinier, is not better. Polishing the mandrels will cause the surface to not hold lubricant and will drag on the smooth NS tube. The raw mandrels can be obtained in .001” increments. The steel rods available from MSC, J&L and Travers are in increments of .0025 - .003 millimeters. They may be acceptable for some sizes of tubing. We discovered that a 20% step-down turned or ground into the end of the mandrel gives enough grab to pull the NS tube through the dies. It also gives a constant diameter to grab with your draw bench jaws to pull in a straight line. We had a 3” step ground on one end of the 3’ mandrel. You may want to also grind or turn a small step-down on the opposite end of the mandrel to grip with your jaws when pulling the mandrel out of the NS tube. If you grip the finish diameter of the mandrel with the jaws, they will dig in and kick up burs that prevent slipping the die down the mandrel for pulling out the mandrel.

Fig 5 – Rolled NS Tube and Step-Down Mandrel

Jaws: the mechanism by which you hold the pointed NS tubing, or in our case, the mandrel. Several designs will work. It has been suggested that even a 3-jaw chuck may work. However, the jaws are a key component of the draw bench. Alignment with the die is a critical factor in draw bench performance.

Fig 6 – Split Cone Jaw Set with Holder

Lubricant: a mineral oil/wax mixture or commercial lubricant available from Castrol, Safety Draw 722X Cutting Lubricant is available from MSC. You can also use a product like lard or Ivory Soap shavings and water slurry.

Fig 7 – Drawing Lubricant

Draw Bench: the basic machine for drawing tubes through a die. It is a simple mechanism consisting of a die holder and a gripper attached to a sled that is pulled straight along a bed. Several methods of pulling are chains, like a bicycle or motorcycle chain, Acme threaded rod through a nut, or a hydraulic ram. Something even as simple as a cable attached to a take-up can be used if it will pull straight. The sled needs to have something to guide it; rails or linear bearings can serve the purpose. You don't need a lot of power; the motor on my draw bench is 1 hp at 1725 rpm that is stepped down to turn the Acme screw at a constant speed. Stepping the rpm down gives additional torque. My draw bench pulls at a rate of 28 inches per minute. There is a micro switch that shuts off the motor to prevent pulling the sled into the end of the frame or acme screw. The frame simply holds everything.

Fig 8 – Draw Bench

<u>Arbor Press</u>: most arbor presses of 2 ton rating and higher will work just fine. The reason you want 2 tons or more is because the throat (working area) of the arbor press is larger. A three ton press is ideal, usually having a throat around 10”-12”. You will need to have a die holder that centers the die under the ram.

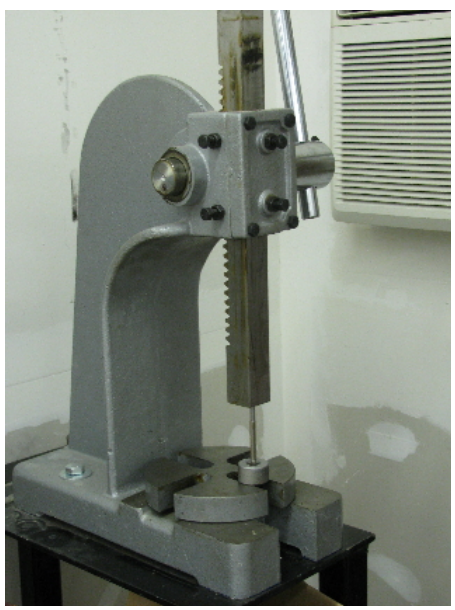

Fig 9 – Arbor Press for Pushing Tubing

<u>Annealing the Tube</u>: this is the process by which you soften the tube. You heat the tube to about 1200 – 1300 degrees and heat-soak several minutes and then let it cool down. It causes the molecules to become unaligned. After annealing, you will need to clean the tube, normally done

with an acid bath. A 20% Sulfuric acid solution does this quickly. The tube will be shiny again after the acid bath and the tube will be soft.

Swaging and Pointing: if you choose not to use the step-down mandrels you need to get the NS tube through the die opening. Since the die opening is 1/64th smaller than the NS tube's OD, you have to swage it. This process is called spinning and you are “pointing” the tube. Initially I had to manually swage the tube to point it. This is not an accurate process and it resulted in banana-ing despite my best efforts. It also wastes the portion of the tube that is pointed, usually a couple of inches. This is the method Dickerson used. By rolling the NS tube-end over and using a step-down in the mandrel, you waste less than ¼ of an inch.

Drawing Process

A word of caution: drawing NS tubing is not a clean process. The drawing lubricant will get everywhere -- hands, tools, etc., so wear old clothes. The lubricant is easily cleaned off your hands when you finish. Wash your hands with GoJo Orange Brite type hand cleaner, a combination of pumice and orange cleaners.

The process of drawing the mother tube down begins when you select a target tube size. You want the last pull for the female tube to be done with a mandrel. We normally pull down in 1/64th increments, alternating using a mandrel and without a mandrel.

I first choose a mandrel two sizes smaller so the first pull is equivalent to not using a mandrel, since it is undersized and is just pulling the tube through the die without it being ironed. The second pull utilizes the mandrel and the tube is ironed on the inside.

One word on mandrels: again, shinier is not better. Prior to use, I use gray Scotchbrite pads to both clean and dull the finish to give the lubricant a surface to adhere to. Lubricate the mandrel prior to putting the NS tube over it.

Select the tubing you want to start with and cut to a starting length. I like to start to draw pieces that are only around 12” – 15” long. Remember; as you draw down it in size, the tube will lengthen. My mandrels are roughly 30” with a working length of approximately 26”. Remember to allow for the growth in length. If you are drawing down to a small size, cut a shorter piece to start with.

First, spin a point on the NS tube end so the mandrel step-down will pass through the spun end. If you close the end down too much you will need to drill it open, so I keep a drill bit chucked in the tailstock, just in case. Make sure you have good contact with the mandrel. This is sufficient to pull the NS tube through the die. The force required to pull it off the step-down is more than required to pull it through the die.

Now lubricate the outside of the NS tube and feed the mandrel and tube through the first die size, normally 1/64th smaller than the OD of the tube. Attach the jaws to hold the mandrel.

Pay attention to center the mandrel in the jaws. This is critical if you want straight tubing and not curved (banana-ing).

Fig 10 – Carbide Die Set with Mandrels

Once the mandrel with NS tube is in place, turn the motor or crank the handle to pull the mandrel and tube through the die. This first draw reduces the tube to the next smaller size. It does little to harden or thicken it. Now remove the mandrel and NS tube from draw bench jaws.

Fig 11 – Drawing NS Tube through a Carbide Die

Next, remove the die and switch to the next smaller die. Return the draw bench jaws to the start position. Again put the mandrel with NS tubing through the die and clamp it with the jaws. Check for proper center position and pull through again. This time the NS tube will harden because it is pressed against the mandrel.

If the mandrel does not readily pull out, reverse the mandrel and tube and using a die just a few thousandths over the mandrel size and use the draw bench to strip the mandrel out of the tubing. I normally use my old steel dies for this process. Stripping plates can be made out of steel to accomplish the same thing. You place the die or disc over the mandrel and slide it down until it touches the tubing. This is the reverse of what you previously did. Grasp the mandrel with the jaws. Again, once you have determined the length of your draw bench and trimmed the mandrels to that size, I recommend that you put another step-down on the back end of the mandrel to give your jaws a place to grip. If the jaws grip the working surface of the mandrel, they will bite in and kick up burs that will prevent sliding a die or draw disc over the mandrel for pulling it out of the NS tubing.

If the tubing has a banana shape then there are two primary causes: the first is not having a concentric die opening. With the carbide dies, that issue has been eliminated. The second cause is in the draw bench. Look at the alignment of the center of the die with the jaws. Examine how you are gripping the tube and mandrel. With the step-down mandrels we have eliminated the swaging and pointing issues. Lastly, make sure the draw bench is pulling in a straight line, perpendicular to the die axis. If the die is cocked at an angle to the pulling line, then banana-ing will occur. With a tuned up draw bench you should have little trouble with curved tubing. If you do have a slight curve, the tube is perfectly usable. You can roll it out just like rolling out a bound up rod blank after gluing. Cleaning the tubing prior to or during ferrule making is easily done with denatured alcohol, acetone, lacquer thinner, or other solvent. If you don't want to use these solvents, I have found that you can also use something like "Purple Power" found at automotive stores. "Mean Green" household cleaner used with water will also do the job. We have also found out from Drawn Metal Tube Company that you can use animal fat based products and they will clean very easily with Dawn dishwashing liquid. Remember, the lubricant is simply an agent that allows the tube to be easily drawn. It is just messy to use.

This completes the introduction to Drawing NS Tubing. Once you do it, you'll discover it is a simple and straightforward process. I recommend that you do the following: do a series of practice pulls and record your results. Also record your starting length and the length you end up with for each die and mandrel. Having this documentation will serve you well. It will also form the basis from which you can tune your mandrel and die sizes in the future. Record this information on a reference chart that you can refer to each time you draw NS tubing.

In summary, you now have the basic information to give you total control over drawing NS tubing for making ferrules. You have NS tubing drawing knowledge that has taken many years to accumulate and was held by a few elite rodmakers. Now you can join that fraternity. I encourage you to experiment with wall thicknesses that will make fitting ferrules easier. Experiment with ferrule design and proportions to achieve the look you want. You will also find that you can make an incredible number of ferrules from very little NS tubing. It is the one part of rodmaking for which the cost savings are incredible. In addition, you will have ferrules superior to commercial ferrules. Ferrule making requires only basic machine skills to achieve outstanding results. Good luck in your new journey.