The Ring Thing

By Paul Novorolsky [Scholarship payback article]

Introduction

I recently had the privilege of receiving an UMBA scholarship to attend a class at the New England School of Metalwork in Auburn, ME. The class title was Fundamentals of Blacksmithing, Level 2 “The Ring Thing” taught by Mark Aspery.

I consider myself an intermediate level. I had wanted to take a course that challenged my skills, and this course fulfilled that desire.

It covered both design and practical aspects of making “The Ring Thing”. The design work included determining how to create the tools, as well as how to approach forging a series of pass-throughs. The “Ring Thing” in and of itself has no real utility. It can be included as an element in a larger piece, but it is otherwise little more than an ornament. Nonetheless, forging and assembling one requires some skill and understanding of the materials and principals of blacksmithing.

We learned to plan the pieces and the work, as well as to calculate the amount of material and where to place our tooling. We learned how to make and adjust the tooling, as well as anticipating and accommodating some challenges. Some of the techniques learned are covered in this series of articles. In a few cases, there may be better ways to solve some of the challenges in assembling a piece like this. But some of the techniques we applied were new to many of us and perhaps weren’t what might otherwise be a first choice at approaching a new assembly. But if we look at this project from the point of view that it was a vehicle to demonstrating and teaching these techniques, we can more readily accept and add these skills to our repertoire. This gives us more options in solving future challenges.

In several of the following examples, drawings were used instead of photographs, as the sketches conveyed more detailed information and dimensions. The free Google Sketchup application was used for all generated CAD drawings.

Tooling

I’ll cover the tooling we made before I describe the use of tools. The selection of the sizes of the tools will also be discussed later. This section will focus on the actual fabrication of the tools.

Swages

The project required 3 swages: A half round bottom swage to hold the ½ inch round stock to avoid excessive deformation while punching, and a matched pair of top/bottom ‘V’ swages for shaping the sides of the square punched holes after drifting. Many of us made a 4th bottom tool, a simple block used as a “narrow” anvil surface, and also for scarfing before forge welding. This allowed us each to customize the radius of the edges to our own liking, without modifying the school’s anvils.

I must admit that prior to seeing this done, I felt making bottom tools like this was much more difficult than it actually is. While it is labor intensive (swinging that big hammer), it is not really all that difficult. We used a bottom swage to upset our tools to save wear on the anvils. Old anvils may not hold up to the stress of the heavy forging. I have seen hardy tools made directly in the anvil, but I would be wary of mass producing them in my good anvil. A home built swage such as this is described in Mark Aspery’s first book “Mastering The Fundamentals of Blacksmithing”.

Figure 1

The upsetting swage we used at the school is shown in Figure 1. It was made by the school staff, and had an interesting adaptation. There were two handles welded on the sides so that the swage could be chained onto an anvil. This made a very stable and well supported base that worked very nicely for this task.

All of our swages are started in the same way. Start with a 4” piece of 1.25” square mild steel. The swage is first drawn to a short taper, mostly over the horn of the anvil to speed up this process. The length of the taper should be about 2½+ inches, and be drawn to about 5/8” at the end. This will leave just under 3” of unforged stock. The measurements here are approximate, and precision is not extremely important.

The tapered stock is then heated in the coal forge for upsetting. It is placed in the forge so that the bottom of the swage is at a higher heat than the top. The intent is that the bottom of the swage will upset more than the top at this stage. The blank is inserted into an upsetting swage (we used a 1” in square hole). Despite this strategy, the block will not upset uniformly, and it will be necessary to dress the sides of the swage during this process to keep it in shape. If the block gets out of square, 2 sides should be made parallel before squaring up the remaining 2 sides.

The final size of the “top” of the swage should be about 1 7/8” square, and about 1 ¼” tall. The “tall” dimension is more important than the surface area for these tools, as there must be sufficient thickness to drive other shapes into them, and still have them adequately support forging with them. Following final forging all of the swages were case-hardened with “Kasenite” hardening compound to increase their durability.

Half Round Swage

The half round swage is made with a ¾" round bar driven into the swage blank to make the half round depression. The ¾" size provides plenty of clearance for a ½" round bar. When forcing the bar into the swage, start at one end, holding the round bar at near a 45 degree angle at the far edge. This will reduce the surface area of the hammer blows transferred to the swage, and therefore improve the penetration of the blows. Once some depth of the far side is established, something less than 3/8" deep, start to drop the ¾" bar closer to flat. Carefully transfer the line of the swage to the near edge, and drop the bar and mark the near edge. Drop the bar further to about a 45 degree angle, and repeat the forging as was done on the far side.

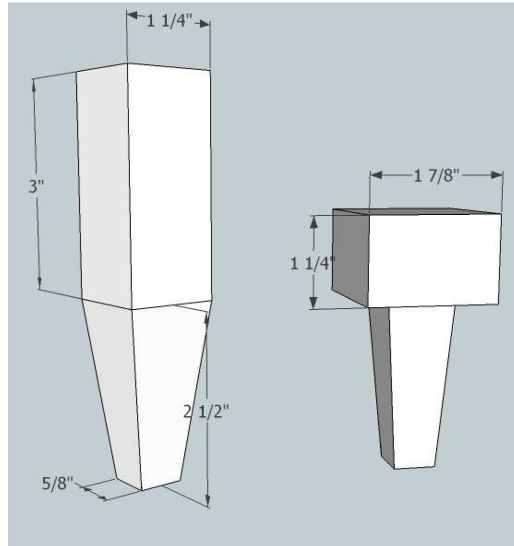

Figure 2

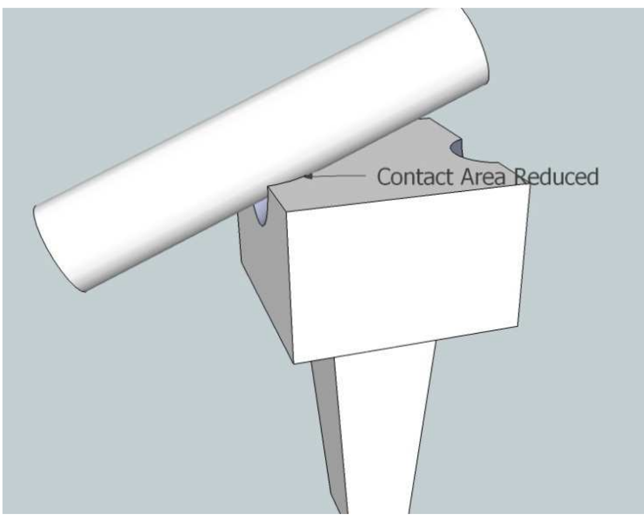

Figure 3

At this point, the swage will have 2 depressions which are in line with each other, sort of as if a lazy "U' had been driven into the corners of the swage. We now need to join these two depressions so that there is a single half round in the swage. To reduce the amount of effort needed, continue to use bar at an angle that becomes shallower and shallower to "walk" the forging into position. At each blow, the round bar will only be in contact with a small area, concentrating the force of the blow onto that small area. Trying to simply muscle the ¾ inch bar into the swage takes a great deal of unnecessary effort.

Once the half round is formed, the edges need to be relieved to avoid galling any work. There is no need to keep the sides of the swage dressed while forging the half round depression in the swage. All sharp edges are to be avoided.

"V" Swages

The project requires 2 "V" swages. One of these will be a bottom swage; the other will be given a rod handle and used as a "Top" tool. These tools are made in the same manner as the half-round swage. There are, however, a couple of differences, other than the shape of the tool. A piece of ¾" square bar was used to create the "V". The square is held on the diamond, and must be positioned so that the top edge remains in the center directly above the bottom edge. Any off-center rotation will result in a non-symmetric "V", with one leg longer than the other. In the class, most of us used the hydraulic press that was available to us.

Be mindful of the depth of the ‘V’. It must be deep enough to shape the outside of the square bar after it is drifted, but if it is too deep, it won’t contact the surface of the drifted bar.

When making the top swage, the swage blank should have a slightly shorter taper than the bottom tools, ending with a heavier end. This will be needed to absorb the heavy hammer blows on the top of the tool. The mild steel will deform under the hammer blows. If a harder steel is used, the hammered end should be annealed so that it doesn’t shatter under the hammer blows.

A ½” fuller was used to cut into the stem near the transition to the body of the swage, and wrap a ¼” rod around it to serve as a handle. We used a piece of ¼” round, about 40” long. Take a heat in the center of the ¼” bar and wrap it around the swage twice, but so it completes the wrap on a corner of the swage. Place the rods in a vise, with the swage about 2” inches above the vise. Twist the swage about 2 revolutions to tighten the rods around the swage. The rest of the handle can be shaped to your liking. In our class, we twisted the rods together a second time, in a similar fashion, about 2/3 of the way up the remaining length, and forge welded the loose ends into a closed loop.

Punches

Two punches were made from a 7” length of ¾” round 4140 stock. The punches were made as described in “Mastering the Fundamentals of Blacksmithing”. The struck end of the tool was given a very slight taper by bringing the round to a lazy square, and then bringing the end to an octagon shape. A video of this process is also available on YouTube.

Approximately 1 ½” from the end of the tool, an index depression is forged to help align the tool during use. The end of the tool is then filed so make a slightly crowned surface. The working ends are forged to a slight oversize, so that after hardening, the tool can be ground to final size, removing any decarburized material at the surface. The forged ends will be 9/16” x 3/16” and 3/4” x 3/16”. The taper continues from the tip to the index mark. The final grinding will bring the 3/16” dimension to about 1/8” inch.

Figure 4 Punches and Drifts

The orientation of the punches is to be 90^{o} to the index mark. This way, the index can easily be held so that the punch is in line with the bar being punched. The axial corners (those corners running parallel the long body of the tool) are broken, so that a sharp corner is not cut into the bar, creating a stress riser during use.

The punches were brought to critical temperature and annealed in vermiculite overnight prior to hardening.

Hardening and Tempering

The next day, the tools were brought back up to critical temperature, and then the lower inch of the tip is quenched in water. The piece is to be moved around during the quench to prevent forming a steam envelope, which would interfere with quickly cooling the tip of the tool. Care should be taken to keep heat in the remainder of the tool, as this residual heat will be used to temper the hardened tip.

To temper, the surface scaling should be quickly removed with a piece of abrasive stone. Keep the tool off of the anvil at this point, as the anvil will draw the needed heat from the tool. Watch the colors of the forming oxide layer run to the end of the tool. When the color becomes a "bronze", immediately quench the tip again. Once again, polish the surface of the tip, and let the color again run to bronze. Repeat this process until there is no longer sufficient heat to draw color. Set the tool aside and let the remainder of the steel normalize.

Once the punches are cool, carefully grind to final shape and size, being careful not to overheat the tool and destroy the temper or hardening.

Drifts

Two drifts are required for the ring thing. A round drift to size the holes in the square bar for the ring to pass through, and a square drift for the piercing center bar to pass through. The square drift was made from 4140, but the round drift was made from mild steel. (a tougher steel is preferred for the round drift, but there was none available.)

As is commonly accepted, the drifts are tapered at both ends. The leading taper forms the hole, and the trailing taper, which must be longer than the thickness of the material drifted, allows the drift to fall through the hole when drifting is completed.

The square drift was made from a 7" length of 9/16" square 4140. This piece was not hardened, but allowed to normalize after forging.

The tip of the square drift is a critical component at this stage. As the drift is hammered through the hole, edges near the tip will need to line up and register with the edges of the punched hole. If these are out of line, the drift will not track squarely in the hole, and the drifted hole will be "racked" into more of a parallelogram than a square.

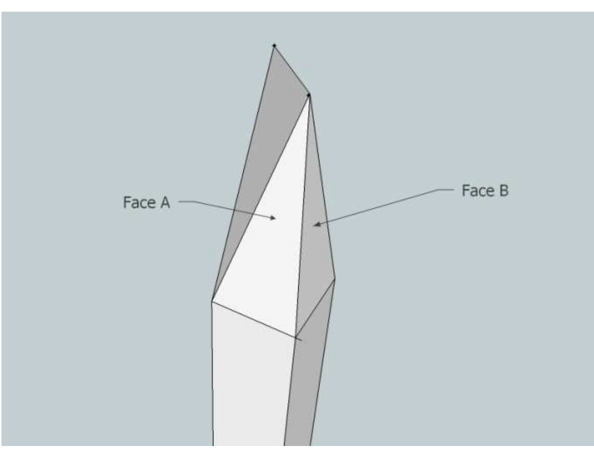

Figure 5

To make the square drift: draw an even taper about 1.5" in length that closes to about 3/8" square at the tip. It is critical that this 3/8" section is quite close to square. It will be brought to a chisel edge on the diamond and if it is more rectangular than square, the resulting surfaces (shown as Face 'A' and Face 'B' in Figure 5) will be unequal, making it impossible to drift a symmetric, square hole.

Once the initial taper is complete, turn the drift onto the diamond, and carefully forge the tip down to a blunt point (about 1/16" thick). Examine your work to see how close to you came to getting Face 'A' and 'B' (on both sides) to equal.

Some filing is expected to bring the 4 faces into symmetry. Once that is complete, forge the short taper on the struck end, and file the hammered end surface into a slight crown. The remainder of the drift should be filed smooth to reduce dragging friction as it is driven into the punched hole, and to relieve the corners so there are no sharp edges.

For the round drift, we began with a 4” piece of ½” round bar (Hot rolled A-36) and isolated a heat to the approximate center. The drift was then upset with just a few hammer blows, so that the upset was in the middle of the bar. About 1 inch of the struck end was then tapered, and then the leading edge was tapered to a flat taper about 1/16” x 9/16”. This would then easily fit into a punched 9/16” slot to drift it for a ½” round bar.

Figure 6

Sizing

Drifts must be forged slightly oversized to account for the expansion of the metal while hot. The drift itself will be slightly smaller when it cools after forging, and the hole that is hot drifted will also contract a small amount as it cools. The drift therefore must pre-adjust for 2 levels of contraction. Trial and error is an adequate technique for the final size of our drifts. Meaning that, after the initial forging to the expected size, we would test the drift, and file to size until we found the size that worked for the application. The finished thickness of my square drift (after filing) is 0.550”. Round drift is 0.560”, both measurements were taken after all fitting and filing.

Note that in addition to the oversize for contraction of the metal, the round holes need to be slightly oversized to accommodate the arch of the ring as it passed through the hole. From Figure 7, which shows the two pieces in a cross-section, you can see that in order to pass the ½” round bar shaped into a 3” inside diameter ring through the ½” square bar, the actual clearance required is just under 9/16”, so a 9/16 drift will produce a properly sized hole.

The measurement in Figure 7 was taken directly from Sketchup, so its accuracy is subject to my drawing skills. Hopefully, it conveys the point that the hole must be larger than the simple diameter of the bar passing through it.

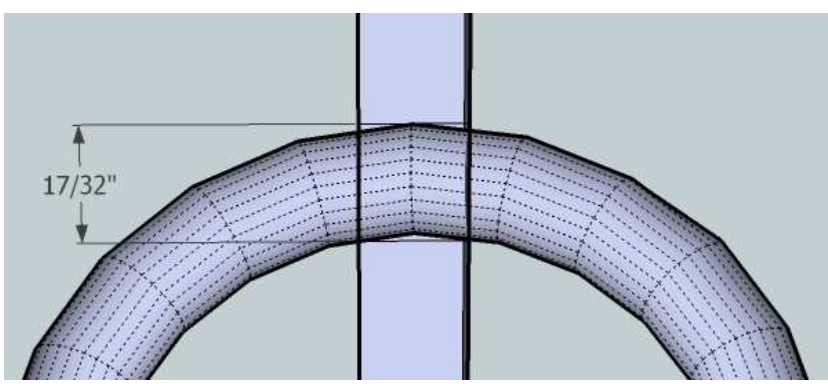

Figure 7 Cross-section of ½” round through ½” square

Similar considerations need to be made for the square bar passing through the ring. The hole is punched and drifted before the round bar is bent into a ring. Then on bending, the inside surface is compressed making the inside hole slightly smaller, and the outside diameter surface is stretched, making the outside hole slightly larger. In order to avoid making additional drifts, a slightly undersized 9/16" square drift was selected. The holes in the ring are re-drifted after the ring is formed, so we remain with a drift that is slightly under 9/16" at its widest point.

Both drifts are tested with sample pieces and adjusted so that the bars pass thru with sufficient clearance for assembly, yet tight enough so that the fit is not excessively loose. Note that the square holes in the square bar are further shaped between the top and bottom tool to their final dimension. So be sure to have those tools available while adjusting the square drift.

Bolster

A small square-holed bolster was made to support the stock while drifting the square holes. This is more of a concern with the holes punched in the round stock, where this is less material to support it than with the holes in the square bar. Nonetheless, the bolster is useful for both pieces.

The size of the bolster must be slightly larger than the size of the square drift, so that it can pass through the bolster without interference. This amounts to "3 increments of oversize" when the bolster cools. The drift is already 2 increments over-sized, so the bolster needs to be an additional increment to allow for a non-binding fit around the drift, plus an additional amount to accommodate the contraction upon cooling.

So if the square drift is slightly oversized when first forge (before filing), it can be used to drift the bolster before it is filed to its final dimension. Some additional filing may be necessary on the bolster, but this will get you close.

We started the bolster by drilling a ½" square hole in a piece of ¼" plate, approximately 3"x3".Then the oversized square drift is used to drift the hole. Take care to get the corners of the drift aligned so that the corners are closely aligned to the horizontal and vertical axes, as this will make it easier to line up the close-fitting bolster during use, while the hole is obscured from view. Relieve the edges on the hole in the drift to further avoid any binding as the bolster aligns with the drift.

Scrolling Wrenches

The scrolling wrenches we made are also described in "Mastering The Fundamentals of Blacksmithing", and a video of the process can also be found on YouTube. I'll describe them here, as the YouTube demo leaves out the calculations and dimensions. The book devotes an entire chapter to this process, so this is quite abridged. Nonetheless, I believe this description, together with the YouTube video will be sufficient to produce these wrenches.

Begin with a 24" length of ⅜" x 1" bar. This should be enough material to make 2 wrenches, one from each end. The "fork" end is formed first, and we need to determine the amount of material to isolate.

In Figure 8, the top representation shows the dimensions of the end. We will calculate the volume of material needed. The total length of 7/16" by ½" material, which is from "Point P" to the end of the bar, is: $1\ \frac{3}{8} + \frac{1}{2} + \frac{1}{2} = 2\frac{3}{8}$

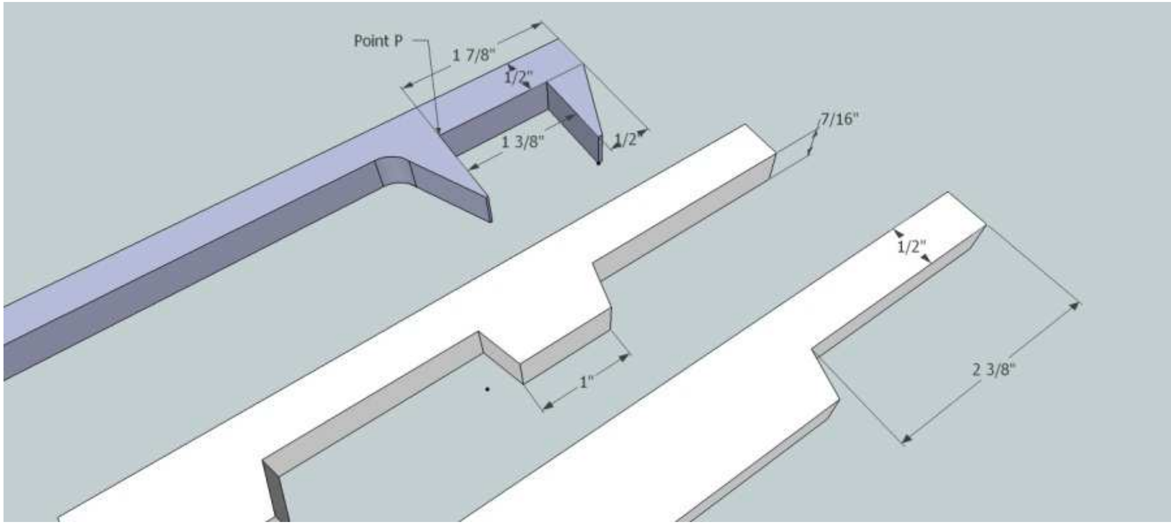

Figure 8

Multiply that by the area of the cross section: $2\frac{3}{8} * \frac{7}{16} * \frac{1}{2} = \frac{133}{256} = 0.519\ in^3$. Then to determine how long of a section of the 3/8" x 1" stock to use, divide that by 3/8". So you have $.519\ \div\ .375 = 1.384$ or a little over 1⅜". I used 1½" because it was easy to mark and forge and "close enough" here.

So lay about 1½" on the anvil, take a couple of half-faced blows and draw out the isolated material to approximately 7/16" x ½" and about 2⅜" long. It should look like the far right/bottom representation in Figure 8. Next lay about 1" of the unforged stock off the far side of the anvil, and forge it down so it is similar to the piece in the center.

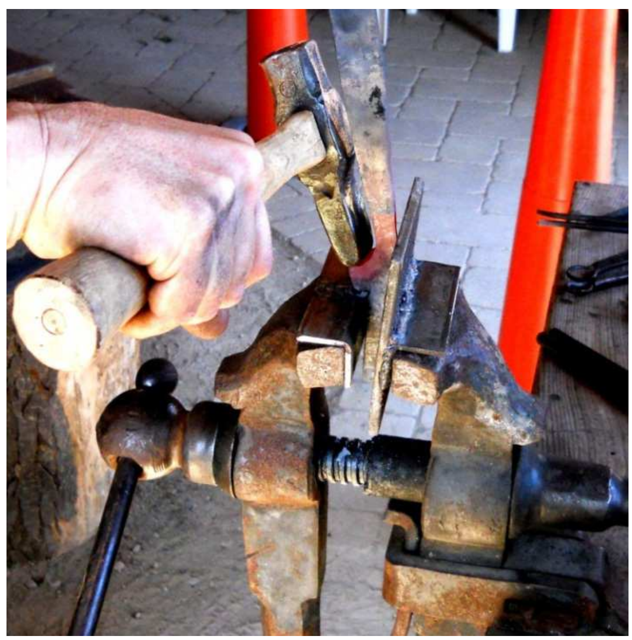

Figure 9

Figure 9 shows forging the inside tine. To do this, a vise insert is used. The insert is made up of a piece of angle iron on the front jaw, and a backing plate welded to another piece of angle on the back jaw. The backing plate supports the work piece while using a fuller to forge down the isolated blob into a tine.

Be sure to dress the tine as work progresses so that the inside edge is always tight against the front jaw insert. Otherwise you run the risk of a cold shut here.

Cones

The rings are shaped around a frustum of a cone. A frustum is a truncated cone, in this case with the “top” removed. The use of a truncated hollow cone makes it easier to use the dog wrenches to pull the ring around cone. In addition, the small cone segment then allows cutting channels into the sides to accommodate the bar it passes through.

The top of the cone must be small enough to allow the ring to slide over, and the slope will accommodate any differences in size of the ring. For this exercise, we make a cone that is about 3” outside diameter at the top and about 4” inches at the bottom. The diameter of the ring is about 3 5/8” at its center, which makes the inside diameter about 3 ¼”, so it should easily fit easily over the top of the ring.

To calculate the material for the ring, we will start with the midpoint of the outsides surface of the cone, which will be a 3½” diameter circle. Then to account for the compression of the inner surface and stretch of the outer surface, we will calculate based on the center of the material. Since the material is ¼” thick, we subtract 1/8” from each side of the diameter (or ¼”) to arrive at a diameter of 3 ¼”.

The circumference is $\pi * diameter$. We’ll approximate by using 3 for pi, making the length of material needed 9 ¾”. In order to shape the cone, the top diameter must be shorter than the bottom diameter. This can be achieved by first bending the stock the hard way. The inside edge will become the top of the cone, and the outside edge will become the bottom edge.

Next, draw the layout for the cone. This is done by setting up 2 parallel lines, separated by a distance that matches the width of the stock. In this case 2 1/4”. A center line is then drawn. From the center line, make a mark at half the small diameter of the cone on the top line. In this case, we mark at 1 ½”. Similarly, mark the bottom line at the radius of the larger diameter, which is 3 ¾”. Now use a straight edge that connects those two marks, and continue that line until it meets the centerline.

Take a length of string and a pencil or soapstone and using the intersection of the centerline and the line you just drew as the center, measure off an arc to each point where the centerline intersects the parallel lines, and sweep an arc so your sketch looks something like the right side of Figure 10. This is now the arc to which you will forge your cone segment.
As in the other components, there is a video of this procedure on YouTube.
Remember that, as the arc is formed, the inside edge will be compressed and “push out”, and the outside edge will be stretched and the corners “pulled in”. So, to keep the end “in line” with the radius, we pre-deform the ends so that after they move, they are in line with the center point. This is done by upsetting the inside edge, and then walking that taper to the outside edge

Take a good heat along one end of the bar, and hold it on the anvil so the long edges are horizontal, one above the other, and perpendicular to the far edge of the anvil. Now upset that corner along the long edge about 3/8”, so that the length of that edge is now about 9 1/8”. (No need to measure that 9 1/8, I only added that so it is clear which direction you are forging.) Dress the flat of the bar to maintain control, but there is no need to flatten the upset. We'll just leave that on the inside of the cone. Walk that upset to the near corner so that it forms an even taper.

Repeat this process on the other side. Be sure that both upset ends are on the same long edge of the bar! Also, try to move the upset to the same face, so that will become the inside of the cone.

Next, take a good heat over about 1/3 of the bar. Again place it on edge on the anvil, with the length of the bar horizontal and perpendicular to the far edge. Keep the far end on the anvil while you lift your tong hand so that the bottom edge of the bar is about 3/8" above the center of the anvil, and strike the top of the bar a short distance nearer the tongs, driving this gap onto the face of the anvil. Repeat this process while feeding the bar away from yourself, and you should get a reasonable curve. Reverse the bar end for end and repeat so the entire bar has an even curve. Check the bar against your layout. If you overshoot the curve and make it too tight, remember that you have effectively upset the inside circumference of the bar, and you can forge that edge back down a bit, which will stretch it and straighten the bar slightly.

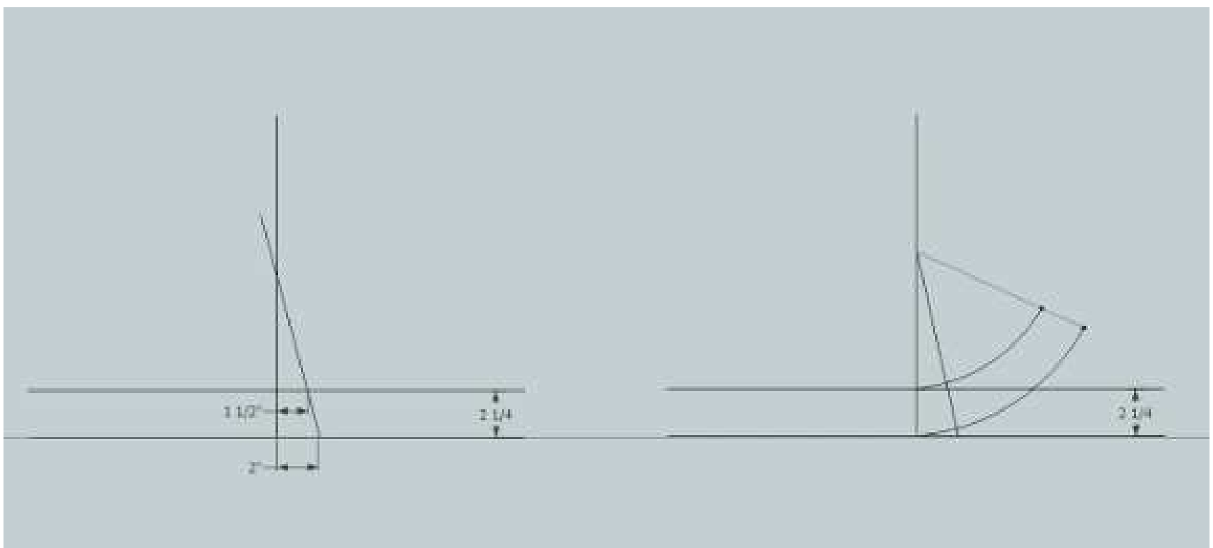

Figure 10

The next step will be to roll the bar into a cone. But before we do that, we need to pre-distort the shape once again. As the cone is rolled up, once again the inside surface will be compressed, and outside surface stretched. This will result in cupping. To avoid this, the bar must be "pre cupped" in the opposite direction. Heat the bar, and using a shallow swage, or possibly a log stump, forge the bar to create a shallow depression along the length, with the concave side on what will be the inside of the cone.

Once this is complete, take a good heat, and repeat the process used to bend the bar the "hard way", but this time bend it the easy way, with the concave surface from the previous step on the inside. This step is a little tricky, as you are basically shaping a circle freehand. To make the process less daunting, I found it helpful to draw a circle of the appropriate size on the layout drawing and test the piece against that. This helps make it easier to see where the adjustments need to be made. A pair of hoop tongs

(Figure 11) is also helpful in forging the cone, as it can then be held securely while shaping around the horn or on the face of the anvil.

Dress the cone as needed during the forging process and correct any deformities early. A small gap at the joint of the 2 edges is acceptable for this cone as we will be cutting clearance slots for the pass through bar. We used a plasma cutter to hurry things along in the class, but given my lack of experience with that tool, I think the cleanup consumed any time savings the cutting may have provided. Cutting with a hacksaw would certainly be adequate, and for me, preferred.

Figure 11 Hoop Tongs

Before cutting the slots, weld the cone onto a base, and add a short piece of steel angle or tube to the base so that the cone can be held in a vise or anvil hardy hole.

There are 2 slots cut into the cone, 180 degrees from each other. The slots are about ¾" wide, and about 2" or more deep. These recesses will accommodate the square bar while the ring is formed around it.

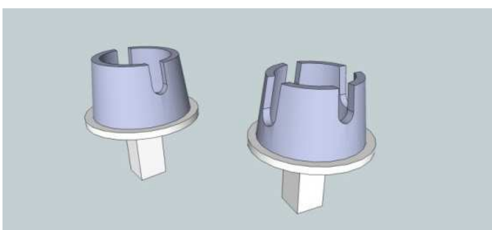

Figure 12

A second cone is also needed. This should be the same size, but have 4 slots. The second pair of slots will be perpendicular to the first. This will be used to true up the ring and re-drift the holes in the ring after it is welded. The first question is, "why not just use the cone on the right, and not make two?". The problem with using the second cone to initially bend the ring is, the additional holes make it difficult to anchor the dog wrenches as there is too much open space. Having 2 cones makes this much easier.

Chainmaker's Swage

A simple swage is made to simplify the welding of the ring. This is similar to a chain maker's swage. It consists for a 10" length of 1" square bar, bent to 90° in the hardy hole. The length of material within the hardy hole is about 2". Once you have this bend, with the long end of the bar laying on the face of the anvil, forge a ½" round half round into it. The half-round must be arched so that as the ring lays across it, the center of the ring is supported, but the arch of the ring is not galled by the edges of the swage.

The Ring Thing

The ring is about 3 5/8" diameter at the **center** of the ½" round ring stock. We'll do most of our calculations based on that number. The ring is pierced in two places for the ½" square bar to pass through, and the ring passes through the ½" square stock in 2 places. So the ½" square stock has 2 round holes to accommodate the ring, and one square hole, on the diamond to accommodate the central ½" square piercing.

While that sounds simple, the challenge is where to put those holes so everything lines up for assembly. Figure 13 shows the approximate measurement and placement of the holes. The drift for the square hole in the center is slightly less than 9/16", so the finished (and cooled!) hole will be slightly smaller than that dimension. Note the flats on the sides of the square hole. These were left flat, as there is insufficient material at the corner to fill it to make a point.

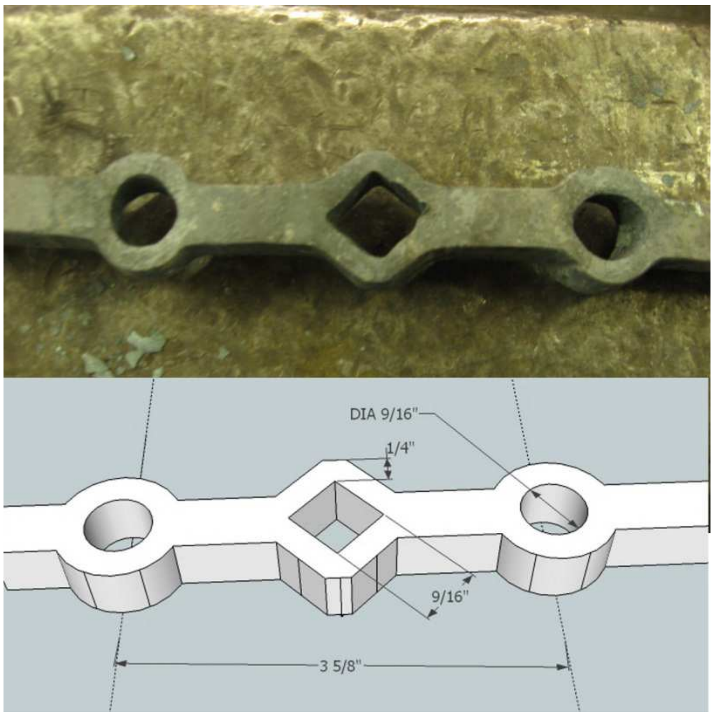

Figure 13

Ah, but maybe if we slit and drifted it instead of punching it, there would be enough material. Before we go there, consider that if there is no loss in the dimension from punching, the side walls would still only be ¼". The corner represents a diagonal across a ¼" thick wall. That diagonal is $1/4 \times \sqrt{2} = 0.35"$. So the diagonal is about 1/10" larger than the ¼" sidewall. Which means unless we upset the piece, it there isn't enough material to fill an outside corner there. There are some other alternatives, like forging the walls down, but that would also result in some lengthening. So we left our outside corners with the flats on the edge.

The round holes are also slightly oversized for the ½" round bar. The ring makes an arch as it passes through the hole. This requires more space than the diameter of the bar. (See Figure 7). The spacing of the round holes is chosen so the centers of the holes are slightly less than the 3 5/8" diameter of the ring. This dimension was selected so, if the placement is slightly off, it is easier to draw the bar slightly between the holes to make a correction, than it would be to upset a segment.

As for the ring, it will have 2 square holes punched on the diamond. The choice here was to punch and drift one of the holes before inserting the round bar through the square bar, and the second hole after assembly. Before punching both holes are laid out, and the ends of the bar upset and scarfed for welding. Note however that the holes will NOT be laid out in the same plane, nor are they equidistant from the center of the bar.

Strategy/Explanation

The ring is made from 11½" of ½" round bar. This will make a ring just slightly less than $3\frac{5}{8}$ " in diameter (diameter taken at the center of the round bar). Logically, to get the holes opposite each other, the distance between them should be the length of the bar minus the length of the 2 holes, divided in half.

We'll call the length of the 2 holes ¾" each, as that's the size of our punch. So $\frac{11\,½-2\left(\frac{3}{4}\right)}{2} = 5$" apart, near edge to near edge. Because we need to be accurate, we will mark our holes by marking an edge on which to align our slot punch. We could put it at the center mark then center our punch on it, but marking the edge will be more consistent.

There is one more thing to consider before marking those holes. This is the location of the forge weld in relation to the square bar that the ring pierces before the weld is made. The weld is performed with both holes punched and drifted into the ring. So the weld must fit between one of those holes and the square bar through which it passes. While we can slide the ring freely so that it rotates within the square bar, the thickness of the bar effectively shortens the exposed length of the ring. This works against us as we try to weld within that length. In order to give ourselves some additional working room, we offset the position of those holes so that there is a longer length of the ring available for welding on one end. We do this by marking a substitute center ½" from the true center of the bar, then make our measurements to this reference mark.

Figure 14

To complicate matters further, punching and drifting a hole along a radius is trickier than punching and drifting along a surface than can lay within our half round swage. Also, because our material is round, we can punch the hole "the easy way" and then twist the bar to put it in alignment. What this means though, is that we need to mark the second hole so that it is in a plane 90^{o} to the other hole. Then once the round bar is passed through the square bar, we punch and drift the second hole, twist the bar, and complete the formation of the ring, as is shown in Figure 14.

Layout

Round bar

On a 11½" long ½" diameter round bar, scribe or make a light mark at the center(5 ¾" from either end) then make a reference punch mark ½" to one side of that center. The end of the bar that is now further from this mark will be referred to as the LONG end.

Then we measure out 2½" from that mark and make a punch mark here for one hole. Then measure 2½" in the opposite direction, and scribe a mark here. Then rotate the bar 90^{o} around its axis and make a mark for the second hole. Be very careful with these measurements, as well as the placement of your punch when making these holes so that the edge of your punch results in holes whose edges are 5" apart.

Square Bar

The length of the square bar will be left unspecified. While we a minimum of about 8" to work with, having a longer bar makes it easier to handle, as tongs aren't necessary. A 24" length is convenient, and provides enough material to make a "ring thing" on each end, if you are doing something like practicing for a public demonstration of the piece.

We’ve established that the centerlines of the round holes should be $3\frac{5}{8}$” apart, and we can easily agree that the square hole needs to be centered between them. We’ve also established that the marks for the round holes will be on the edge of the punched slot.

Let’s consider which edge of the punch position to mark. If we mark the outside edge (the edge away from the center hole), the mark will be away from us when we punch the hole closer to us, assuming we are holding the long end of the bar. This orientation will make it difficult to easily see the mark, so we chose to mark the edges closest to ourselves. This means that one hole will be marked on the edge closer to the center hole, and the other marked on the edge furthest from the center hole.

Now we need to know where those holes are placed. The square hole is easy. Make a center mark about 4 to 5 inches from one end of the bar. This leave sufficient material so that the hole nearest the edge has sufficient material to support the punching and drifting. This mark becomes the center of the completed ring-thing. The square hole will be punched with a ¾” punch, so make a second mark ⅜” from the center mark, on the long side of the bar. This will be where we align the edge of the ¾” punch.

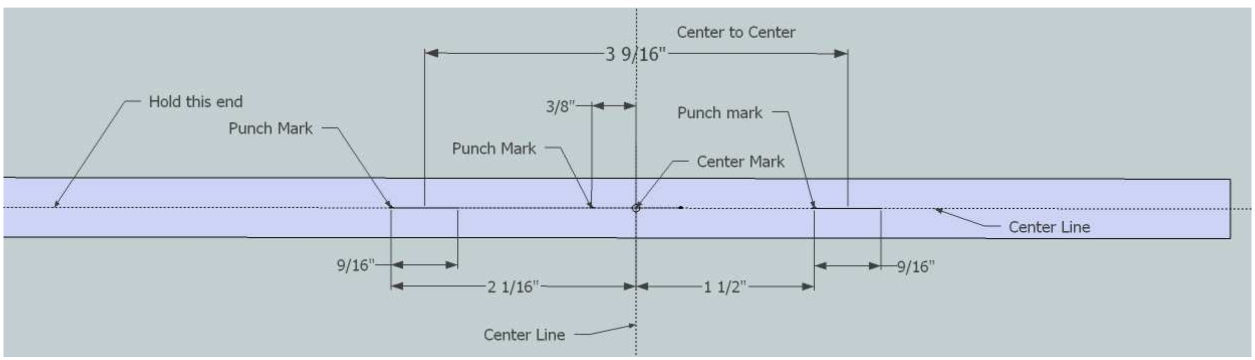

Figure 15

Measuring out toward the short end of the bar, we will mark for the first round hole. The ring centers are 3 5/8” apart. We will space our hole centers 3 9/16” apart, leaving a 1/16” for error, so we can draw the bar out slightly if needed. Drawing is easier than upsetting if a correction is needed.

Since the punch is about $^{9}/_{16}$”, the inside edges of the holes will be about 3” apart. This places the inside edge of the far hole about 1½ “ from the center. For the other hole, its inside edge will also be 1½” from the center, but we will be marking the opposite side, so we add the $^{9}/_{16}$“ for the hole, placing the mark at 2¹⁄₁₆” from the center, on the long side of the bar as is shown in Figure 15

Punching and Drifting the Holes

Before we start making holes, a few things need to be said. First, the *slit, upset and drift* vs *slit and drift* vs *punch and drift* methods were discussed. I should have taken better notes on this, but I’ll try to summarize the discussion from what I chose to learn from it. While all are acceptable methods, slitting generally seems to leave more “rag” in the center of a hole slit from both sides, where the metal tears apart. Of course, the slit is narrower, so less force is needed to drive it into the bar.

Punching provides more of a shearing cut when punched from both sides. We punched about half way through one side, and then finished the punch on the other side. This avoided the “flare” or spreading of the piece as the punch bottomed out on the anvil, and forces material to the sides of the punch, as well as allowing the hole punched in the first side to effectively become the bolster for the hole punched in the second side.

Punching from both sides this way took a little practice, but can be mastered fairly quickly. Having less rag in the center of the hole meant that the drift came into closer contact with the sides of the hole, and provided a tighter fit with the piercing bar without having to forge the sides of the hole back into position to compress the rag.

To punch from both sides, simply start the punch, and stop just short of half way through the bar. Then turn the bar over, there will still be a slightly dark spot under the punched area, and there will be an easily recognized bulge. Center the punch in this bulge, and punch through. Try to complete the punch at a lower than red heat, which will help shear the biscuit, rather than stretching and tearing. A few practice holes were needed to gain confidence in locating the hole on the other side. But once you get it, you’ll have a valuable skill.

When punching, we were taught to align the long edge of the punch along our line of sight, and beware of shadows. With even lighting, this orientation makes it easier to center the punch. The first blow should be somewhat light, to mark the position. Remove the punch, and if the hole is not where you want it, now is the time to correct it. Once you have the hole marked where you want it, proceed with heavier hammer blows. There are times when you will need to punch with the long edge perpendicular to your line of sight (even in this project). Extra care must be taken when starting the punched hole, as it is much easier to get it started off-center in this orientation.

Because the tips of the punches are fairly thin, they heat up quickly. So it is important to hold to the “3 strikes and out” rule. That is, no more than 3 hammer blows to the punch, then quench the tool tip to cool it. Be sure to tap the punch to remove any excess water before resuming punching. The water will not only cool the work, but it can also create a steam explosion as it comes into contact with the hot work piece.

Square Bar

Punch and drift the 3 holes in the square bar. The far round hole is punched an drifted first, as the end of the bar is stiffer before the other holes are cut and shaped. I made both round holes first, then the square hole. A bolster was not needed for the round holes, as the pritchel hole was close enough in size that it adequately supported the bar during drifting. If your pritchel hole is too small for this, a bolster plate may be needed for the round holes.

The square hole is punched, then drifted using the bolster plate so that the drift does not pull material down into the hardy hole. After the initial drifting, the piece is reheated, and the drift inserted in the square hole. It is then forged between the 2 ‘V’ top and bottom swages to dress the sides of the square hole. Forge one side in the swage, then rotate the piece so the other side is up and forge again. The “point” of the hole’s side will not be prominent, so it should be flattened to make it uniform and pleasing to the eye.

After both round holes and the square hole are punched, drifted and forged, the square bar should closely resemble that in Figure 13.

Round Bar

Before punching the round bar, the ends should be upset and scarfed in preparation for the forge weld. Be careful to keep the upset to a size that will pass through the round holes you just drifted in the square bar. Test this fit as you upset the bar. Also note that the scarfs will need to be at 90^{o} to each other. The scarfs should be oriented so that the flat of the scarf is parallel to the axis of nearest hole (See Figure 14). Remember, one side of the bar will be twisted 90^{o} after punching and drifting.

Punch and drift the hole at the LONG end of the bar, using the half-round swage to support the bar and prevent a flat spot. Punch halfway through, then turn the bar over and carefully align the punch so that it is centered on the slight bulge that now appears in the bar. Drive the punch through the bar. When you feel the punch begin to bottom out, the slug should be loose. Move the bar over the hardy hole and knock out the biscuit. The second hole will be punched later.

Forming the Ring

After punching and drifting the one hole, it’s time to start bending the ring around the 2-slot cone. As there is a hole in the bar, this section will be weaker than the solid bar. So an attempt to bend it as it is will result in a sharp bend at the hole. To avoid that, a short piece of ½” square is inserted into the hole just prior to bending.

Take a long heat on the LONG end of the round bar. Then insert the piece of ½” into the square punched hole, and place the round bar against the cone with the square bar passing through the slots in the cone. Then, using one of the dog wrenches, anchor the bar to the side of the cone. Use the other wrench to gently bend the bar around the cone. Try to keep the ring fairly straight at this point. Take additional heats as needed and continue bending until the ring is slightly more than 180^{o} in arch. The ring will be inserted into the square bar before more work is done, and having more than 180^{o} of arch will help hold it in place as shown in Figure 16. The punch mark for the second hole can also be seen in the photo. The round bar twisted a small amount while bending. The slot will be punched perpendicular to the anvil’s face and not directly on the punch mark in this case.

With the ring passing through the bar as shown, punch and drift the second square hole in the round bar. The positioning of the bar so that it is stable in the bottom swage is a bit challenging. A third hand makes this easier. One suggestion was to turn the bar so the punched segment is parallel to the length of the anvil, and set the ¼” bolster under one end to hold it more or less level in the swage for punching, while holding the square bar between our legs. This had the disadvantage of now punching with the length of the punch across our field of view, making it more difficult to center it on the bar. A third hand here avoids this situation, and really does make this maneuver much easier.

With the second hole punched and drifted, it needs to be twisted so that the hole is in line with the radius of the ring. Heat the end of the bar and quench it to the hole, so that the hole is now cold, and will be protected against deforming. Place a piece of ½" square stock in the hole and carefully twist it so that the scarf will line up with the scarf on the other end.


Figure 16

Reheat the end of the bar, and return to the 2-slot cone and carefully bend the rest of the ring around the cone. Be cautious around the punched hole so that it does not over bend, and be sure to align the ends so that the scarfs in properly positioned for welding. When you are generally satisfied with the shape of the ring, manipulate the ring so that the scarfs are positioned so that they can be accessed for welding.

Bring the scarfed area up to heat and flux. Get the chain-makers swage ready, and bring the scarfs up to welding heat. Use the swage and horn of the anvil as you see fit to perform the weld and dress the weld and the rest of the ring to reshape it to round. Return to the slotted cone to shape the ring. Once the ring is reasonably round, use the 4 slot cone to re-drift the square holes. The hole in the center should not need to be re-drifted, but the holes in the ring were likely distorted in the bending and welding processes. The drift should only be driven from the outside of the ring toward the center. Avoid any temptation to drive the drift through the entire piece and out the other side. This will allow the cone to support the area around the holes, avoiding distorting the ring.

All that is left is to insert the remaining square bar though the center holes to complete the ring thing. While careful layout will get the holes close to alignment, there is sometimes some additional adjustment needed to get the fit. Much of this can be done on the "castle" cone. I'll leave the final adjustments for personal discovery, as I'm still learning the many things that can go wrong on the way to making "the ring thing".

I can be reached via the UMBA website (http://umbaonline.ning.com/) member's page if you have questions or constructive comments.