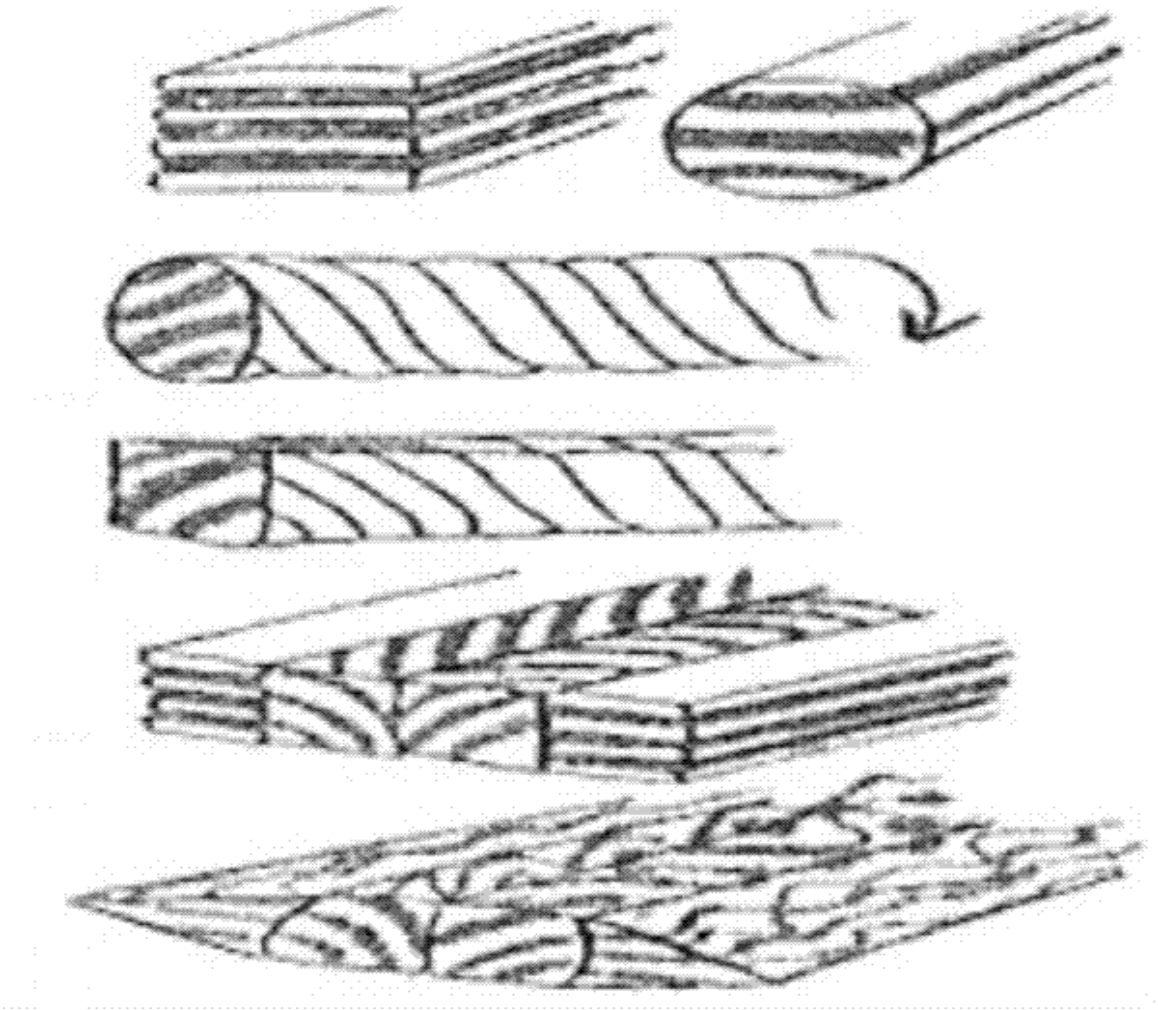
Basics of Coal Forging Laminated Steel (Damascus)



Above is a basic view of the process for making a Viking style Damascus. This style is easy and relatively quick for production of some fancy knives or swords. This also lends itself to decorative tools, hammers, and ornamental items on objects.

To start, you want to pick two metals that can work well with each other in the forge while still giving a good contrast to each other after etching. Some, but not all combinations are: Wrought iron and any most tool steel; 440c and D2; O1 and L6; 5160 and 1018, D-2 and 302 SS and AEBL; 1095 and 203E; 1095 and pure Nichol; 1084 and 15n20; 1095 and O1. There are many other combinations, as well as some of the above combined to each other for even greater contrast.

Be sure that the metal you choose is the same width and length. Thickness can be variant to affect your patterning. Average sizes to use are 1” by 6” with an average of 1/8” thicknesses. Once you have chosen your metals, you will want to grind them

smooth on both facing surfaces. You can also give it a slight convex shape when grinding. This allows the centers to weld first and then the edges (in one heat). Once the pieces have been cleaned, stack them in alternating layers and wrap with wire to insure they stay tight and neat when you weld on a handle. (Welding on a handle is optional, but some times a good idea if you are working with small pieces.) Place them into a clean fire. Your fire should be totally clean of slag and clinkers. It should also be free of impurities from raw coal. Coke your coal before hand. Be sure to have the stack on it's side when heating, and rotate often to the opposite side while applying air. A steady, but not over powering blast of air is all that is needed. If the fire is too hot, you will burn away the outer layers before the inner layers are hot enough.

Bring out the stack and brush away any and all scale and slag from between the layers. Apply your flux to the edges and ends, as well as the flats of the stack. It is not necessary to cake on the flux. Just give it a good coating to cover all surfaces. Place the stack back into the forge. (If your stack is longer than 4 inches, start at one end and work towards the other. Usually the furthest end first.) Bring the temperature up on the forge slowly and steady. You are going to be looking for certain signs. First, the flames will change color from a bright yellow flickering flame to a dark yellow orange (or pumpkin orange) steady flame. Second, you want to be able to see the surface of the stack, look for the surface to start "flowing" like water on the surface of the metal. (Keep in mind that you are still turning the stack often.) Once you see the watering, you can bring out the stack and work it closed to weld it. If you start seeing sparks rise out of the flames like a child's July 4^{th} sparkler in the fire, you are burning the steel and loosing the carbon needed for both a good weld but also a good hard steel. A few are ok, but a shower is really bad!

Welding can be achieved in a few ways. First, on a clean anvil, the flats are hammered down to join the metals. This throws a good shower of slag and molten flux out, so be aware of this and keep your gloves and safety glasses on! As soon as the metal has cooled to an medium orange, stop hammering and replace the piece back in the forge. Most hammer welds are only a couple of inches at a time. The second way to weld is by pressing the stack together. One way to achieve this is with the post vice. Place the ready to weld piece length wise into the jaws and squeeze the stack together as tight as you possibly can. This will often get a longer weld in one heat and little hammer welding is needed after wards. The third and most difficult to control is with the power hammer. With this method, be sure that your wire holding the stack together is cut away just after the initial weld. If not, your piece will have the wire welded onto the surface which is one more thing you have to grind off later.

If you have good wire welding skills, you can weld on a rod handle for both holding the stack during production, and keeping the stack together during that initial welding. Once the initial weld has taken place, continue to weld the entire stack until it is a solid piece. If you have any “Dark Spots” on the surface of the metal after you have welded the stack, this usually indicates an air or slag bubble in the stack. With that, there will be a gap on the stock that is called an inclusion. These are bad, especially when you are making Damascus for knife blades or other cutting tools. To fix the bubble, heat the stack up to just below welding heat and use a center punch to punch a hole into the un-welded layers.
Flux and re-weld the stack with the bubble surface face down in the forge. Any slag should liquefy and come out at welding heat. Bring out the stack and hammer up the area with the bubble until it is the same color as the rest of the stack. If the color is even through the entire piece, then there should not be any inclusions between the layers.

Draw out the new bar of laminated steel to either cut and fold, or make it square and round to twist up for patterning. If you are folding the stack to increase the layers, keep in mind the original number of the stack. If it was 15 layers, one fold will double the count to 30. But if you cut the bar into four equal lengths and stack them on top of each other, the stack will now be 60 layers.

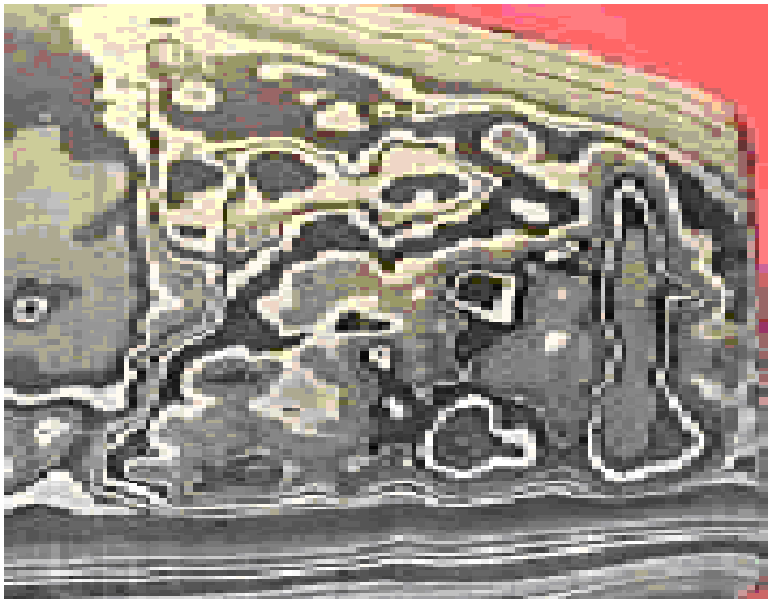
Here is the point when making Damascus becomes real fun and also a bit challenging. There are thousands of ways to change the pattern all on how you hammer and restack the “Billet.” Lower numbers of layers create bold layering while multiple restacking and welding create thinner and thinner layers for a higher count. It just depends on what you want the Damascus to look like when you’re done. Stacking and twisting will create diagonal layers in the steel when it is etched. (see above diagram) Do some research and image searches on the web to see some amazing patterns.

Once the billet has been forged out to the final shape of what ever you are going to make, be sure to sand down the scale on the surface to expose the “raw” steel below. Do this regardless of the shape of the item. Any area that is not sanded will only have a black area with out any patterning exposed. The best method for exposing the pattern is with Ferric chloride. This is the same etchant you can get at your local computer parts supply store. You will want to mix the Ferric Chloride acid 50/50 with distilled water.
*(Remember! Always pour acid into water and never water into acid. Water into acid will erupt into a volatile mixture that will go everywhere.) Place the etchant into a glass dish big enough to place the entire piece below the surface, or into a PVC

tube long enough and large enough to immerse the piece totally. An older mix will cut better than a new mix of acid etchant.

Once the piece is finished being sanded, polish on a cloth wheel and then clean with a degreaser. Any grease left on the surface will prohibit the etching process, including from fingers. After every minute or so of being in the etchant, remove the piece and clean it under running water before placing back into the etchant. Etch until the pattern is well defined. (Some people will only bring out the pattern coloring, while others may etch until the surface is ridged between the layering.) After, rinse the metal under running water and also use baking soda to neutralize the acid left in the crevices or corners. Many of the pieces can be blued, or chemically colored to enhance the pattern further.

Once you understand the basic process of welding the billets, now comes some basic different patterns starting with the layered laminate.

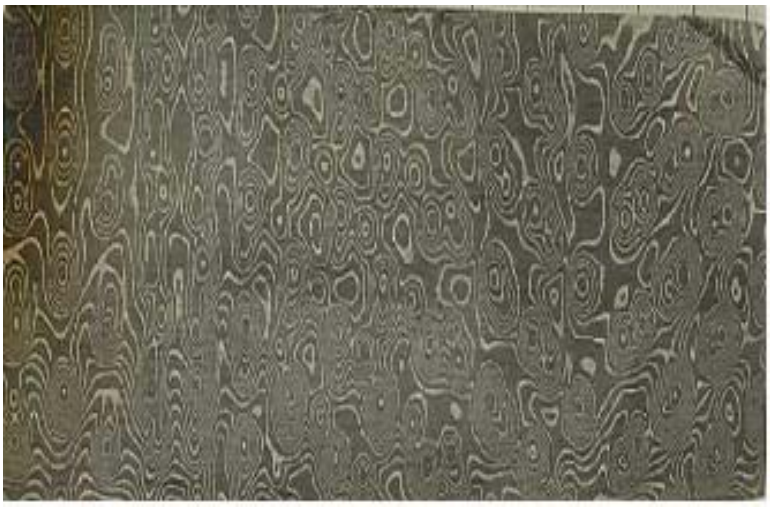


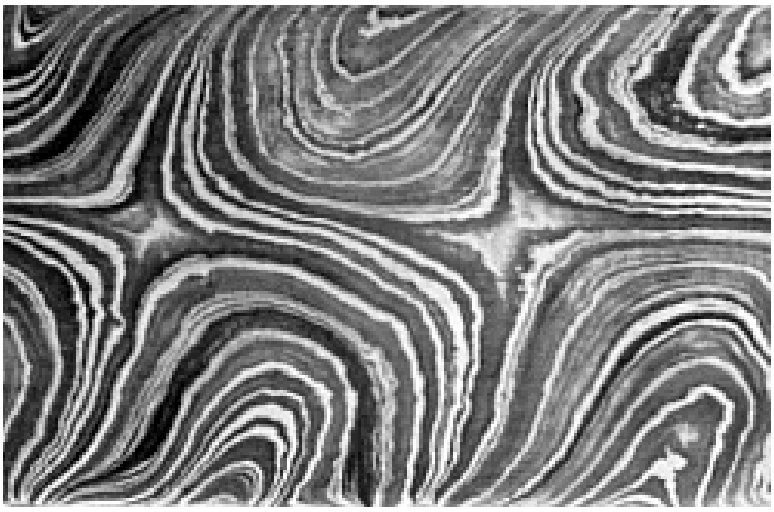
-First is the random pattern. Once the billet is forged welded and folded to the desired layer count, take a grinder, hammer and sander to the flat surface and cut, gouge, and divot the surface going about 1/3 the depth of the thickness. Do this to both sides. Next re-forge the surface smooth and flat. This will expose the lower layers and bring them to the surface. The pattern will totally be random according to how you affect the surface before forging smooth.

-Next is a ladder pattern. This pattern will start out with a thicker, at least a 3/8”s thick billet. Fill or mill 1/3rd the depth of the face lines across the surface of the billet. Next turn over the billet and do the same between the cuts on the opposite side. The ridges and valleys now are re-forged down to smooth the surface. This exposes and

bring up to the surface the layers in a pattern looking like a ladder.

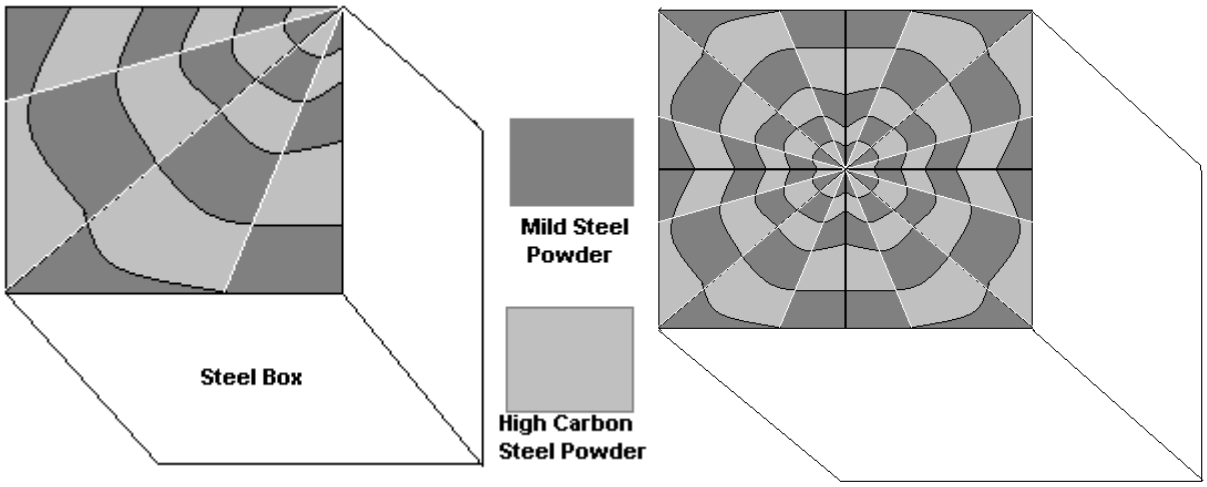
-Next is the rain drop pattern, also know as Oden's eye. This is probably the next easiest and fun to make. On the flat sides, use a broad shallow face drill bit and drill random divots into the surface. Some deep and some shallow but none need to be deeper than 1/3rd the thickness. This can be done to one or both sides of the billet. Once again, forge flat to bring up the inner layers. The emerging pattern looks like rain drops in water or on a side walk.





-Next, the twisted patterns are all a variance of this next method. Once the billet has been forged to its final number, forge the entire piece to a square bar. Now you can choose to round the corners to make a round bar, or keep it square and heat one end to start. Just like twisting a regular square bar, twist the bar using a vice and a wrench. This can be done in short lengths, or with a torch, it can be achieved in one big twist using a socket wrench and the vice. Either way, be sure to both have the heat at or near welding heat as you are twisting, and flux just before each twist. You can twist the billet as fast or as slow as you want depending on the amount of twisted pattern you want to see. You can also reverse twist every so often as you go to change up the pattern. Once the twisting is done, you can either grind away the surface to cut down to the center core of billet for one pattern style, or hammer forge the billet flat (still using a welding heat) and then grind away the surface. Other variances are cutting the bar into four pieces forge weld into one piece as they are stacked in a square and twist the entire piece. Also, cut the piece in two pieces from the original billet and twist each section. Next place the two together facing the twist in opposite directions and forge weld together. Cut then down or hammer flat and grind to expose the pattern. (This last one is the same as the diagram above.)

With a coal fire, be sure to keep the fire clean from clinkers as you work. Each welding period will add to the slag in the fire and packs up with a huge clinker in record time.

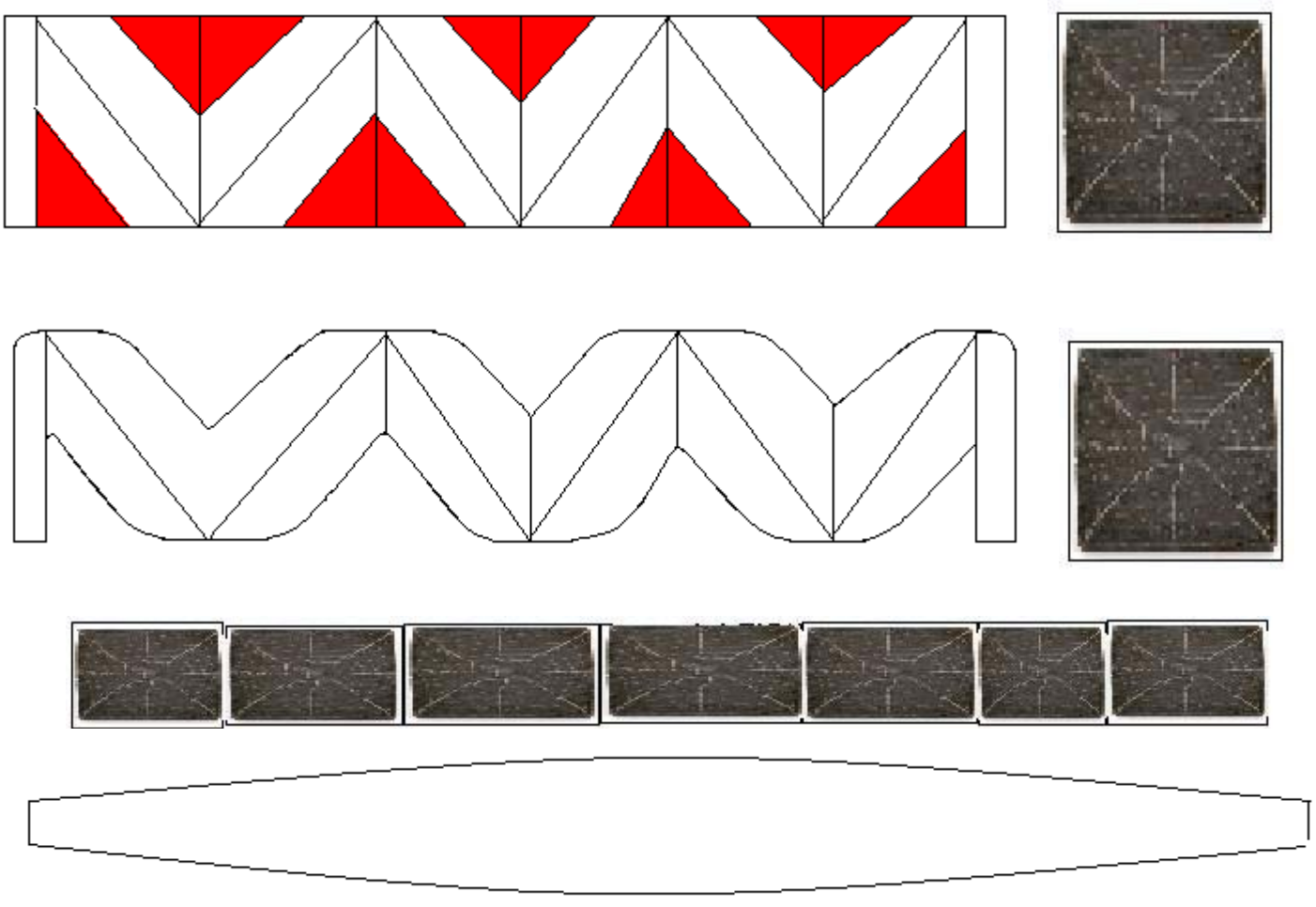


-This final method is for the folk who has a gas forge, a hydraulic press and lots of time Start with a square tube of mild steel that is any size 2 inch or bigger, cut it to be equally square all the way around. Weld a plate to close up the bottom. Line the inside of the box with Stainless foil. The foil will prevent the stock from welding to the box. With rods of tool steel or key stock, cut them to the same length as the length of the tube, or use sheets of 16 gage spring steel or greater thickness, cut the sheet into strips that can span the inner area standing in the box to make your design. Use a small matrix of bailing wire to weld in the loose pattern inside the box. If using the rods, have several different types of material labeled in groups. Stack the rods in the pattern much like filling in graph paper to make a picture. In each of the ways, fill in all the open areas with powdered steel. If you do not have powdered steel, you may be able to find in at industrial supply or sand blasting supply company. They should more than one type of steel. After filling in the entire box with the powdered steel, pack the powder as tight as you can. Next, make and weld a cover plate to complete the box. Drill a 1/8 in hole in one end and fill the entire box with WD-40©. This will help to remove the oxygen inside the box and the WD-40© will burn out as you forge the box down to shape. Finally, weld on a good long sturdy handle to the box end (not over the hole!) Bring the entire box up to welding heat on a slow burn. This may take an hour or more! Using a Hydraulic press, begin pressing the box down on its sides being sure to turn and keep the box as square as possible. Once you have worked it to the length and size you want, you will need to cut and grind away the box itself from the steel inside if parts have welded to the steel. The ends of the bar will show the pattern.

At this point you can cut and stack the bar to create a larger pattern or multiply it. Remember to keep it square when finished. Do not flatten out the bar! Forge the bar to the final size around 1” square from the original 4” square, creating a bar

1”x1” and however long. Now is the time to expose the pattern. Let’s say that the bar is 2”x2” and 13” long. Look at the end pattern (after cleaning and etching) and determine the one side that is the top and mark it. Next, roll the bar on its side. Starting a half inch from one end, mark the bar every 2” with a line. If it is 13” long there should be 6 marks. Now draw a diagonal line starting at the first ½” and work back and forth creating a zigzag to the other lines reaching the ending ½” mark. With the bar being 2” square, determine how thick you want the thickness to be before forging the desired product. Average thickness is ¾” to give plenty of stock to work with. At the corner of the zigzag, move back towards the center and draw a point. The space between the points should be ¾” or the thickness you have decided. Draw lines parallel to the zigzag, sectioning off the waste area. Drill a hole inside the point of waste area. Cut away the waste area with either a hack saw or band saw, leaving the upper part of the hole as a pivot point. Round the corners left by the removal of the waste area. Next forge it flat at near welding heat. Be sure to take your time and work it hot, not cold! Working it too cold may rip or fracture the forge welds. Sand or grind the surface flat to the final thickness before making it in to your desired product.

Spider web or Rose pattern



All Pictures are the “side” view.

Stars and Stripes mosaic with twisted pattern edged.

http://ajh-knives.com/metals.html

http://damascus-barrels.com/Movie.html

http://damascus.free.fr/f_exp/com.htm

http://damascusknifestore.safewebshop.com/damascus_steel_making.html

http://www.caffreyknives.net/bsteel.htm

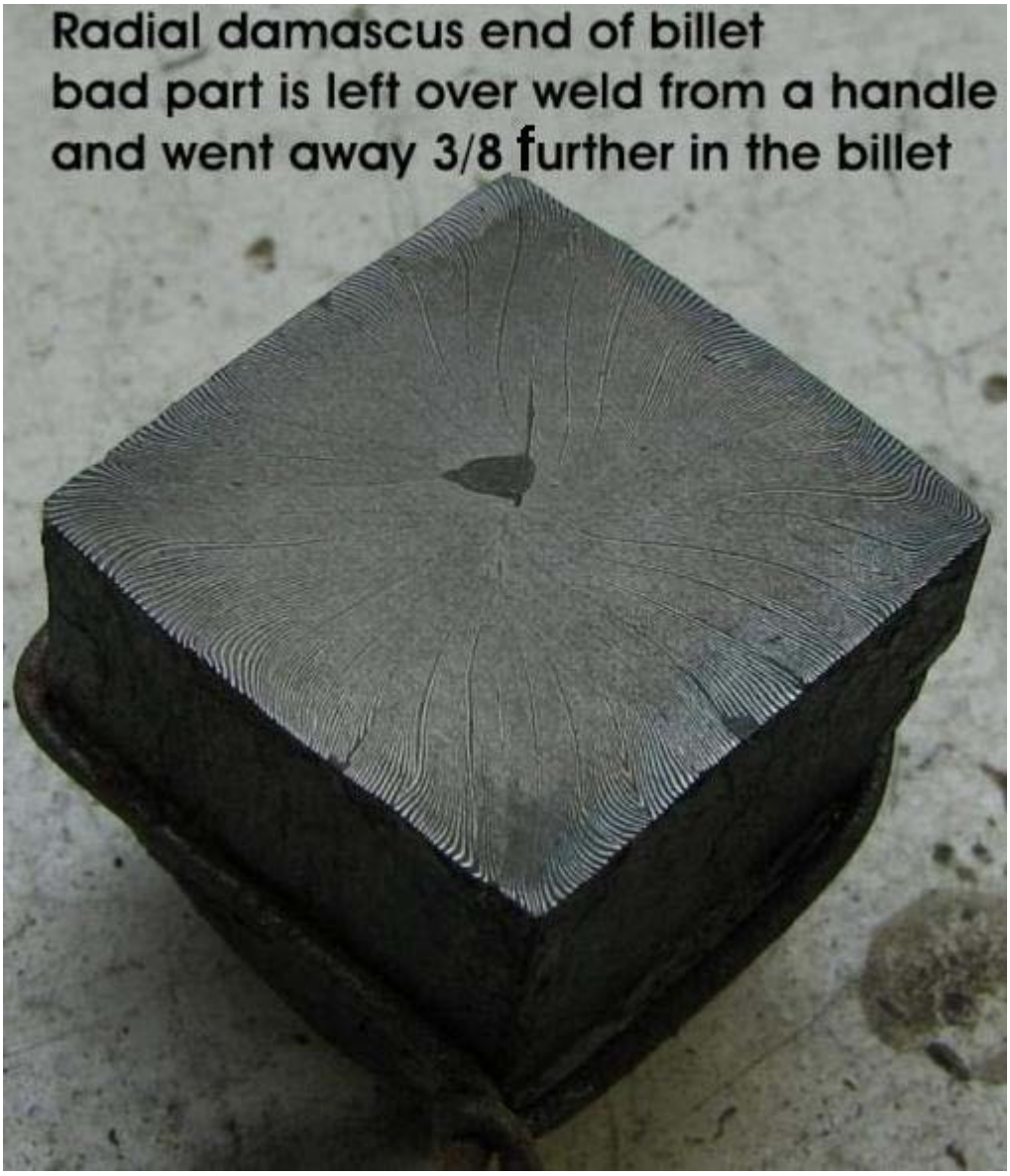
http://www.minnesotafarriers.com/Damascus.htm

http://machinedesign.com/article/damascus-steels-from-powder-metal-1118

http://smartflix.com/store/video/4739/Forging-Mosaic-Damascus

http://www.aescustomknives.com/docs/tutorial9.htm

Dancingfrogforge.com



By: Plain ol Bill

Radial damascus pattern

This is the radial I made using the cutting and squaring dies on my press. The bad spot is left over weld from a handle and cleaned up 3/8" further into the billet. The billet itself is 10" long and this was the first cut off the end of it.

http://www.farwestforge.com/Forum/bsgview.php?cat=