Procedures for NJBA Anvil-Repair Workshops

by Bruce Freeman and Andy Vida

Introduction

Over the years, NJBA has held a number of anvil repair workshops in which we have restored over fifty anvils in varying degrees of disrepair to good working condition. From the first, our success has been good. A 124 pound anvil, that served as the test bed prior to the first NJBA anvil repair workshop, spent three years at the shop at Historic Allaire Village where it was used and abused by novices, without failure of the repairs. But over these years our procedures for conducting these workshops have improved significantly. This article is intended to document the procedures NJBA has used to run these workshops successfully.

Be sure also to read the articles by Robb Gunter and Larry Brown, also in this issue.

Summary of Anvil Repair Procedure

Grind the anvil to chase down cracks and to provide a good, clean surface for receiving the weld.

Place the anvil on a grate over a wood fire for the pre-heating.

Heat wrought iron anvils to 400ºF; cast iron anvils to 450ºF.

Carefully monitor the temperature of the anvil, especially at the horn and tail, and shift it on the grate as needed to prevent overheating, or use pieces of sheet metal to shield these parts from the heat.

When the anvil reaches the desired temperature, either remove it from the fire, or move it to a cooler region of the fire to maintain its temperature without heating it further.

Take the hot anvil to one of the welding stations, or wrap it in mineral wool to maintain its temperature until a welding station becomes available.

Clamp copper strips (preferably 1/4" thick, as thinner material may melt while welding) to appropriate parts of the anvil, if necessary to minimize flow of the molten welding rod or wire beyond the area it is wanted.

Apply an underlayment weld, allowing a small excess to be ground to shape.

Grind excess underlayment weld to prepare the anvil to receive the hard-facing.

Apply hardface, allowing a small excess to be ground to final shape.

Reheat the anvil, as before, and take it to a welding station for hard-facing.

Grind anvil to final finish, and check whether additional welding be necessary.

Allow the anvil to cool slowly, wrapped in mineral wool, either before or after the final grinding.

Planning

Choose a date in a cool month (e.g., November) not likely to be rainy or very windy.

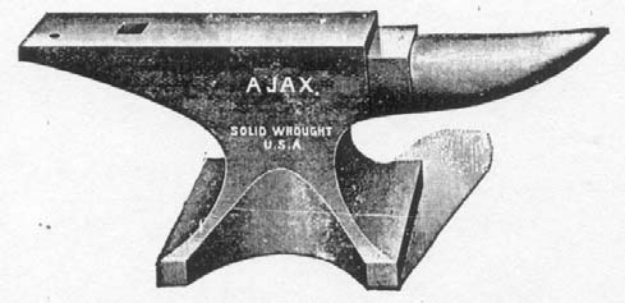
Decide how many anvils you can repair in a day. Participants should be able to begin their final grinding while at the workshop, but may finish it at home. With three welders, NJBA can easily repair eight anvils in a day, but 14 was brutal.)

Determine the largest anvil you can handle.

Publicize the workshop, making clear: who may participate; what sort of repairs will be done, and what repairs would be beyond the scope of the workshop; what it will cost; where and when it will be held; and what participant should bring and how much work they should expect to do at the workshop.

Give preference to those who pre-register, but don't be surprised if some folks just shop up.

Encourage members who do not have an anvil to repair to help out with the event.



Fees. The fee NJBA charges has risen over the years, mostly in proportion to the cost of power and supplies. The least we ever charged -- many years ago -- was $50 per anvil. At the Nov. 2011 workshop, the charge was $120 per anvil. In all cases, this is for routine restoration of edges and faces, including around the hardy hole if desired. (Think twice before repairing hardy holes, as once these are repaired, the hardy tools will no longer fit.)

The fee does not include filling swayback or replacing large pieces of the faceplate. (We do not weld on faceplates. That's another technique entirely.) Anything above and beyond the normal sort of repairs we charge extra for, and this extra charge should be a large multiple of the cost of the additional welding rod or wire needed.

Anvils Appropriate to Repair. Examine each anvil before beginning work on it. Know whether the anvil is wrought or cast, either by brand or by spark test. Anvils appropriate to repair will have nicks, gouges, welding cuts, or miscellaneous damage to edges that don't require pounds of welding rod to fix.

Refuse anvils which need repair of swayback or are missing major chunks from face. These take too much time and material and can spoil the workshop for other participants. Watch out for hidden cracks and separation of the face plate from the body. These can sometimes be "heard" by tapping with a hammer. It is possible to replace the tip broken off a horn by welding on a new piece, but the horn of a wrought-iron anvil might better be repaired by reforging (as suggested by Robb Gunter -- is a technique outside the scope of these workshops). The weldors have final say what is and what is not reparable.

Participants. The paying participants at NJBA workshop should be NJBA members of the group or should join on the day of the event. This provision ensures that our insurance will cover them in case of an accident. Participants should provide their own safety equipment -- gloves, goggles, masks, etc., and should bring their own angle grinder, if possible. All paying participants are expected to do most of their own grinding, and also participate in maintaining the fire, monitoring anvil temperature, and carrying anvils.

Equipment and Supplies

Two or three welding machines, MIG or rod.
Welding Rod. McKay Hardalloy 60 rod for hardface.
MIG Wire. Lincor 55 wire (in the1/16" dia.) for hardface.
(See Larry Brown's article for information on underlayment rod and wire.)
Misc. clamps, etc., to facilitate welding operations.
Copper Strips, preferably 12" x 2" x 1/4". (Thinner copper may melt.)
Mineral wool blanket (e.g., 1" thick, 8 lb/cu ft "weight". Need not be new or pristine.)
Tempilstick® crayons (e.g., 300º, 350º, 400º, 450º, & 500ºF, http://www.tempil.com/)
Metal tables for use as welding stations.
Additional tables for use as grinding stations.
Grate (see below) upon which the anvils will be set over the wood fire.
Electric blower to ventilate the fire through appropriate pipe or flue duct.
Anvil carrier (see below) for moving the anvils.
L-hook (see below).
Weldors' protective equipment such as welders' leathers and "helmets" (preferably brought by the weldors).
General personal protective equipment such as safety glasses, dust masks, and gloves (preferably brought by the participants).
Angle grinders (preferably brought by the paying participants).
Grinding wheels (preferably brought by the paying participants).
EZ-Up-type canopies for shade.

Welding Equipment Stations. We typically have three welding stations going -- two working rod, one MIG. The MIG we generally reserve for the hardfacing. The rod stations can do either, but mostly do underlayment. Two of these stations are on steel tables, one on the tailgate of the truck bearing the welder.

Preparation

Lay in a good supply of firewood.

Construct a firepit topped with a grate before the day of the event.

Ensure that the personnel, equipment and supplies needed (below) will be available.

Firewood Supply. It's hard to judge how much wood we consume in a one-day anvil repair workshop because we always seem to gather much more than is necessary. The fire will be run at least eight hours, with an air blast. We consume perhaps as much as half a cord of hardwood. The wood needn't be cut short, but it should be small enough (i.e., split, if necessary) so as not to be too slow-burning. (Some oversized wood may be used when starting the fire, before replacing the grate.) Much of our wood is red oak, a predominant hardwood on the farm where we run most of these workshops.

The Grate. The anvils should be placed over the fire, not in it. A sturdy grate should be fabricated before the firepit is dug. This grate must be a solid fabrication. Loose bars placed across the blocks, or equivalent jury-rigged constructs, *will not work*. (A hot anvil dropped into the fire can be a hellacious thing to retrieve.) Anvils are placed upright on the grate to reduce the chances of overheating the face. The spacing of the bars of the grate must be close enough that the base of an anvil cannot easily slip through.

Our grate was made from the load-backrest from a scrapped forklift, with some struts added to enlarge its working area. All struts are at the same height, on the upper side of the grate, so that anvils can be slid around the surface of the grate with little difficulty. The size of the grate must be appropriate to the size of the firepit, and must be securely supported by the blocks constructing the pit.

The Firepit. The size of the firepit is dictated by the size of the grate. Its two block walls must solidly support the grate, and the firepit (and the fire) *must not* be longer than the grate, lest the heat of the fire

itself prevent access to the anvils. The suggested materials and construction are as follow:

Concrete Blocks, e.g., 16" x 8" x 8", 12 ea.

"Half" Concrete Blocks, e.g., 8" x 8" x 8" (cut or broken 16" blocks), 6 ea.

(Optional) Fire brick sufficient to face inside of concrete blocks.

Sheet Steel (scrap, not galvanized), approx. 24" x 40", 2 ea. (or equivalent pieces of surface area equaling the concrete block walls), plus a few smaller sheets to use as heat shields between the fire and the anvil for localizing heat as necessary.

Steel Spacers, such as rebar or pipe, at least 30" long, several.

Slotted Air Pipe, e.g., 40" of 4" steel flue duct with multiple slots on one side to pass air, and one sealed (flattened and rolled) end.

Extension Air Pipe, e.g., 4", length as necessary.

Electric Blower, with some means of throttling air flow, suitable for use with above pipes.

Grate, as described previously.

Orient the firepit so that the men carrying a hot, heavy anvil between them on the eight- or ten-foot anvil carrier have free access to opposite sides of the fire (the sides with the block walls) pit with no obstacles or tripping hazards whatsoever. Locate the firepit where the walk to any welding or grinding station will be reasonably short. Locate the blower on the end of the firepit that these men will not have to traverse.

Dig a shallow pit about 40" square and at least 8" deep. (The exact length and width must be dictated by the size of the grate.) Build two parallel walls on opposite sides of it from (8"x8"x16") con-

crete blocks. Place the first rows of blocks below grade. Stack the blocks three high, imbricating them for strength, to make a wall that stands no more than 16" above ground level.

Dig a trough about 3" deep and 4" wide down the middle of the pit, parallel to the block walls, and place the slotted air pipe in this. Largely bury the pipe, but do not cover the slots. Connect this slotted pipe to the extension air pipe, whence to the blower. Partly cover the air pipes with dirt to protect them from the heat. (In operation, throttle back the air flow but never shut it off, lest the thin-wall pipe tend to soften and collapse.)

Since concrete blocks *will not survive* the heat of the fire, protect them with sheet metal. Space the metal away from the blocks with steel pipe or rebar, driven into the ground next to the blocks. (Don't use aluminum -- it will melt in the heat.) The sheet metal can be secured with wire to the blocks or to a strut mounted outside the blocks.

If enough are available, use firebricks to line the insides of the firepit, in lieu of or in addition to the sheet steel. (The concrete blocks will still be necessary to produce a wall at least 8" thick to support the grate and the anvils.)

Anvil Carrier. We have had good luck with an anvil carrier about 10' long, constructed from two barn-door rails spaced about 5" apart with bolts and pipe spacers, and equipped with a T-handle on each end. Two short loops of sturdy chain hang below the carrier, near the center, to engage the horn and the heel of the anvil.

Expect one man to be able to carry about 50-75 lb. Hence a 150-lb anvil can be managed by two men, but a 300-lb anvil will require at least 4 men. For anvils heavier than 300#, we have used a tractor with forks to do the lifting.

L-Hook. The tool for moving the anvils on the grate is a 1/2" steel bar at least four feet long, with a 90º bend at one end to slip into the hardy hole. When used from the bottom of the hardy hole, bent end pointing up, this tool is very effective at moving anvils on the grate, and also doubles as a means of guiding the chains of the anvil carrier onto or off of the horn or tail of an anvil.

Techniques

Initial Grinding. Grind all areas of the anvil that are to be restored. When a crack is encountered, follow it with the grinder until no trace remains. When grinding cracks, the edges of the steel often turn blue from the heat thus marking the crack clearly.

The Fire. The fire should be started at least an hour before the workshop. Keep the fire within the pit at all times, as an overlong fire makes it very difficult to get to the anvils to measure their temperature or to load them onto or remove them from the grate. Inexperienced or overly enthusiastic fire monitors may tend to build too large a fire. This is fine when first starting up the fire, but should be avoided when anvils are on the grate. There should always be some flames and a bed of coals, but avoid the temptation of constructing an Aggie Bonfire.

By the start of the workshop, the grate should be in place over the top of the firepit, and there should be a good bed of coals. Continue to feed the fire with split firewood (i.e., not large logs) throughout the day. Never turn off the blower, as this may result in overheating and collapse of the thin air pipe. Should the day turn windy, a sheet metal shield may be placed in front of the windward end of the fire.

The Grate. We have tried putting the anvils in the fire, but have found that putting them over the fire is far better for a number of reasons:

Ease of placing the anvils.

Access to the anvils to check temperature using Tempilstick crayons.

Ease of moving the anvils around to control their exposure to the heat.

Ease of removing the anvils from the fire.

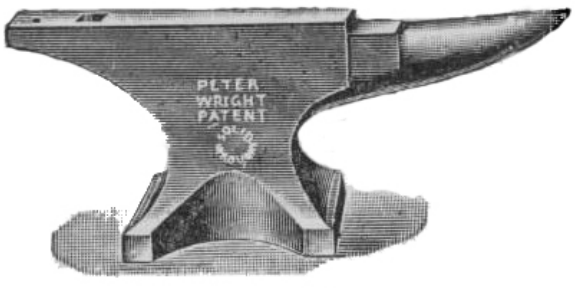
We have tried hanging anvils from anvil carriers over the fire, but this proved awkward and gave little means of adjusting the anvils' positions relative to

the heat. It is all too easy to overheat the tail or the horn before the center of the face comes up to temperature.

By contrast, a grate facilitates preheating the anvils with minimal risk of overheating them. Using a grate, it's a simple matter to slide the anvil (with an L-hook) to a cooler part of the fire or to place a piece of sheet metal between the fire and the thinner parts of the anvil to deflect much of the heat.

Measuring Anvil Temperature. Preheating of the anvil is critical to achieving good adhesion of the weld, however overheating the anvil will ruin its temper. Tempilstick crayons are the best means of monitoring anvil temperature. Use the lower-temperature crayons to follow the heat as it reaches the face. Use the higher temperature crayons to confirm that the proper temperature has been reached but not exceeded. The major problem with using Tempilstick crayons is doing so over the hot fire. Find a tongs to hold them securely or provide some other handle for them. Also, designate a single spot for the Tempilstick crayons when they are not in use, as otherwise they tend to "walk."

A "non-contact IR thermometer with laser targeting" (to quote Harbor Freight) may be useful for measuring the temperature of an anvil *off* the fire, but simply cannot be relied upon for measuring the temperature of an anvil over the fire, as the IR from the fire is reflected by the anvil to the thermometer. Its performance can be improved by shielding the anvil from the IR glow of the fire (invisible to the eye) using a piece of sheet metal, but don't put great faith in such readings.



Anvil Restoration Welding Technique

by Larry Brown

These repairs are to build up edges and restore horns to the height needed to continue with the hard facing to the finished height.

Determine whether the face plate is welded on properly by tapping on the face with a hammer, listening for a change in sound, rebound, or vibration as you move around the face. If the plate is welded well, the edge repair should work well, if not the repair may be questionable. Always remember, the anvil got this way from new, and no repair will last forever. Obvious cracks need to be ground out before heating to where a joint line is no longer visible, colors when grinding may help show cracks.

Anvils must be preheated to 400ºF for wrought iron, or 450ºF for cast iron, prior to welding. After heating recheck to see if there are visible cracks or color variations.

I usually start with the cheapest rod. I have found that many anvil bodies weld well with 7018 and 7014 rod in 3/32 and 1/8 diameters. The same holds true for the horns and steps. I usually start with one or two small short beads in the repair area using the smaller diameter rod, chipping, peening, and wire brushing afterwards. It is best is if the welding amperage is kept to the low end of the rod's welding range to cut down on the mixing (dilution) of the base metal and the rod more than necessary. I try to make these welds in a flat or horizontal position if possible by rotating or chocking the anvil. Many wrought anvils respond well to the 7018 or 7014 rods.

After the welds have cooled a little and been cleaned, check the edges for cracking or pulling from the base metal. If there are no cracks add welds a few at a time until the base metal is covered. If the welds have cracks around the edges they must be ground off and a different rod tried. It is important that the base layer is properly welded as this is what the hard face rod is welded to.

Lincoln Ferroweld, Softweld 55Ni, Softweld 99Ni and Eutectic Xuper 2240 are the rods I usually try, and in the order I try them. The rods get more expensive and contain more nickel as the list goes on. I have also used a Lincoln 309/309L 3/32 Stainless rod with some success, (Worse color match than nickel or steel). Usually these rods are run using DC reverse polarity (electrode +) but some can be run either straight or AC. If they can be used on a setting other than reverse you can try welding short beads in either straight (electrode --), which will give lower penetration, or AC. Check the manufacturer's specifications for their recommendations. Sometimes very short welds, ½" to ¾", or even small spots of weld, are what is needed to get the first layer to adhere well to the base metal. Problem anvils need an open mind and patience. You cannot tell which one will not play nice with you.

Some cast-body anvils are cast iron and some are cast steel, and many older ones vary from anvil to anvil. You may have two anvils from the same manufacturer that look the same and behave differently when repairing them.

I have been asked about using an acetylene torch and cast-iron stick rods for the build-up. I have not tried this, yet, as I am afraid of overheating the anvil in the welded area.

Once the first layer of rod is welded to the base metal, short stringer beads are then used to build up the area. As the layers build up, longer beads may be used. An eye should be kept on the area where the first layer meets the base metal to make sure the stress of the successive layers of weld does not pull the weld apart. Stop buildup passes low enough to allow for several layers of hardface.

Care must be taken to prevent the anvil from increasing heat from the welding, or cooling excessively during the welding. Covering areas not being welded with mineral wool will help slow the cooling. When the anvil drops 50 degrees put it back over the fire to reheat it. I usually am not too concerned about a color match, but the steel electrodes match much better than the nickel or stainless.

The hardface can be rods (stick) or wire (MIG). We have used a combination of both with stick from the sides and MIG from the top depending on availability of welders and equipment. Pieces of copper are used to dam the hardy hole and sides when doing the hardface so there is less grinding and waste of wire and rod. Excess hardface is not easy to remove from the hardy hole and you may have to grind your hardies to fit. Swaybacked anvils may be built up with hardface using stringer welds and then grinding. Care must be taken not to have too much stress built up in the anvil faceplate. I have not had one crack or pull away from the body while welding and cooling, but the potential is there. Many smiths do not mind a small sway in an anvil (and know how to use it to their advantage) and most are happy having edges that are not broken and chipped out that can be ground to a radius of their liking.

After the welding is completed the anvils should re-heated to the starting temperature of to 400ºF for wrought iron, or 450ºF for cast iron and then allowed to cool slowly in insulation or at least in still air until the temperature drops enough to handle with gloves and care should be taken while grinding not to overheat the repair areas.

Rods used;
Lincoln Excalibur E7018 3/33, 1/8
E7014 3/32, 1/8
E309/309L 3/32 Stainless
Ferroweld 1/8 Cast Iron
Softweld 55Ni 1/8 Cast Iron 55% Nickel
Softweld 99Ni 1/8 Cast Iron 99% Nickel
Eutectic Xuper 2240 1/8 Cast Iron

There are many rods on the market and a welder should use what they are comfortable with. Other manufacturers than those listed above make similar rods, try what is available to you. The properties of these rods can be found on the manufacturers internet web sites.

Making the Patrick Pelgrom Tongs

Michael Wollowski

I made the tongs in figure 1 based on an article in the German metalworking magazine Hephaistos (http://www.metall-aktiv.de/). The tongs were developed by Patrick Pelgrom, a Belgian blacksmith who travels a lot by airplane. In order to reduce the weight of his luggage, he developed a pair of tongs that would be able to securely hold square, round and flat stock. This way, he was able to reduce the number of tongs he carries with him. His tongs were inspired by how one would hold a piece of (cold) metal with three fingers. The V angled bottom takes on the functionality of the index and middle fingers and the rounded top that of the thumb. Notice the notch in the rounded top which is designed to give good grip. While they are in essence v-bit tongs, they excel at holding flat and irregularly shaped stock.

Figure 1: Three-quarter view and front view.

They also work well in situations where you need to hold two pieces to forge weld.
In this article, you will find construction notes on how to make these tongs. I find it easiest to rework old tongs as it saves time. While I like to use flat tongs as a donor, any tongs will do provided they have enough material to be reworked. I have made two pairs of tongs, the one described here started out as pick-up tongs in which the business end was approximately 1/2" square. They are going to be on the small side, to be used with 3/8" and 1/2" stock.
Start by cutting the rivet. Next, grind off any burrs and sharp edges. Now is also a good time to remove any excess materials so as to lighten the tongs. Figure 2 shows the result of this step.

In case your donor tongs are pick-up tongs, cut the business end so that you are left with about 2" of material. If you start out with flat tongs, you may skip this step. To make the V-bit bottom, draw the business end to about 1" wide, 1/8" thick and 2" long. If you start out with pick-up tongs, first spread them to about 1" wide and if they are still too thick, spread them out lengthwise. If you start out with fairly thick flat tongs, first draw the bit lengthwise so that it is equally thick. Then draw it out to a width of 1" and a thickness of about 1/8". Next cut the bit to length, about 2". Now, it is time to form the V on a 45 degree V-grove of a swage block. It is important that the V-bit is slightly concave lengthwise, otherwise, the piece to be held by the tongs may wobble. Small imperfections can be removed by grinding them away later on.

Figure 2: Tongs separated, sharp edges removed and trimmed for weight.

To make the rounded top, draw the business end to 1/2" wide, by 3/16” thick by about 2 1/4” long. Figure 3 shows the result of forging the top and bottom. Notice that the top is actually too long.

Figure 3: Forged business ends.

Next, clean-up the pieces with an angle grinder and cut the top to size and add a small V-notch. The length to which you cut the top determines the stock size you can hold comfortably. You may wish to experiment with that by dry fitting the tongs. The ones I made for this write-up open up to 5/8” from the inside of the top notch to the inside of the bottom V. This was measured with the ends of the reigns opened up to about 2 1/2”. They hold 3/8” to 1/2” square and round stock as well as 1/2" flat stock.

The medium sized tongs that I made prior to writing this article open up to about 1 1/8”, measured from inside of top notch to inside of bottom V, with the ends of the reigns opened up to 2 1/2”. These tongs work well with 3/4” and 7/8” square and round stock. However, I primarily use them for knife making where I need to hold flat stock. They comfortably hold 3/4” to 1” flat stock. The medium sized tongs have the following dimensions. Bottom V: 2” long, 1¼” wide, 1/8” thick. Rounded top: 2 1/4” long, 5/8” wide, 1/4” thick. Notice that they have the same lengths as the smaller tongs. This is partly due to the different design of the donor tongs. Figure 4 shows the two pieces after clean-up.

Figure 4: After clean-up.

When putting together the tongs, I like to insert a thin piece of cardboard between the pieces, such as from a cereal box. This prevents over tightening of the tongs when setting the rivet. I just burn off the cardboard piece when finished and tighten the tongs if necessary. Figure 5 shows the medium sized tongs holding the small sized ones.

Figure 5: Big brother holding little brother.

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Northeast Blacksmiths Association

Northeast Blacksmiths holds its meets twice a year at the Ashokan Field Campus in New York State.

The Ashokan campus is located in Olivebridge, N.Y., several miles west of Kingston, N.Y. The meets are held the first weekend in May and in the first weekend in October every year. The main demonstration is in the blacksmith shop and there is a "Hands On" workshop for beginners. A main demonstrator is brought in for each meet, food and bunk-house style lodging are provided as part of the cost of the weekend long meet.

Contact : Tim Neu
to register for hammer-ins
or subscribe to the newsletter;
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For more info check out the web site;
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New Jersey Blacksmiths Association
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