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BRONZE PIT WELDER

FOR WELDING PITS IN SILICON BRONZE

With Companion videos
Bronze PIT Welder – How It's Made
Bronze PIT welder - How It's Used
Bronze PIT welder pellets – How They Are Made
that can be found here:
http://www.westgate-works.com/efiles/etutorial.html

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INTRODUCTION

Been fussing with removing pits in polished silicon bronze castings for several years. Finishing a piece of polished bronze sculpture is mostly spent welding and refinishing pits. Weeks and months spent doing this. There is no doubt that many others that have had to deal with this problem. Finding a solution to this PIT problem has been a major issue for some time.

A TIG weld leaves a pit in the bronze on every start of the arc – not good for a polished surface, which can be avoided by drilling and pinning each pit with a short piece of filler rod and starting the arc on the pin, but this leaves a lot of material to remove and re-finish. Cast bronze should never be cooled quickly as it will cause cracking.   To avoid cracks using a TIG welder requires preheating the bronze workpiece to between 500 and 800 degrees, peening the weld overburden while hot and letting it cool very slowly.

On thin cross sections, welding with a jewelers Oxygen/Acetylene torch and using filler rod flattened and cut lengthwise to get a smaller size works O.K. A copper backing plate avoids burn-through. For thicker work pieces, a larger torch tip is required and often requires lots of metal removal. It is best to preheat the piece before welding and let it cool slowly to avoid cracks. Gas welding has it's own problems – depending on a person's welding expertise.

Welding a very small area with a spot welder would be the IDEAL solution and eliminate a lot of effort with cleanup. Lady Google located one company in the USA that sells a DOT welder (http://dotwelder.com). Their machines are designed specifically for this type of welding on steel, chrome and other metals and they provide the pellets for their welder - but they do not support bronze welding.

Silicon bronze has properties that make spot welding very difficult compared to other metals. It quickly dissipates heat from a weld point, requiring much, much more power. The size of the work piece also affects the power required because it seems that the entire piece is 'charged' and the larger the piece the more power required.

It has taken well over a year of innovation with different cable setups and testing to develop a BRONZE PIT WELDER that welds pits in cast silicon bronze that solves this vexing problem. This document and the companion videos describe the results of this endeavor. This welder does not cause heat cracking because only very small areas are heated and the heat is dissipated very quickly.

Several manufacturers, such as Harbor Fright Tools, Hobart and Miller, sell similar 220 Volt hand held Spot Welders rated at 5,500 Amps and 50% duty cycle. The Harbor Freight welder was chosen because it sells for a lot less money than the others and the tongs are included. However, Harbor Freight does not supply replacement metric thread welding tips for their tongs – and they possibly can't be found anywhere else. To use standard welding tips (like Miller 040211) with the Harbor Freight welder tongs requires either re-threading the tongs or the tips.

NOTE

This document is provided for information only. No safety precautions regarding using this welder either for it's intended use or as documented herein is provided. Working with 220 Volt equipment can be dangerous - and mistakes can be fatal. You have been warned!!

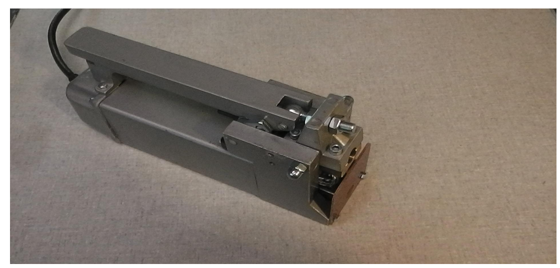
MATERIALS

(1) 230 Volt Spot Welder - Harbor Freight Tools $170 on sale
(2) 12' of flex braid cable 0.40 thick x .07 wide (40800) - under $50 from Storm Copper components (http://electrical-insulators-and-copper-ground-bars.com/)
(3) 2-1/2” length of round copper rod 5/8" diameter (see notes)
(4) 1” long piece of 3/4” clean to bare metal soft copper water pipe
(5) A suitable handle
(6) Hardware (nuts and bolt etc.) for fastening the handle and the tip holder
(7) 3/16” thick 1/2” x 1-1/4” steel plate (can be up to 1/4” thick)
(8) Fat tire bicycle inner tube - from many bike repair shops
(9) Miller 040211 standard spot welding tips - from most welding suppliers. The two Harbor Freight tips supplied with their tongs are threaded 8mm and not replaceable by Harbor Freight, or possibly anywhere else. The welding tips need to have the point diameter reduced from 1/8” to 1/16” to work properly for small welds.
(10) 220 volt 6.5 amp or better foot pedal switch - $10 and up (not shown in this document) and two heavy duty spade connectors found at most auto parts or electronics stores.

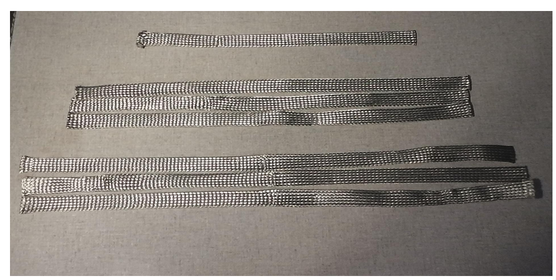
FABRICATION

(1) The Harbor Freight welder out of the box.

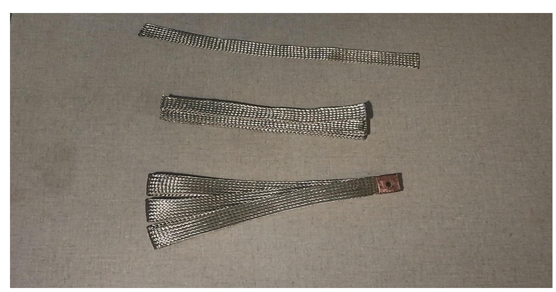
That was easy!



(2) The 12' long braided flex cable was cut into three 24” pieces for the top cable and three 20” pieces for the bottom cable leaving an extra foot of cable that is used as an extension for reducing power for welding small pellets.



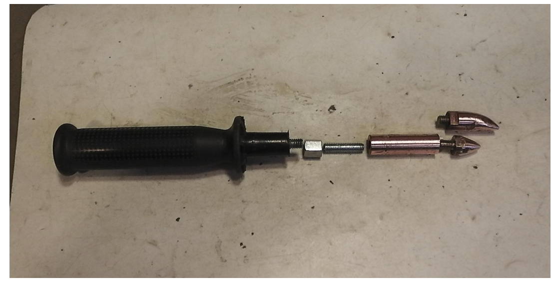
(2, 4) The ends of the bottom cables were clamped and soldered to eliminate fraying and were folded in half.
The three top cables were folded in half and stuffed into the 1” long copper pipe with the cable ends flush to the end of the pipe. The pipe and cables were squash flat in a vise and the sides of the copper pipe were peened with a flat tipped punch to make the sides square and to fit the flex cables as tightly as possible to make a lug. The bottom surface of the lug was filed smooth for electrical contact to the tip holder and a hole was drilled in the center for the tip holder bolt.



(3) The 2-1/2” long piece of 5/8” diameter copper rod was drilled and tapped one end for the welding tips, but no deeper than necessary and the other end for the cable lug and handle, again no deeper than necessary.

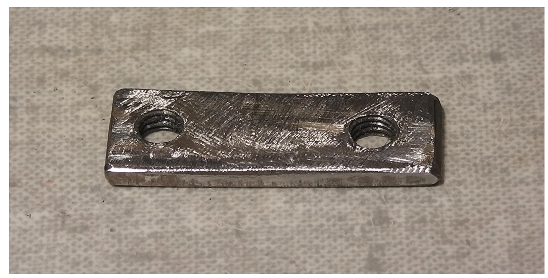
Note that the ends must be flat and smooth for good electrical contact.

(5, 6, 9) This nice comfortable handle had a threaded stud that was too short to fasten the conductor lug to the tip holder so an extra stud and extender nut were used to make it work.



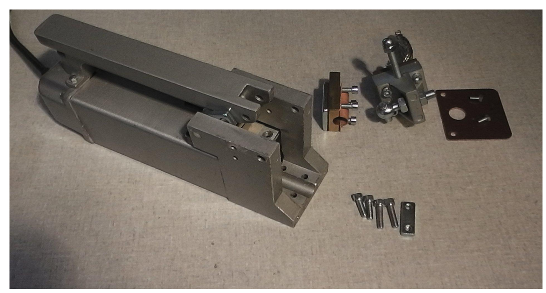
A special corner welding tip was fabricated from the end of an extra tong purchased from Harbor Freight (about $40) to make the tip holder – before learning that Storm Copper sells 5/8” diameter copper rod.

(7) The 3/16” x 1/2” x 1-1/4” steel plate was drilled and tapped (6-1 MM metric) to duplicate the welder's top flex cable clamp plate and is used for the bottom flex cable clamp plate.



ASSEMBLY

All of the welder's top and bottom tong holder parts were removed and saved for spot welding. The swivel adjustment pin in the handle (knurled on one end) was removed by punching it out of the handle. The two front bolts in the top tong holder were used for the top cable clamp to accommodate the extra cable thickness. The top cable clamp plate, two bottom bolts and the two bolts from the front of the top tong holder were re-used.



The folded ends of the bottom flex cables were fitted between the bottom bolts and the fabricated bottom clamp plate using the existing bottom bolts. The clamp was tightened evenly to make good electrical contact. A 3” piece of bicycle inner tube was secured with a plastic tie to insulate the cables from the frame, leaving the soldered ends exposed for clamping to the workpiece.
During use, another piece of bicycle tubing (not shown) was used to insulate unused cables from the workpiece.

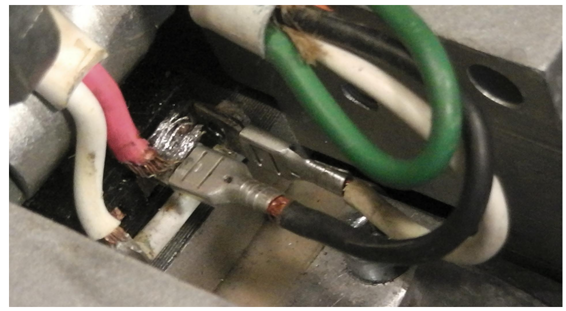
The folded ends of the top flex cables were inserted between the top bolts and clamp plate using the two screws from the top tong holder - to allow for the extra cable thickness. They were tightened evenly to make good electrical contact.

A 12” piece of inner tube was slipped over the top cables for insulation. It did not require fastening because it is held in place by the tip holder.

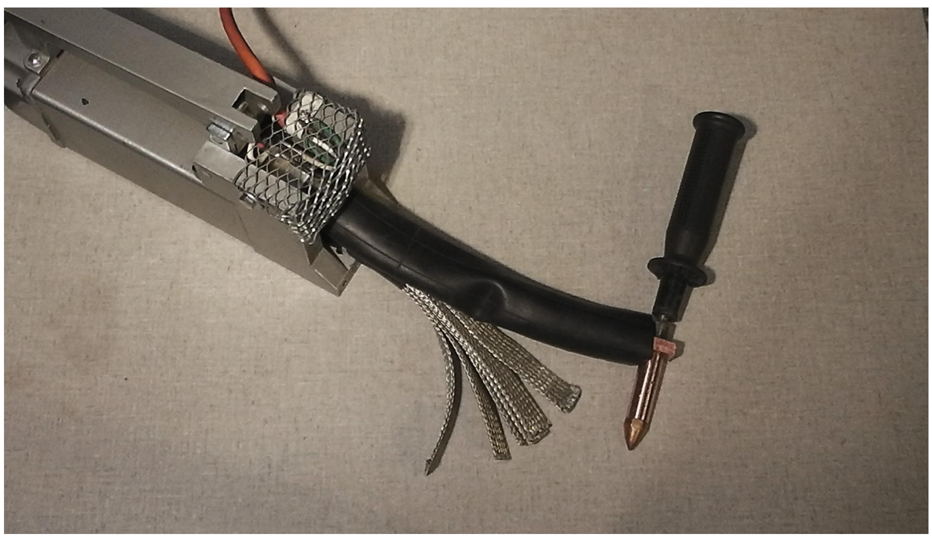
This is the assembled top cable with the bicycle inner tube insulation, the handle, the tip holder and special corner welding tip .

(10)
The foot switch (not shown) was connected across the existing switch connectors with spade connectors by soldering heavy duty spade lugs to each of the switch terminals. The cord is grounded to the frame for safety.

The foot switch is indispensable and allows using either a hand or foot - but the foot wins hands down.



This is the modified assembled welder ready for use.



An expanded metal mesh protective cover was used for fastening the foot switch cable to the welder. It was used rather than a sheet metal cover to increase ventilation.

USING THE BRONZE PIT WELDER

The Harbor Freight spot welder is rated at 50% duty cycle for it's intended use, but this cable setup is <u>far beyond</u> the welder's capacity to operate at 50% duty cycle under full load because of the large size conductors being used. The welder must be protected from overheating and welding must be stopped when the cables get hot. Using the welder at full power for a very short time (a few seconds, not minutes) raises the temperature this high, so it is important to check the temperature and let it cool down, which takes 20 minutes or longer.

The length and size of conductors is critical to power loss in these type resistance welders because of the low voltage, so the shorter and heavier the conductors the more power available. The power required for a weld can easily be adjusted by the number of bottom flex braid cables being used and the distance between the contact point and the weld. For very small pellets, the extra piece of flex cable can be used to extend the length of the bottom cable. For working with small bronze workpieces under 25 pounds, this flex braid cable setup works quite well with this welder and can easily weld 1/8” diameter pellets.

Proper preparation of pits (any weld) is important for good results. Pits are cleaned to bare metal, peened with a small punch to make a slight depression (and rise in the surrounding metal like a volcano) for the pellets to sit in. This allows the pellet to fuse just above the workpiece surface so that when removing overburden and finishing there are no dirt rings. Before welding, a very dilute (water) solution of paste flux is applied. A good weld will be pink around the overburden button from the cleaning action of the liquid flux. Experience has shown that it is a must to make welds with the diluted liquid flux on the weld area, otherwise oxidation occurs and the welds are not always good. These kinds of fluxes are toxic and personal protection is required.

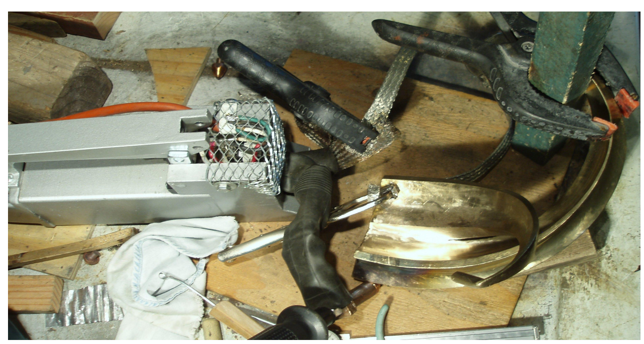
Welding requires stabilizing the workpiece and clamping the bottom cable(s) to the workpiece. Sometimes the welder needs to be raised or lowered in order to clamp the bottom cable, depending on the size and shape of the workpiece.

Welding tips are reduced to 1/16” diameter for small pits, which can be done in a lathe or with a file. During use the welding tips deform and have to be kept clean and to the correct size.
When the tip sparks, there are several possible causes. The most common is that too much power was applied. Or the tip was dirty. Or not enough pressure was used to make good electrical contact. Inadvertent lifting of the welding tip with the power on will cause arcing and pitting – and a lot more work.

WELDING EXAMPLES

This shows a few setups for welding different areas on this particular piece of bronze.

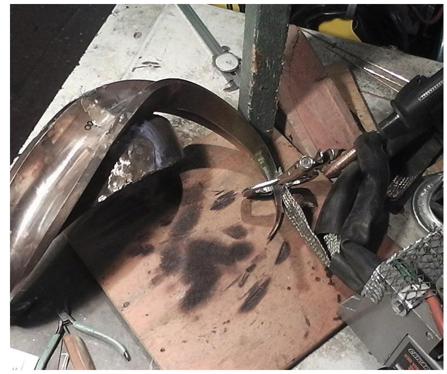
For small welds the extra length of flex cable is used to reduce power as shown in the last image.



To weld, pressure is applied to the pellet or filler material with the tip and power is applied. For small pellets, power is adjusted by using fewer of the bottom cables and/or clamping the bottom cable farther from the weld point and/or using the extra piece of cable. Adjusting duration of the power cycle with a fast flick of the power switch (hand or foot) can also control power applied.

SMALL PITS

This welder setup is a demonstration of welding two small pits 0.020” in diameter in this bronze workpiece. A single bottom cable is clamped to the workpiece about 12 inches from the weld area to reduce power for these small pits.



This sequence of images shows how the pits were welded. The first image shows the two pits circled in black. The second shows the 0.025” diameter pellets in place after applying flux (the stained area). The third is the result of welding these two pits.

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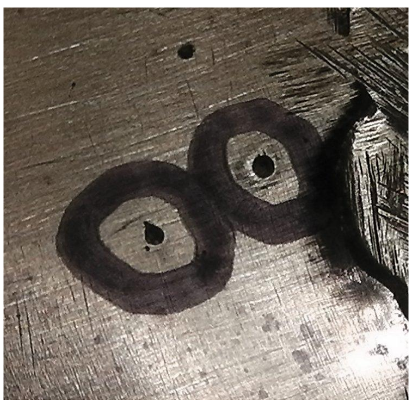

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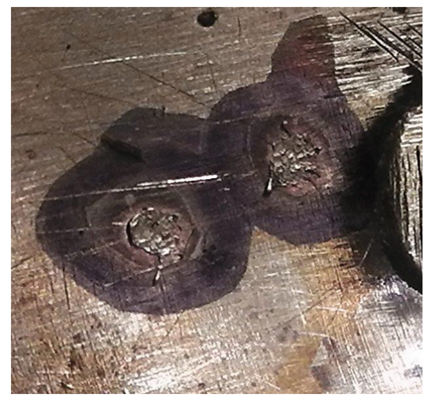

The fourth shows the result of this welding after grinding the surface. Neither weld was successful because the pellets were not large enough to fill the pits and small pitting and rings around the welds are visible. The fifth shows the two pits (still about .020” in diameter) re-welded with pellets 0.40” in diameter. The sixth shows the results of this welding after grinding and re-prepping. One of the welds was dirty and deeper than expected and required another welding session.

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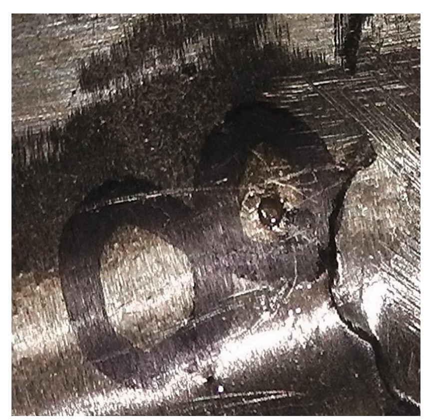

The seventh shows this now larger 0.040” diameter pit welded with a .060” diameter pellet. The eighth shows that success eventually comes with persistence.

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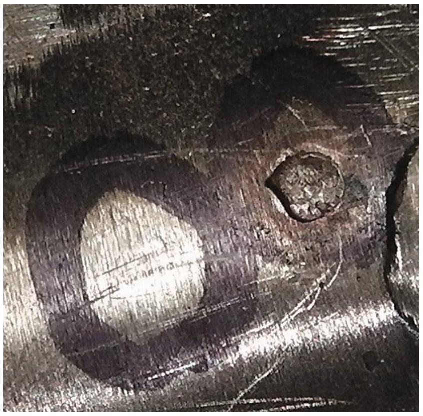

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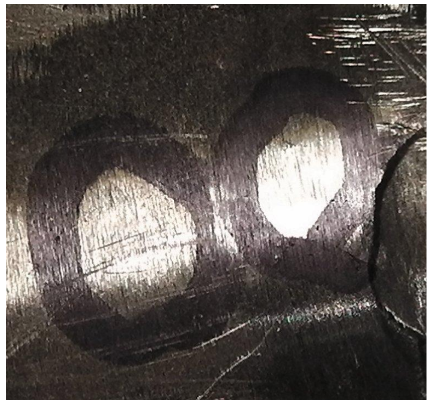

MEDIUM PITS

These three welds are two medium sized pits and a small pit that have been welded with proper sized pellets. The pink rings are a result of the cleaning action of the flux. These were good welds.

LARGE PITS

This is a demonstration of welding large pits. These three pits were cleaned by drilling with a 1/8' drill at various depths in this 10 pound ingot. All six bottom welder cables were connected for maximum welding power.

The first pit was about 1/8” deep and the weld was done using a pellet about a tenth of an inch in diameter.

The first welded pit looks good.

The second pit was about 1/16th inch deep and a pellet larger than the pit was used. The third pit (closest in the photo) was welded with a pit that was smaller than the pit and a second pellet was used to make up the difference. The welded surface was ground and polished with red rouge to show any defects. The first two welds were perfect, but the third welded pit had a ring around it. This weld was peened with a flat punch to show where the edges of the pit and the pellet metal did not fuse.

EDGE “V” WELDS

A welding tip was modified for welding sharp edges by filing a “V” groove in the face of the tip with a square file. Flattened filler rod is bent into an angle to fit over the sharp edge. After fluxing, the “V” tip is placed over the angled filler and power is applied, repeating along the length of the weld area.

The sides of the flattened filler can be welded with the side of the tip holder, but care must be taken to not let the tip holder slip and cause arcing.

FILL WELDS

Filling shallow areas can be done by flattening filler rod to the desired thickness and width, cutting it to size and after fluxing, welding at full power all over, from the center out, in this case using the special corner tip. Large pellets can be used to do this at increased risk of additional pits where fusing does not take place.

FLANGE WELDS

Flange welds are done using a flattened filler rod because balancing a pellet on such a narrow surface is next to impossible. After welding, the excess filler rod is cut off with side cutter pliers.

CRACK WELDS

Cleaned cracks are peened with a small flat dull-pointed punch to create a channel below the surface of the bronze. After fluxing, the channel is welded at full power using flattened filler rod on edge. The finished weld is peened to reduce stress and prevent more cracking. This sequence shows how this was done. The first image shows the punch and filler rod used and the channel made in the crack. The second shows the crack after the first weld with the filler rod in place. The third shows the welded crack.

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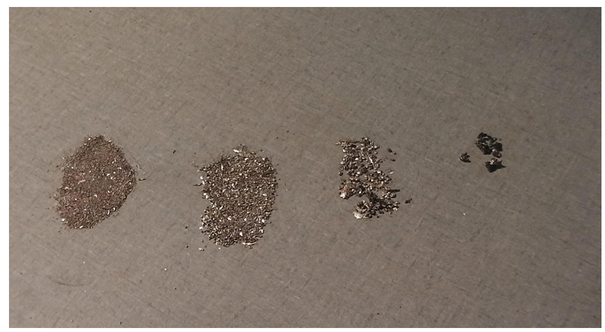
MAKING PELLETS

Pellets can be made individually the desperate difficult way by flattening bronze filler rod on an anvil with a hammer and then cutting the flattened rod lengthwise to make smaller pieces of metal. These thin strips are then cut into small chips with side cutter pliers. The resulting pellet size is dependent on how much metal is in the chip. The chips are spread on a piece of ceramic and each chip is melted into a pellet with a small oxy/acetylene torch until the flame turns green – to avoid black oxidation on the pellet. The pellets are scraped off the ceramic and stored for use. In some instances the chips work well as-is. An example of this tedious pellet making process is shown in the companion video “Bronze Pit Welder Pellets – How They Are Made”.

The easy way to make pellets of all sizes is done with a plasma cutting torch and a piece of bronze stock held in a barrel with water in the bottom. This process makes all sizes of pellets. Some of the pellets are flattened like plates and others have fish tails but are still usable in some places.
Metal that misses the water is wasted splatter.

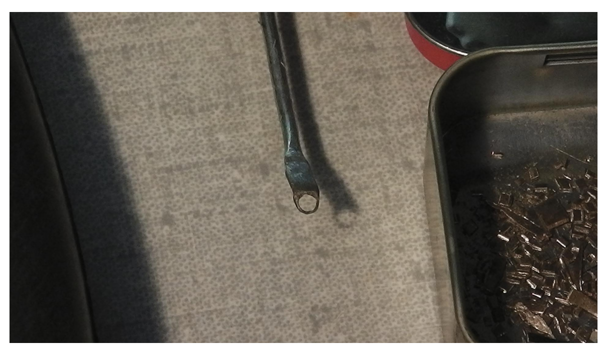
This short plasma session in the barrel using a thick piece of stock and low air pressure. After drying and then sifting through fine and medium sized screens, the percentage of very small unusable pellets is determined. The size of the pellets can be controlled somewhat by the amount of air being applied to the plasma torch and the thickness of the material – less air pressure and thicker material makes more larger pellets.

This is the result of a short plasma session in the barrel using a thin piece of stock with higher air pressure. After drying and sifting, the ratio of large to small pellets is almost reversed from the example shown above, with a large amount of very fine stuff that is not usable.

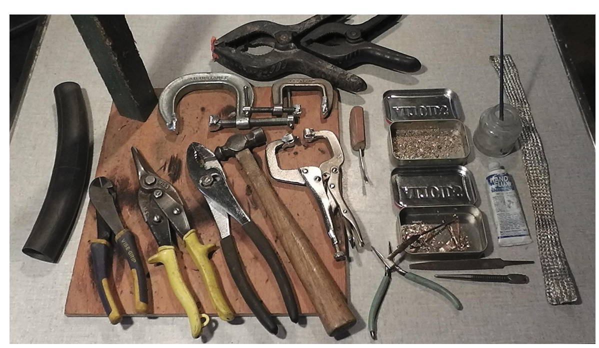


USEFUL TOOLS

This doo-dad pellet mover is a most useful tool that was made from a piece of wire flattened at one end with a 3/32" hole drilled and then made into a ring with a grinder and file. The wire was bent and fit into a small wood handle.



These are other useful tools: The extra piece of flex cable (with the ends soldered to keep them from fraying), diluted brazing paste flux, bronze pellets of all sizes, chips, strips and "V" filler strips, a small file to clean the welding tip, a punch for punching pits, small jeweler's pliers for handling pellets and strips, a small hammer, pliers, metal shears, side cutters, a piece of rubber bicycle inner tube for insulating the unused bottom flex cables, a piece of plywood with a 2x2 post for holding small workpieces in place, clamps with aluminum tips for clamping the bottom cables to the workpiece and various plastic clamps for holding the workpiece.



NOTES

Overheating of the cables and tip holder parts from aggressive full power use results in oxidization to the electrical connections, which increases the electrical resistance, causing even more heating and loss of power. Restoring power is accomplished by bare metal cleaning of the bottom surface of the top cable lug, both ends of the tip holder and the contact face around the thread of the welding tip.

After much use and wear, the ends of the bottom cables weld to the workpiece when clamped. This was fixed by removing and shuffling the cables so that new surfaces are used.

A bottom cable that touches the workpiece and is shorter than the cable being clamped will weld or deform the workpiece where it touches because the electrical current will take the shortest route. This is avoided by insulating unused cables with bicycle inner tube. This can also happen when the cable being clamped touches the workpiece before the clamp point.

The length of the welding tip holder was arbitrary. The 2 1/2” dimension used was made for welding in deep areas. A holder just long enough for top and bottom threads is the minimum necessary. Copper rod 5'8” in diameter can be purchased at many places, including Storm Copper Components, Grainger and other on line stores.

The special corner welding tip that was fabricated from the end of a Harbor Freight extra tong (initially purchased to make the tip holder) was unnecessary as these type tips are available from most welding suppliers.

The dilution ratio of water to flux of the water-based brazing paste flux is not critical. A weak solution is all that is required. When a strong solution is used it will cause discoloration, but works just as well.

The companion BRONZE PIT Welder videos

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Bronze PIT Welder - How It's Used
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