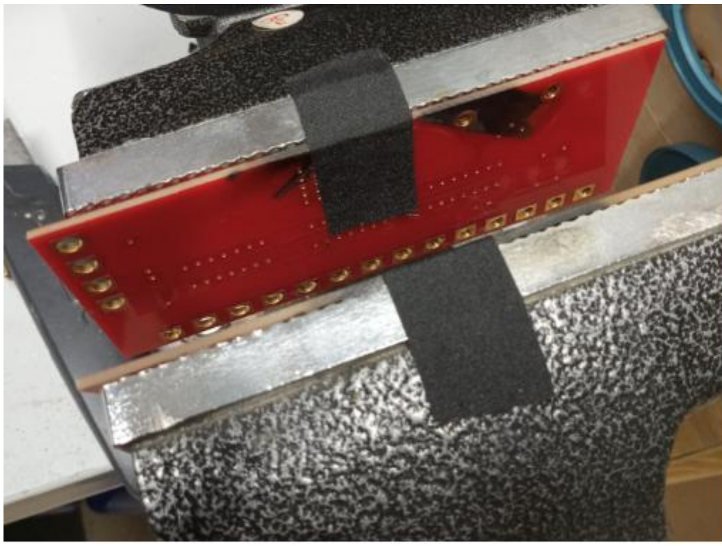
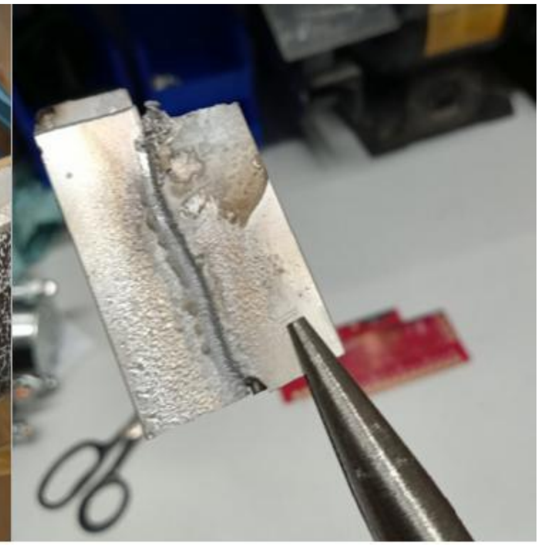
Aluminum Brazing

Contents

Initial Attempts

My first attempt was in a vise using some FR4 material as an insulator. This came out pretty good for a first try (I have 1000s of hours of electronics soldering experience, but zero on aluminum stock.)

However it quickly became obvious that more complex shapes will require a cleverer fixture than a vise. These are pieces off the bottom of an ADT sign! After this I went and bought 1/16" aluminum L bracket at Lowes which was much easier to use.

Note that this was done using a propane torch with a torch head that I'd had laying around for probably 20 years or so.

Attempts with Better Tools

Aluminum Saw Blade

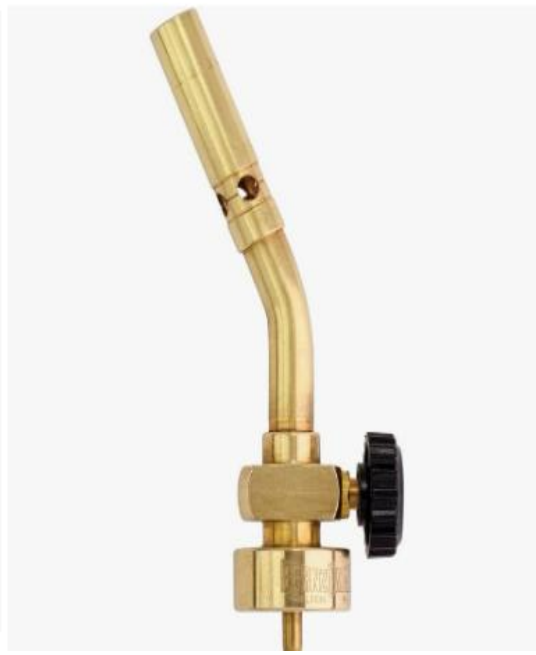
After my initial attempt, it quickly became apparent that I needed a better way to precisely cut the aluminum pieces so that they fit together properly with a clean joint. Using a hand hacksaw was messy, imprecise and time consuming so I decided to get an aluminum saw blade for my miter saw.

I chose COMOWARE Saw Blade- 12-inch 100 Tooth 1 inch Arbor Heavy Duty for Aluminum and Non Ferrous Metals - - Amazon.com but you can use whatever you want. Some reviews even suggest that you can use a basic “wood” saw blade to cut aluminum.

This allows me to cleanly and quickly cut any angle needed on the aluminum stock.

Improved Torch Head & Welding Rods

I ended up choosing the following torch head: [Amazon.com: Master Appliance PT-2000Si Propane Torch Head – Propane Torch Lighter - Optimized High Intensity Adjustable Flame, Heavy Duty Blow Torch Head, Plumbing Tool, Compatible with Propane Tank or Mapp Gas : Tools & Home Improvement]



NEW torch OLD torch

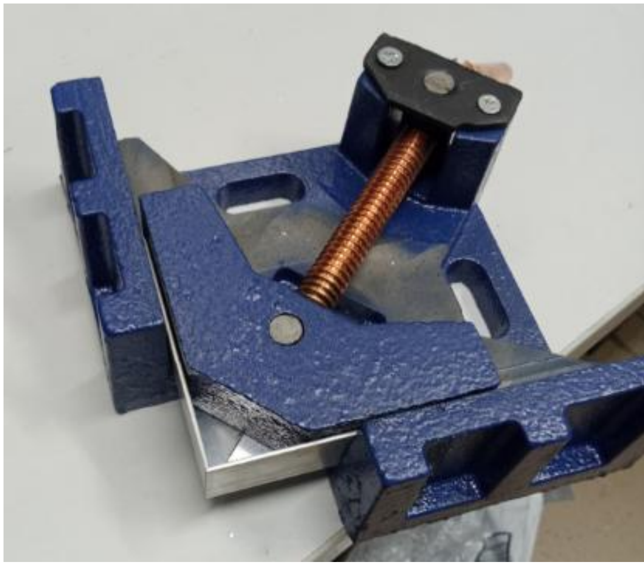
The new torch head provides:

- an improved flame by swirling the gas at the exit tip
- a more comfortable grip
- a push button lighter – a HUGE improvement!
- The ability to turn the flame off without changing the flow rate adjustment

I used the following welding rods, but I am sure there are dozens of others just as good: [100Pcs Flux Core Welding Wire Aluminum Welding Rods 550°C/1022°F Low Temperature Easy Melt Aluminum Brazing Rods Solution Welding Flux-Cored Rods (1/16''x13'') - - Amazon.com]

Welding Clamp

I then tried using a welding clamp (ATPEAM Cast Iron Welders Angle Clamp Heavy Duty Two Axis Welding Clamp Right Angle 90 Degrees Clamp Self Centering Jig and Fixture Clamp for Woodworking - - Amazon.com) which was very difficult because the clamp acted as a heat sink and it took forever to perform the braze. However the braze was good quality, but the entire clamp was red hot afterwards.



Fire Brick & C Clamps

I then found that I could use a "fire brick" (Amazon.com: Lynn Manufacturing Insulating Fire Brick, Heat Insulation Block, Low Thermal Conductivity, 1.25" x 4.5" x 9" Split, Single Pack, 2600-F Rated, for Kilns, Forges, Furnaces, Soldering, 3146P : Arts, Crafts & Sewing) as a base which worked pretty well.

Because the fire brick is a poor thermal conductor, the metal heated much quicker. At first this seemed like a bonus (and it was) but introduced another problem where the metal would "over" heat if I wasn't careful and bend/melt. This is the reverse problem of the welding clamp issue. Using this method required much more skill and practice but eventually I got it down pretty well.

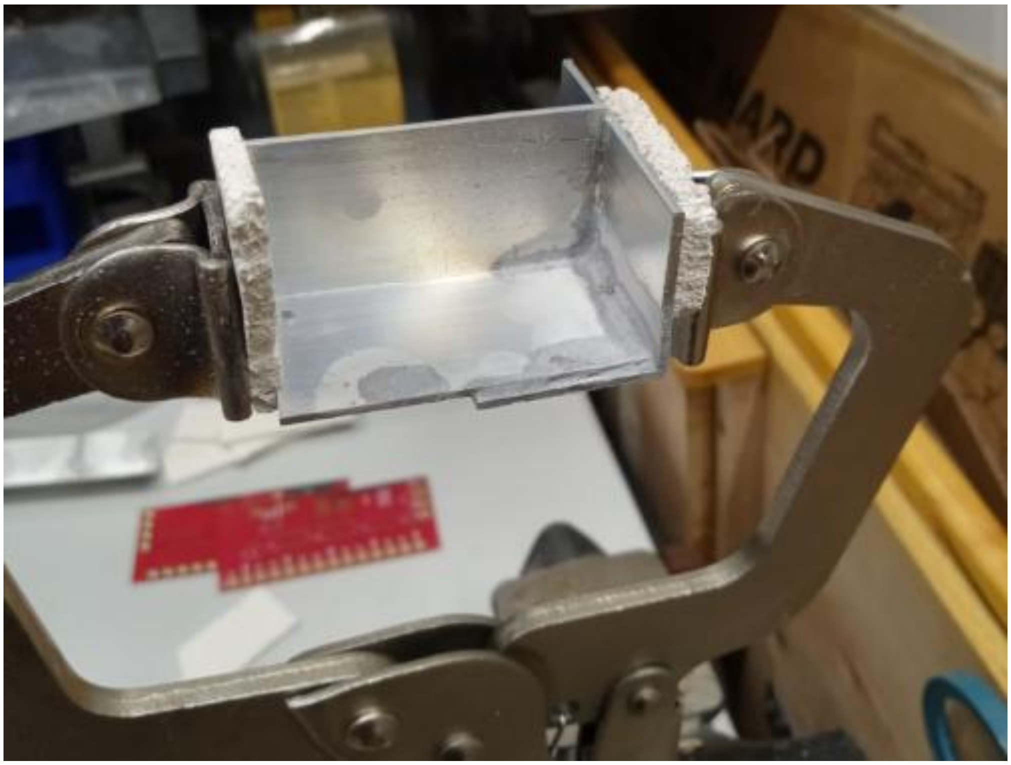
As you can see below I was able to cut an aluminum bracket into multiple pieces and braze it back together pretty cleanly using the fire brick

This worked for simple "butt" joints but not so well for "lap" joints.

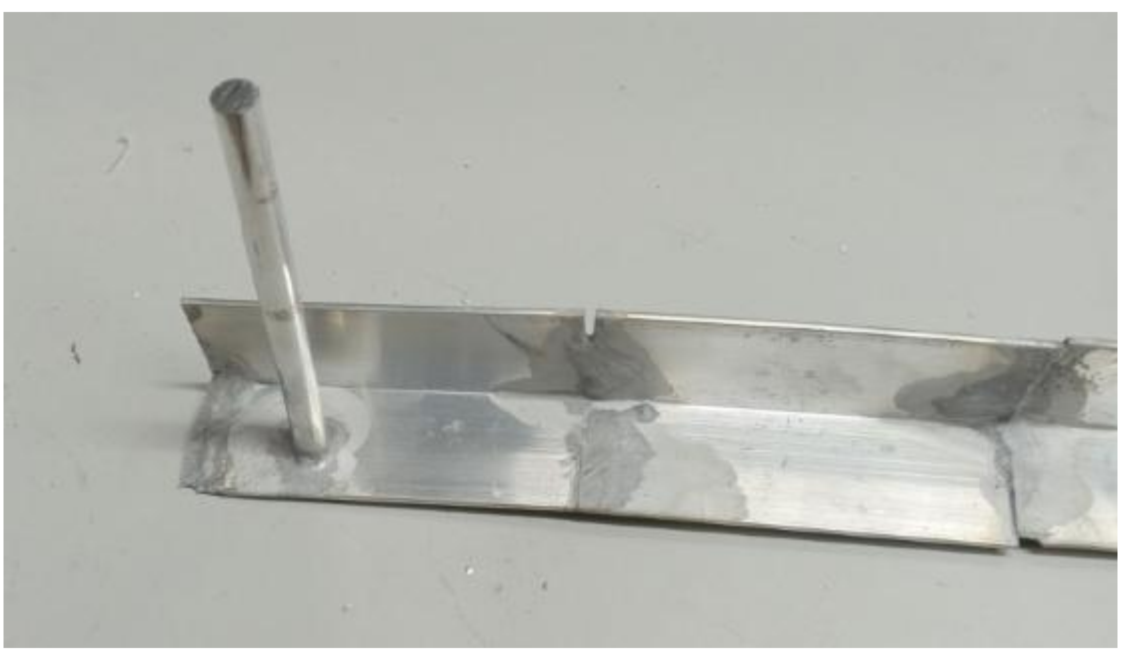
For lap joints I found it better to use C clamps to hold the metal. My first try was not so great as I initially brazed the outer (of 3) joint edges, and the then moved the torch "into" the other two edges to complete them. However the velocity of the torch air flow caused a corner to melt while heating the inside junction- as you can see below.

I then realized that all three joints could be heated from the outer edge. After flowing the solder on the outer edge, you simply keep heating that edge and move the solder to the other two edges. This turned out much better as you can see below.

Ultimately this was further refined by adding thin pieces of the fire brick between the clamp and the aluminum to reduce heat flow into the clamp. This made a big improvement and cut the braze time in half reducing the risk of overheating damage. I'm ordering some ceramic washers for this purpose in the future because the thin fire brick is pretty brittle and crumbles easily.



I was also able to successfully attach an aluminum rod onto the L bracket. This turned out to be easier than I expected. This is needed for the "hinge" portion of the solar panel bracket.



Examples

The following sections give examples of actual projects and how they turned out.

Test Solar Bracket

My first attempt at making something practical was to build a bracket to allow some test runs with a small solar panel.

Building the Bracket

I first built the "U" shaped part of this bracket using 45 degree butt joints which worked as expected using the techniques learned from the previous sections. I then had the more difficult task of brazing a stabilizing bar to the "U" bracket.

As you can see in the picture to the left below this is how I initially setup the fixture. The problem however was that it was taking forever to get the metal hot enough to melt the solder because: (a) the braze point was "on" the fire brick, and (b) there was a "C" clamp just to the right of the braze point.

I then moved the braze point so that it was not making contact with the fire brick, as can be seen in the center picture.

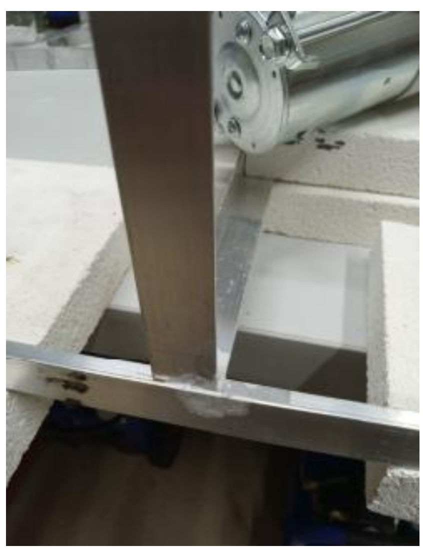
However when the torch was applied to the closest joint edge in the center picture, what happened took me by surprise. Rather than the solder flowing properly, as you might expect, what actually happened was the part of the stabilizing bar to the right of the torch application literally MELTED and dropped on the floor as can be seen in the picture to the right below.



This, of course, is perfectly obvious in hindsight as the brazing would drastically weaken the braze point and the unsupported weight of the stabilizing bar caused it to droop and then fall on the ground.

I then re-designed the fixture to provide support to all points of the bracket around the braze point as can be seen below. Note how a “C” clamp couldn’t be used for the part further back on the table – so instead the material is sandwiched between two pieces of fire block with a metal weight on top to hold it steady.

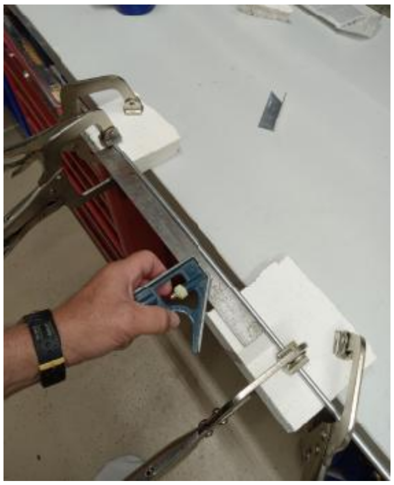
This worked much better. Because I was worried that the “U” section butt joint might melt in the process, I started brazing on the side where there was the least amount of “U” joint material (see left picture below.) I then brazed the back (see center picture), and finally the side where the “U” joint had the most material (see right picture.) Note that there was only a 5-10 second delay between brazing the different sections. Brazing in this order allowed the job to be completed without damaging the already brazed “U” butt joint.


Creating the Hinge – Try #1

I had bought some ¼" aluminum rod that came in 13" length, however it turned out that this was too short (by a few inches) to work in this application. Rather than go back to the store I decided to simply braze two of them together as shown in the pictures below.

The left picture shows the fixture, the center the brazed rods (which don't look too pretty), and the right the rods after grinding and brushing the braze point (which looks a little better.)

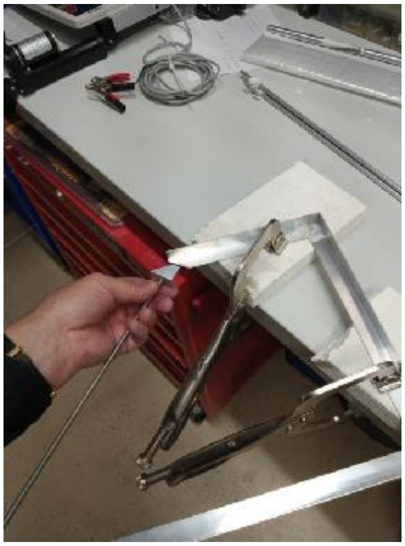


I then cut two "L" brackets to size and attached them to the back of the solar panel. After running the elongated rod through the "L" brackets and temporarily clamping the rod to the frame bracket (from the previous section) the solar panel was able to rotate around the rod axis as shown below.


Creating the Hinge – Try #2

The more I thought about it, using the hinge setup in "Try #1" would be difficult because of the fact that the rod would be brazed onto the bracket and would be very difficult to remove or make modifications.

A solution that "screws" in seemed much more reasonable, so I cut a small piece of aluminum and tapped a ¼"-20 threaded hole into it, and then brazed it to the tip of the bracket as shown below.



I could then use a threaded ¼" rod as a pivot point. Additionally, the modified bracket end was now flush with the solar panel bracket which provided a smoother pivot. This worked much better, as I was now able to easily detach and re-attach the solar panel multiple times as I continued to work on the actuator.

Mounting the Linear Actuator

My original intent was to connect the actuator from the bracket base to the "higher" corner of the solar panel. This presented a big problem as the actuator motion was in a different plane than the hinge motion of the solar panel around the hinge rod. My initial thoughts were to connect the two with some sort of flexible (yet rigid enough to support the panel weight) connection like a spring.

After some time of trying to resolve this dilemma, it finally dawned on me to simply tilt the actuator down and connect it to the "lower" (not "upper") edge of the solar panel. This solved the problem as now the actuator and the solar panel both moved in the same plane!

As can be seen in the images below, the actuator now moves the solar panel through almost 90 degrees of rotation.


Lessons Learned

Material Tips

After doing research on-line, I realized that I had picked probably the hardest case of brazing to practice - 1/16" aluminum. Most reviews suggest that you only attempt brazing 1/8" or larger as a beginner - because of the melting and deformation issues that I ran into.

Fixture Tips

You should fixture the material in such a way that the fixture absorbs as little heat as possible. This would include obvious tips such as the following:

- Use clamps made of thermal insulating material (i.e. not metal) – failing that, place a layer of thermally insulating material (fire brick, ceramic, etc.) between the clamp and the material being brazed.
- Place the clamps as far away from the braze point as possible.
- Clamp the material to the fire brick in such a way that the braze point is not touching anything.
- Do NOT leave any long portions of material "hanging" in the air to prevent them from drooping or falling off during brazing.

Flame Tips

- Use the smallest flame that will get the job done.
    - Yes, this will take longer to heat, but will
        - Allow you more time to determine when the metal is hot enough for the brazing rod
        - Reduce the chance that the flame “wind” will bend, or blow a hole, in the hot metal

The exact setting will depend on your torch head, etc. and you will need to do a bunch of practice brazes to determine what works best for you.

On my torch, it turned out to be about ¼ turn of the gas knob. This resulted in about 30 seconds or so to heat up a joint that was properly fixture.

Welding Rod Tips

It takes a lot of practice to know when the metal is hot enough to melt the welding rod.

You can keep applying the rod to the metal until it finally melts. If you don't remove the flame as the rod is applied, this results in messy joints because the flame tends to cause a piece of the rod to melt off each time – resulting in too much solder. If you remove the flame, then the material starts to cool and the braze takes longer.

If you are doing a lap braze you can cut a piece of welding rod (about 1/3 of the braze length) and position it in the braze joint before applying the heat. Then by positioning the flame in such a way that it "blows" the welding rod "into" the lap joint.

This Works   This Fails

The example on the left above works and the rod melts at exactly the time the material gets to the right temperature. The example on the right fails because the torch wind immediately blows the rod away.

If you watch the aluminum carefully as you are applying heat, you will notice a change on the surface that appears as dozens of very tiny "bubbles" (almost as though you were looking at boiling water) – this is a good sign that the material is near the correct temperature.

Ultimately, this is a skill that requires a lot of practice.