'Fiberglass Heat-Welding'

As It Applies To 3D-Printing

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Foreword:

This document was originally thought of as something like a design handbook – though I am worried that level of technical writing may turn people away. I will instead try to make this something easily digestible and turn to a more design handbook-style document later if warranted. I believe this process can be used to greatly increase the usefulness of 3D printed parts (especially those in fatigue-sensitive applications) without incurring excessive cost (my setup for doing this sort of thing is a seven dollar soldering iron, a Dremel tool with a cutoff wheel, and cheap 3M fiberglass like you find at hobby or home improvement stores – maybe 50 dollars total in supplies). More on the setup required follows in this document!

Introduction:

(Fair warning – this section is mostly just backstory. If you are just interested in the process and techniques and not the justification, you can skip it)

Fiberglass heat-welding is a process I had independently developed when experimenting with repairing a broken 3D printed part. I have later come to find that this technique is not original to me but is used in composite manufacture in industry (albeit with expensive machines and a far more precise approach than will be discussed here). I found that using a cheap soldering iron to re-melt printed parts that experience fatigue along their z-axis (such as magazines that are 3D-printed for firearms) would improve the fatigue life of those parts MASSIVELY – in the case of magazines for AR15 rifles, magazines without treatment would fail after 60 rounds fired from them – while magazines which had been re-melted in the area where the untreated mags failed were able to fire over 600 rounds without failing – over a 10x extension in fatigue life. I used a seven-dollar soldering iron to treat the magazines, so it is easily evident there's usefulness to this technique.

Figure 1: AR15 magazine with re-melted feed lips shown in green

Over the course of later experiments, I found that using a soldering iron to gently re-melt the outer exposed layers of parts can help them in this same way – overall strength and fatigue life are improved by smoothing out the layer lines using heat from a soldering iron. Basic studies into how printed parts break show it almost always occurs as a result of two layers separating and a crack spreading from there. By melting over where that crack would occur, a stress concentration point is removed – and thus a crack will not start there. This concept was tested out extensively during the development of the 'Plastikov' 3D printed AKM receiver – The AKM has a very violent action, and the receiver takes a lot of impact as the firearm cycles. I found that on early versions of the receiver (before I added lots of extra material to reinforce it), cracks would form in the areas of lowest cross-sectional area (which we expect to happen, given an understanding of functional design) – but the cracks would ALWAYS form in those areas of lowest cross-sectional area where I hadn't melted the layer lines together. This was a sure indicator to me that having a smoothed outer surface is key to preventing cracks from happening.

Figure 2: Plastikov receiver cracked along an area that was not re-melted

Now – you're probably wondering where fiberglass comes into the picture. It was during the Plastikov project that I took a sheet of fiberglass and melted it into a broken receiver section in an attempt to bandage the part back together. I did this because I had another part of the firearm I was interested in testing and needed a working receiver for that - I didn't want to wait 18 hours to print another. I simply took some cheap 3M fiberglass and gently melted it into the outer surface of the part, melting enough plastic that the fiberglass became impregnated with melted plastic. After allowing the plastic to cool (roughly a minute) I went to check the stregnth of the repair. I couldn't pull the crack back open by hand. I couldn't pull the fiberglass patch off at all – it was totally fused to the part. I took a Dremel tool with a cutoff wheel to trim off the excess fiberglass and went to test the part. It surived 60 shots without issue, which was all I needed to test the aforementioned 'other part' of the firearm. I was pleasantly surprised at how well that worked, so I turned to reinforcing the entire surface of the firearm that had been cracking with a fiberglass patch – only this time, I did it on a fresh print. Before applying the patch, I had seen failures of this part around 700 shots – with the patch the part made it to 2500 shots before it cracked in a totally different place – a sure sign that the patch had helped. The fiberglass can lend it's huge tensile strenght to the printed part because of how well the melted plastic impregnates and retains the fiberglass – this added stiffness keeps the part from cracking. It was after this success of 2500 rounds that I decided I should make this writeup – there's a lot of usefulness in this basic technique, and when done properly and safely, it can make the difference between a part functioning acceptably and a part functioning exceptionally.

Figure 3: Plastikov Receiver with full fiberglass helt-weld wrap

Supply List:

Soldering Iron: Literally an actual soldering iron – you can use cheap Chinese ones, I recommend NOT using fancy ones – melting plastic seems to work the irons really hard, and I burned out a nice one quicker than I would expect it to last if I had just been using the tool as it is intended.

Dust Mask: This report is being compiled during the COVID-19 pandemic, so this might be a tad hard to obtain at this exact moment. A simple particulate mask will work (or rubber banding a t-shirt to your face if you do not care as much for risk). I use a mask like this one:

Rotary tool with cutoff wheel: I use a Dremel tool, but any cheap rotary tool will work here. You will also need a cutoff wheel – I use cheap ones meant for cutting metal. You will end up using this setup to cut off excess fiberglass. I use a Dremel 3000, but you can go with a cheaper option (even a battery powered one – just get what is readily available to you.

Fiberglass: I bought 12 square yards of cheap fiberglass off Amazon ages ago and I have only used one square yard in the three years since I bought it – you don't need fancy stuff, buy whatever is cheap.

Sandpaper: This is optional, but it is nice to be able to sand down areas where your hands will touch on the fiberglass coated areas – it can be itchy if you do not sand it afterwards. You can also use a metal file or grinding bit with your rotary tool in place of sandpaper.

Re-Melting Technique

We will start by covering the re-melting technique, as understanding it is essential to understanding fiberglass heat welding. Re-melting is simple – you are aiming to melt together the easily accessible layer lines to give a smooth surface to a printed part. Below is an example of a 3D printed Glock frame that I re-melted the outside of – look closely, and you will have a hard time noticing any layer lines at all. It took me roughly two hours, but I applied this technique to the entire outside surface of the frame. As a result, the frame is resistant to cracks starting on its outside – something extremely useful given the loads and use firearms are subject to.

Re-melting is easy to do. You will need your soldering iron, the part you wish to re-melt, and potentially a dust mask – if you're re-melting ABS or any plastic with hazardous fumes (or anything you don't like the smell of) I recommend you wear a mask and/or do it outside or in a well ventilated area.

1.) Take your soldering iron (set to its highest setting) and gently glide it along the surface you want to re-melt. Do not push very hard, let the heat soak into the plastic. Work on small areas at a time so that you do not overheat the part (which could cause warping). You can blow on the area you are re-melting to cool it.

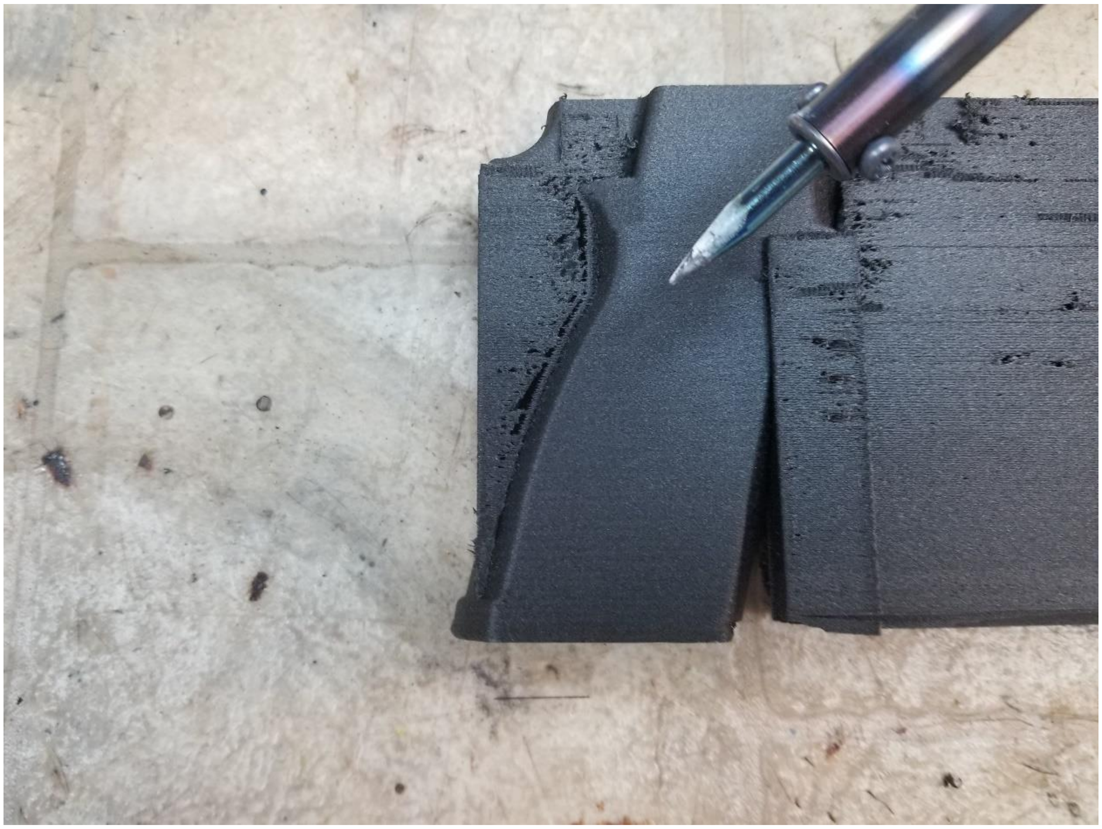

Figure 4: Printed part ready to be re-melted. Usually you would remove supports before this process.

2.) Continue to re-melt the part until you have completed all the re-melting you wanted to do – this could be all the outside surface of a part, just one spot on the part, or some pattern of your choosing. You can go back over areas you missed or did not melt enough – just take care to not overheat the part.

Figure 5: Example of a spot re-melted. Note the change in surface appearance and disappearing of layer line pattern.

3.) Generally speaking, there's no need to re-melt very deep into the part – you can melt until the layer lines are no longer visible, but don't need to go beyond that point.

Figure 6: Another look at the finished appearance.

4.) Let the part cool fully and function test it. Make sure there are no uncomfortable ridges or humps as a result of the re-melt – if there are, you can smooth them out with the soldering iron or sand them away.

And just as easy as that, you have increased the strength of your part while also increasing its fatigue life – for little cost and little effort. Following are a few pictures showing the process on a different part:

Figure 7: Another example spot re-melted - note the disappearance of layer line pattern.

Figure 8: Another angle on the re-melted spot.

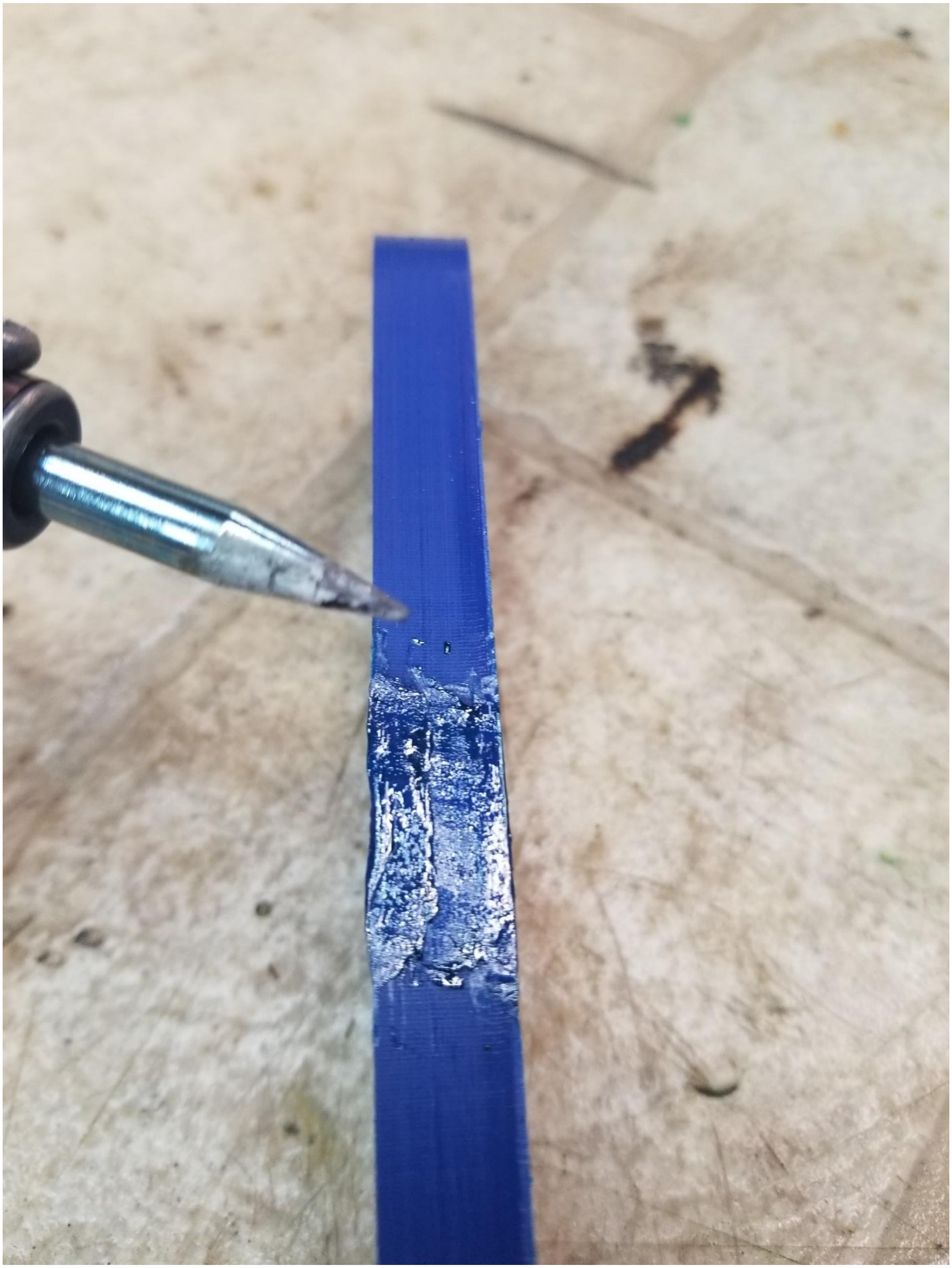

Figure 9: Re-melting applied to the side of the part. Note the layer line pattern disappears, and the finish is shiny.

Fiberglass Heat-Welding Technique

Now that we understand the re-melting technique, we can apply that to fiberglass heat-welding. The general process is just like re-melting, only you place a sheet (I refer to them as patches) of fiberglass on top of the part before re-melting. When you do this, the melted plastic will impregnate the fiberglass and adhere it to the part – giving the benefits of re-melting and adding the benefits of a fiberglass composite shell.

1.) Like with heat-welding, you will take your soldering iron and melt the outer layer of the part – only this time, place a fiberglass patch over the part first. You do not need to cut this patch to size ahead of time, leave it long and hanging off the part. Arrange the patch so it fits against the part without any slack – you want it flat as possible against the part before you start melting it in.

Figure 10: Fiberglass sheet drawn tightly over the part. As you move to melt plastic into it, hold it tight - clamps may help you.

2.) Once you have got the fiberglass patch laid out on the part, you can begin to melt the sheet into the part. Begin with just melting the patch into the part in once place – melt until the fiberglass changes color (this means it is soaking the melted plastic between its fibers). Let that first spot cool fully and ensure that the patch is stuck down by it by pulling gently on that spot – if it is well stuck, you are good to continue melting the rest of the part, trying to keep the same general appearance (color and look) as the first spot you melted in. If your first spot does not seem very well held, try melting it a bit more.

Figure 11: As with re-melting, gently press the soldering iron onto the part.

3.) Continue to melt all the way around the part. Be careful on corners, edges, and areas that have thin perimeters – you can damage them if you are haphazard with your soldering iron handling. There may be a couple spots where your patch will not stay stuck to the part – this is likely because you did not have your patch flat and taught enough to the part when you were melting it in. If there are only a few places like this, do not fret – it is unavoidable sometimes. If big sections of your part are affected by this issue, you may have to throw out your part – it is very difficult to unmelt the patch off the part in order to attempt to redo it.

Figure 12: Note the appearance of the heat-welded spot. The blue plastic has soaked into the fiberglass in the area treated.

4.) Once you have all the part that you wanted to treat masked with fiberglass, you are ready to cut the excess fiberglass off. You should wear some sort of mask to prohibit breathing in chopped fiberglass when doing this. I found a rotary tool (like a Dremel tool) with a cutoff wheel works great for trimming the excess fiberglass off. Be conscious of the fact that fiberglass is stringy and can wrap around the rotary tool's shaft. Do not run your tool very fast and try to keep the strands away from the shaft. If you are a clumsy person, wear gloves just to ensure your hand does not meet your cutting wheel – not life threatening, but it is not comfortable. Do note that if you use a cutting wheel, fiberglass strands will settle on your hair and clothes.

Figure 13: Trim the fiberglass away using a rotary tool. Be careful to not tangle loose strands on the tool!

5.) With the excess fiberglass cut away, you can now take sandpaper and sand down anywhere that feels rough – remember that fiberglass can be very itchy, so it's a good idea to sand down the places where you will be touching.

Figure 14: Excess fiberglass cut away

By following this process, you will greatly increase the strength, fatigue life, and stiffness of your part. I'll attach a few picture of parts I've applied this technique to – generally speaking, if you have a part that usually fails in one particular part (due to fatigue or lack of strength), and there's ample wall thickness to re-melt it, you can apply this technique to extend the life of that part.

Figure 15: A look at the relative straightness of the part maintained after heat-welding.

Figure 16: Another look at the flatness of the part's face maintained after heat-welding.

Troubleshooting/FAQ

I do not imagine much troubleshooting issues coming up – but I will try and anticipate a few.

1.) Why isn't my plastic melting?
    a. It could be possible that your soldering iron is not getting hot enough – ensure it is turned all the way up if it is adjustable, if not, get a cheap one like is linked in the supply list.
2.) Why isn't my fiberglass patch sticking?
    a. You must let the plastic cool fully before the fiberglass patch will stay stuck. Additionally, if you didn't prepare your patch by pulling it flat against the faces of the part, it may try and bow away from the part – there's not much you can do to fix this if the rest of the patch is already stuck down.
3.) Does this have applications outside of printing gun-related items?
    a. Unquestionably, yes – I just use gun-related items as examples here because they offer a good platform for demonstrating functional prints in high performance environments – things like AR15 mags and AKM receivers model different types of fatigue and load cases where these techniques can be put to the test.
4.) Where exactly can these techniques be applied?
    a. Anywhere you would like to try them – so long as your walls aren't so thin that your part will be damaged by re-melting, you can try applying it. Different soldering iron tips can help you match the contour of different shaped parts.