THREADING 3D PRINTED PARTS: HOW TO USE HEAT-SET INSERTS

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55 Comments

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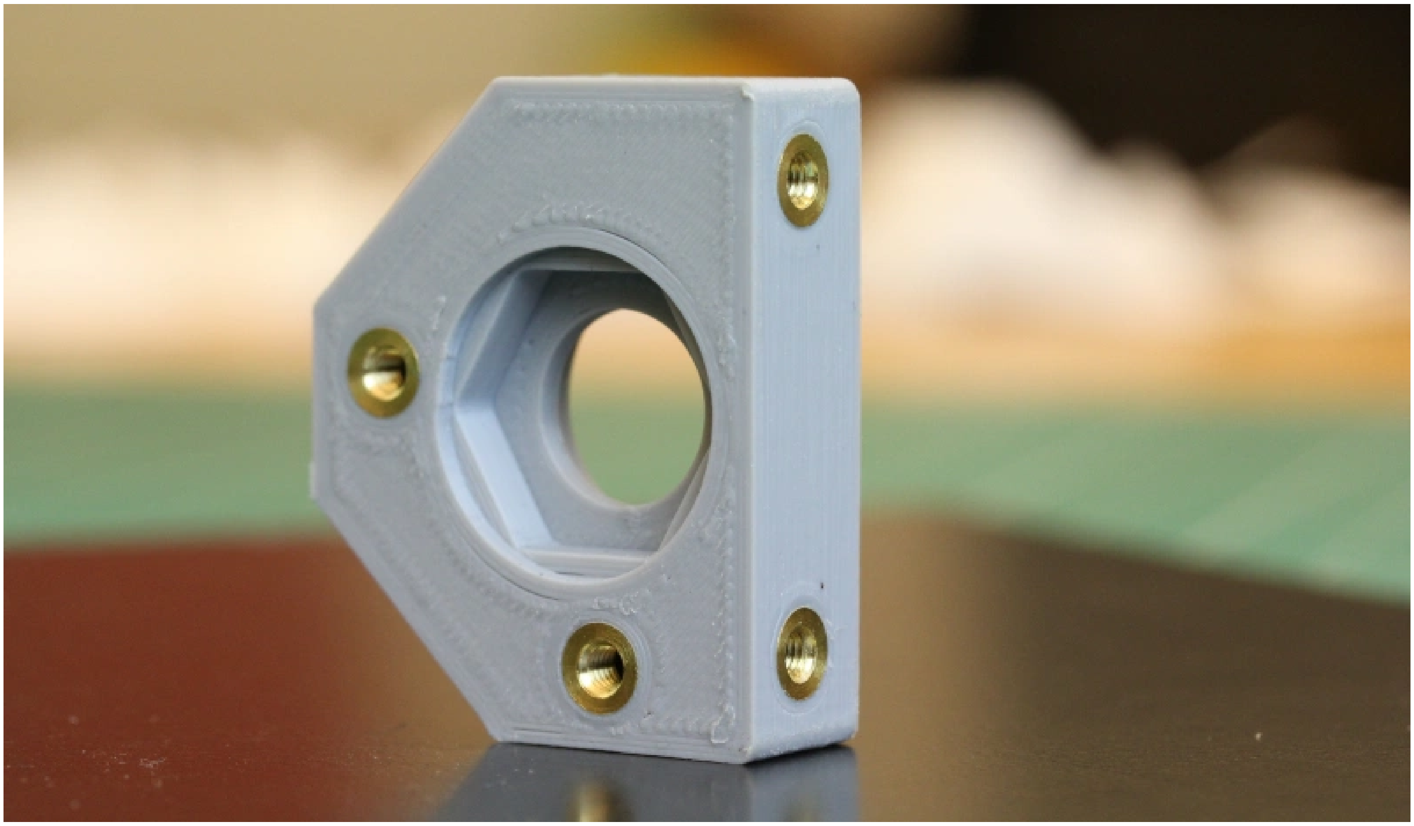

We can make our 3D-printed parts even more capable when we start mixing them with some essential “mechanical vitamins.” By combining prints with screws, nuts, fasteners, and pins, we get a rich ecosystem for mechanism-making with capabilities beyond what we could simply print alone.

Today I’d like to share some tips on one of my favorite functional 3D-printing techniques: adding heat-set inserts. As someone who’s been installing them into plastic parts for years manually, I think many guides overlook some process details crucial to getting consistent results.

Make no mistake; there are a handful of insert guides already out there [1, 2]. (In fact, I encourage you to look there first for a good jump-start.) Over the years though, I’ve added my own finishing move (nothing exotic or difficult) which I call the Plate-Press Technique that gives me a major boost in consistency.

Join me below as I fill in the knowledge gaps (and some literal ones too) to send you back to the lab equipped with a technique that will give you perfectly-seated inserts every time.

HEAT-SET INSERT “THEORY”

Heat-set inserts are stock parts that add threads to a part made from a thermoplastic. Since 3D-printing relies on oozing plastic out of nozzles, literally every single 3D-printed material fits the definition for thermoplastic–so they’ll all work! As far as matching techniques go, it’s almost like these inserts were made for each other! (Alas; they weren’t, but thankfully injection-molding plastic has made these parts a commodity.)

Heat-set inserts work by softening the surrounding material as they’re being installed. Once installed, removing the heat-source causes this molten plastic to re-solidify around the inserts’ knurled feature, holding it in place. Let’s consider thinking about this process in terms of heat transfer. Installation holes are smaller than the inserts themselves (they’re *undersized*), so we can’t install inserts by hand force. Rather, we first heat the insert and then conduct that heat into the surrounding material such that the hole deforms, accommodating the larger shape of the insert.

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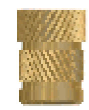
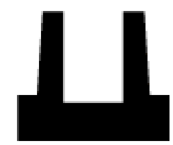




As more time elapses, heat transfers from the insertion tool, through the insert from surface area contact, and finally outwards into our 3D-printed part, where it dissipates. The longer time spent inserting the part, the more time the heat has to travel into the part where it can deform the surrounding part areas. In large scale manufacturing, this process is done by machine. In our case, though, we’re installing by hand, so we’ll need to keep our timing in mind. Finally, don’t forget that when we install the insert, we’re *displacing* molten plastic to make space for the heat-set insert. That displaced plastic needs to go somewhere, and it usually ends up mushed at the bottom of the insert.

THERE’S A TOOL FOR THAT

Our tools need not be expensive. I use an insert “installation tip” combined with a budget 40W soldering iron from Amazon without any temperature control. These “installation tips” aren’t particularly special, but, unlike soldering iron tips, they aren’t tapered. Using a tip without a taper makes it easy to remove the tip once the insert is installed.

You can find inserts on McMaster-Carr (pn: 92160a115) or on Tindie. (I admit that I use the McMaster-Carr one for 4-40 and M2.5 inserts, but also with M3, M4, and M5 inserts without any issues!)

I strongly discourage using a vanilla soldering iron tip for the following reason. Most of these tips are tapered. If we use a tapered soldering iron tip, we risk getting the iron tip stuck in the insert. Remember: metal expands when it heats up and contracts when it cools. As we install the metal insert into the printed part, we're dissipating heat from the insert into the part, causing the heated insert to cool slightly and also contract around the iron tip. The net result is that when we try to pull the iron tip out, the insert comes with it! I imagine that this scenario is akin to a Chinese finger trap.


"Inserts" for a soldering iron. Image Source: Virtjoule on Tindie

All that said, this problem wouldn't happen too often for me back when I used a vanilla soldering iron tip for this process, but 1-out-of-5 ruined prints was enough for me to scrounge up the extra $10 and get the right tip.

Finally, my last tool for this process is a small square of thin sheet-metal, about 150x150mm (6″x6″). This sheet becomes a "flat" reference that I'll discuss in the process later.

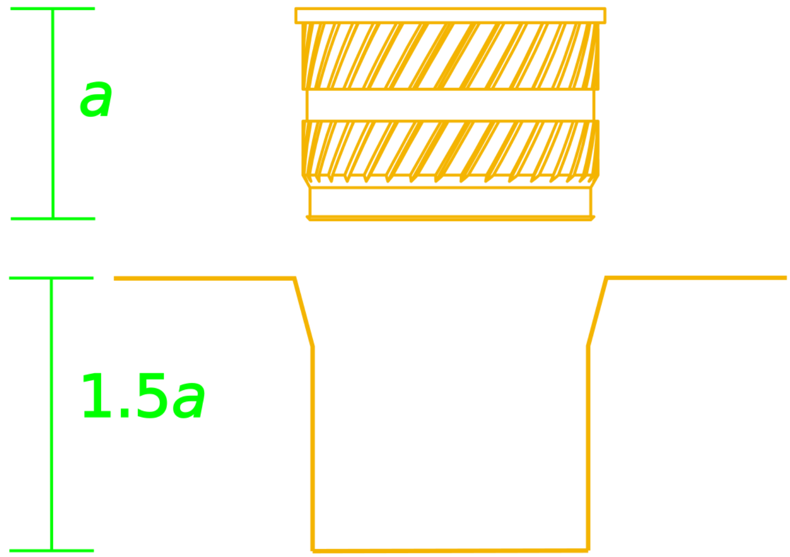
DESIGNING FOR INSERTS:

When it comes to sizing holes for inserts, I'd recommend following the dimensional info that comes with the insert datasheets. As a quick reference, here's a mini compendium of links for some of my go-to inserts and their hole size recommendations.

- UD-43030 short M3x0.5 insert (relevant dimensions, vendor)
- 94180A331 M3x0.5 tapered insert (relevant dimensions and vendor)
- 93365A120 #4-40 tapered insert (relevant dimensions and vendor)

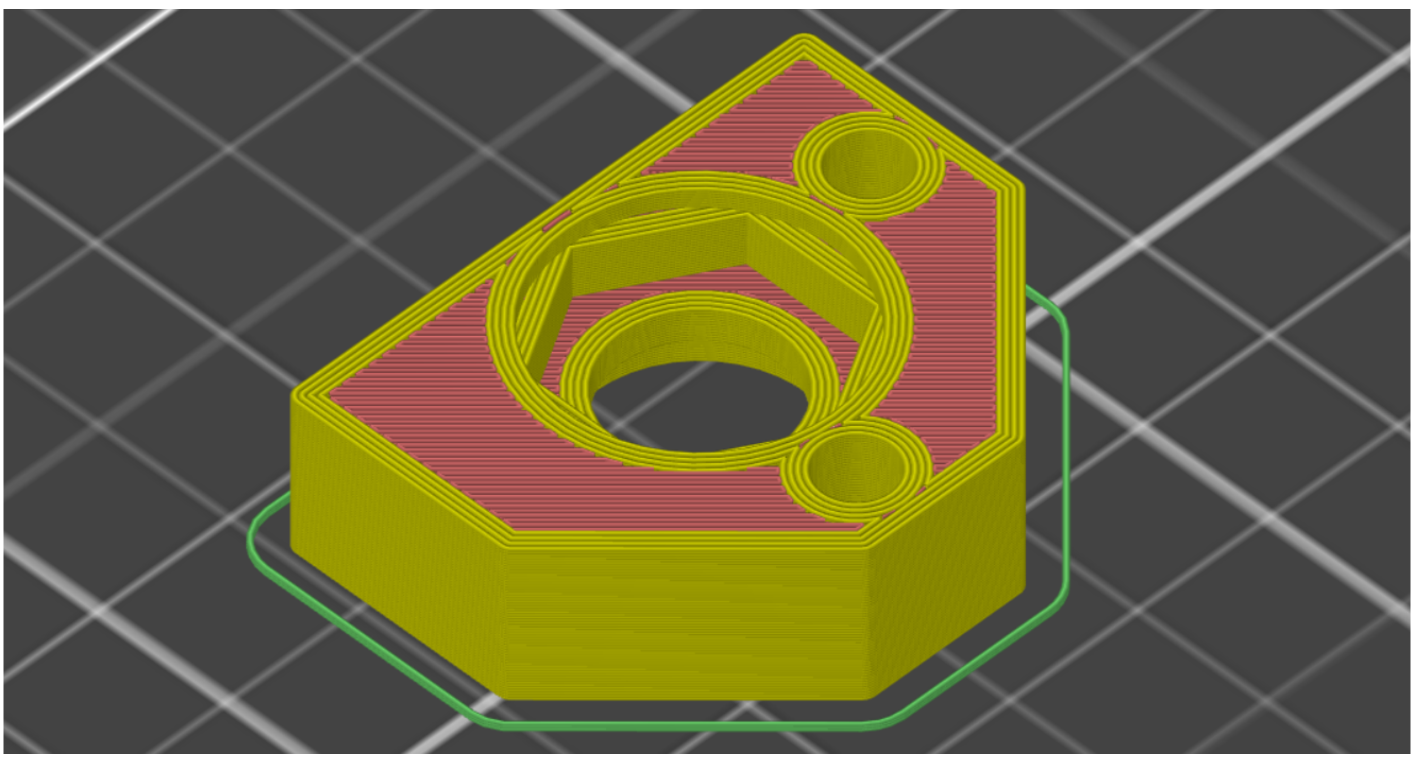
To accommodate displaced material, I suggest increasing the hole depth by about 50% of the insert length. This change ensures that the displaced plastic has somewhere to go and doesn't fill up the cavity where the insert should be.

Other guides suggest adding a small taper to the hole feature. This is a nifty feature that enables inserts to seat themselves into the hole before installing them with heat. Some inserts are themselves tapered, which has the same seating effect on an un-tapered hole. Adding this tapered feature (or buying the slightly-more-expensive tapered inserts) isn't necessary, but it does make the installation process easier.



SLICER SETTINGS:

With a design ready-to-go, I'd recommend tweaking one 3D-printer Slicer setting first, namely the perimeter layers. Slic3r defaults to two perimeter layers for hole features. I'd recommend bumping this value up to at least 4 perimeters for two reasons.

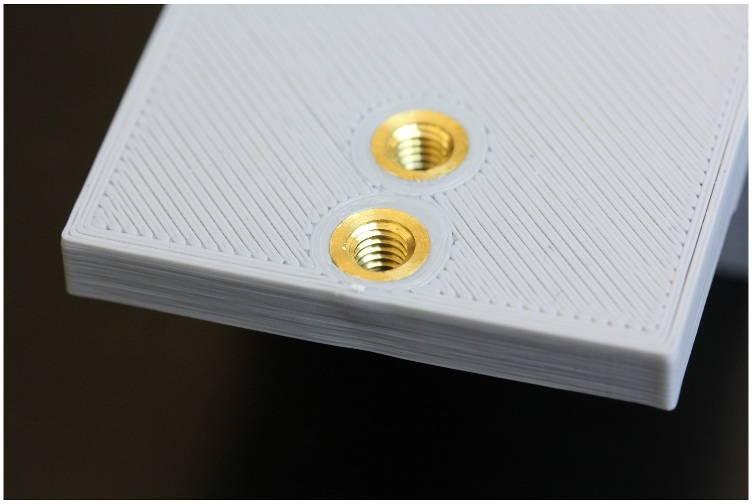


4 perimeter layers for added structure and reduced sink marks

First, we want to make sure that our installed insert is still "grabbing" onto material after we install it. An installed insert displaces material *outwards* during installation, so adding layers improves the odds that we haven't melted through it upon installation.

Second, adding more perimeter layers also reduces the extent to which external indentations form on the part when inserts are situated close to the external surface of a part. These indentations are called *sink marks*, and they're actually a common problem found in injection-molded parts too. Sink marks occur because a part contracts as it cools. I've discovered that adding more perimeters reduces this effect. I can't say for sure why this is the case, but my best guess is that adding solid material reduces the free space inside the part, making it more difficult for internal geometries to change shape.

Sink marks on the perimeter of the part (view a)



Sink marks on the perimeter of the part (view b)

THE INSTALLATION PROCESS AND THE PLATE-PRESS TECHNIQUE:

Now that we've got a handle on designing and prepping parts for inserts, let's get to the installation procedure.

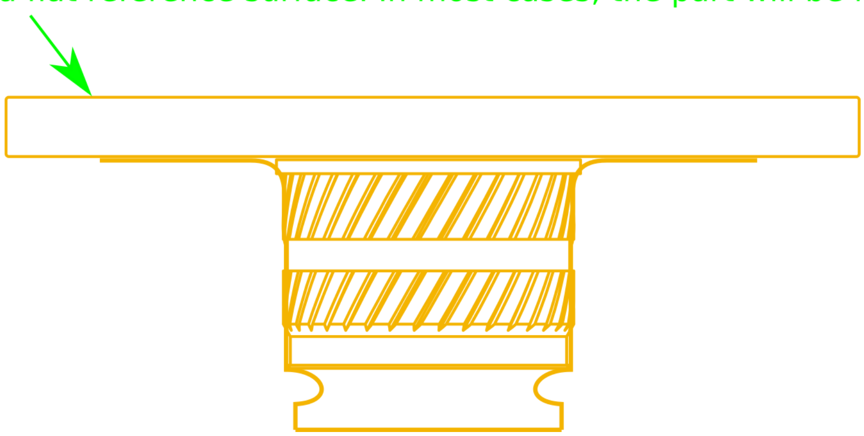
First, make sure that your soldering iron has *completely*reached its set temperature before using it to install inserts. If we try installing an insert while the iron is still rising to its setpoint, the process just takes longer, and all that heat from the iron is spending more time diffusing into our part, causing it to warp.

Next, with the insert positioned in the hole, apply heat to the insert. Let the weight of the soldering iron tool itself apply the gentle force needed to push the insert into position. Gravity should be doing most of the work here. This process takes about 10-15 seconds. Keep applying heat until your insert is about 90% seated into your part.

Remove heat when insert is ≈90% seated.

Ok, here's where we derail from convention. With the insert at about 90% into you part, remove the iron and *quickly* flip the part onto a flat, heat-resistant surface and gently push the part down until it seats flush with the material. (I use a small piece of sheet metal for this step.) Wait about 6-10 more seconds for the part to cool, and you're done! I'll call this maneuver the *plate-press technique*.

Let insert cool on a flat reference surface. In most cases, the part will be flipped upside-down.



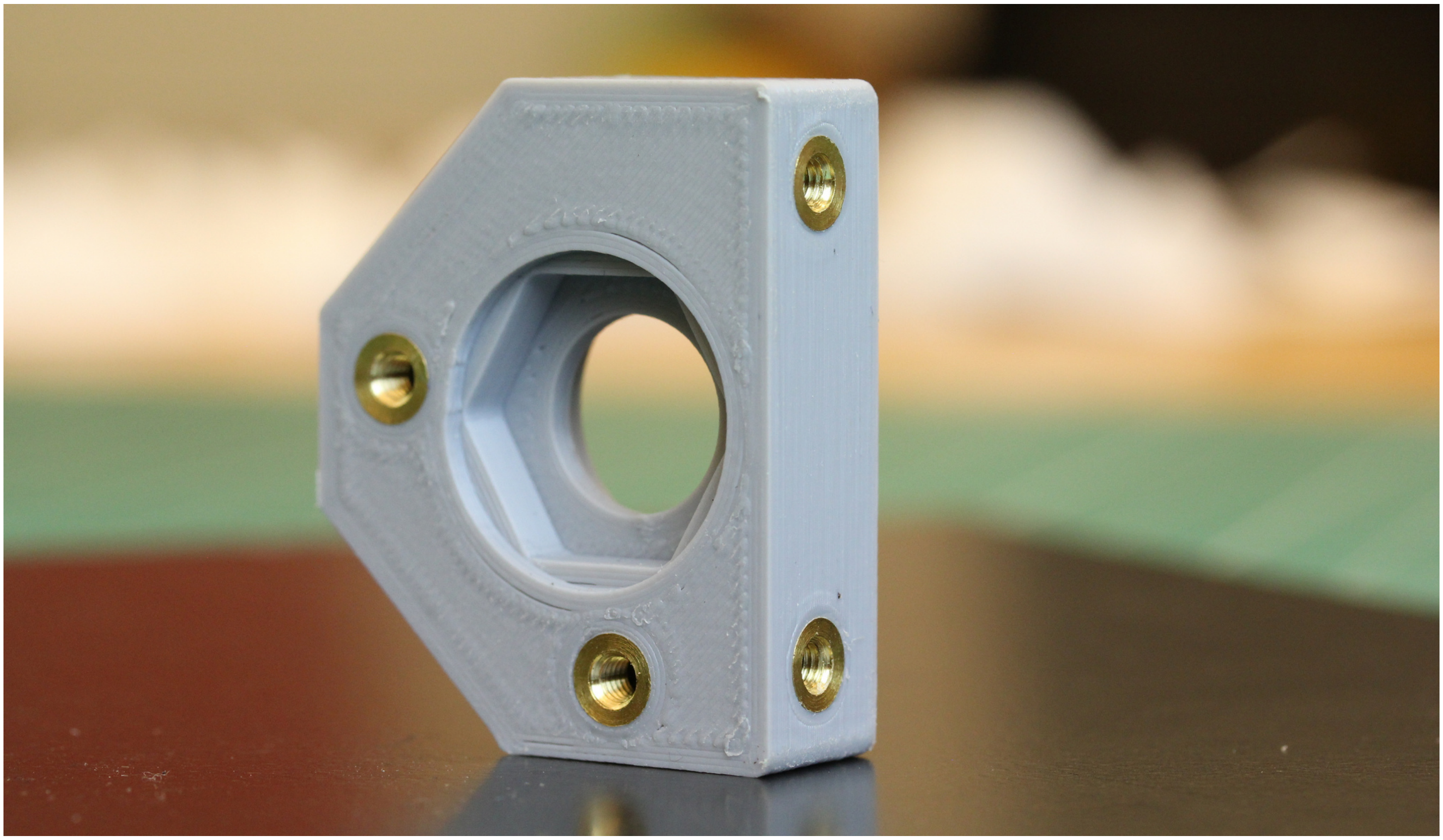
This final step of the process seems odd, but it's critical for two reasons. First, it seats the insert so that it's both vertical and completely flush with the top of the printed part. Second, it flattens any bulging material that flared up while we were installing the insert.

using the plate-press technique

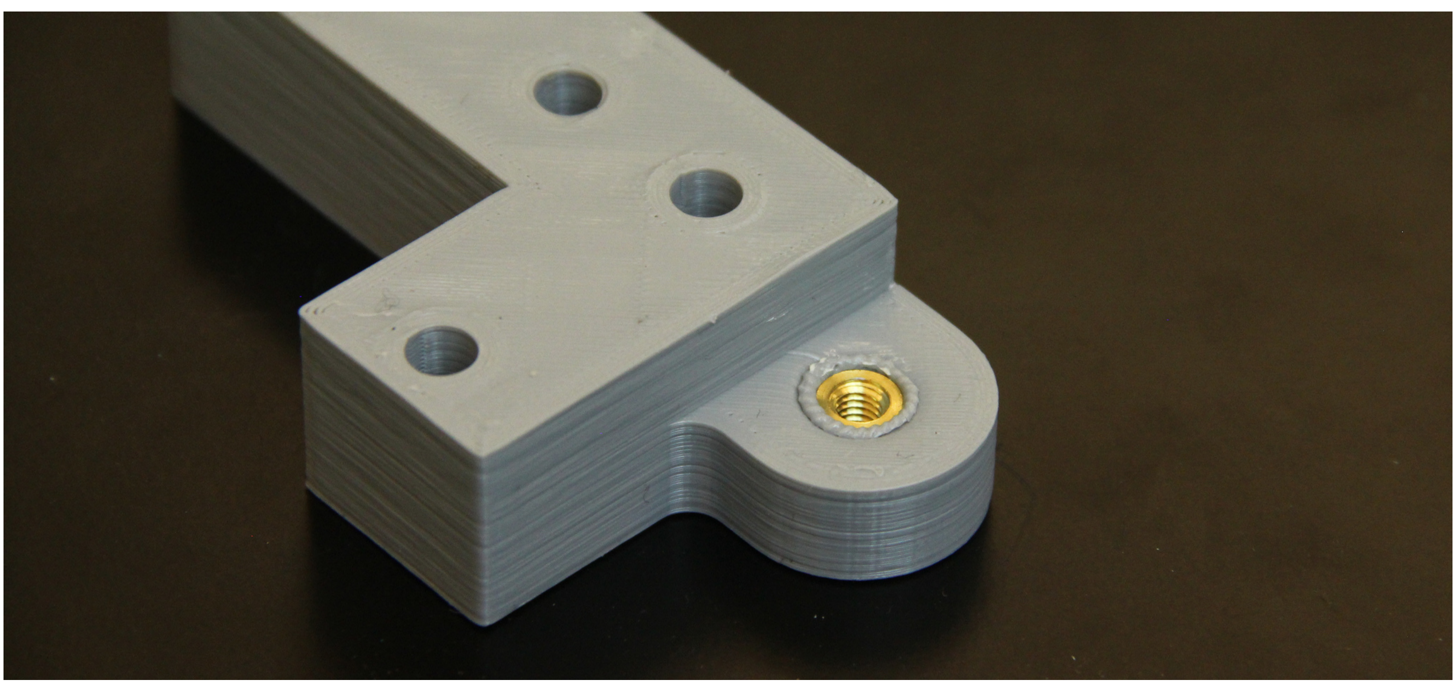
without using the plate-press technique

Results

If all went well, you should have a nice-looking insert that's flush with the part surface. In the image below, I used the iron to seat these parts most-of-the-way in and then cooled them flush with the plate-press technique.



In the next example below, this insert was set without using the plate-press technique. Notice that nasty "bulge" of excess material that beads up around the insert. That's precisely the bulge that we can remove when we use the final plate-press technique.

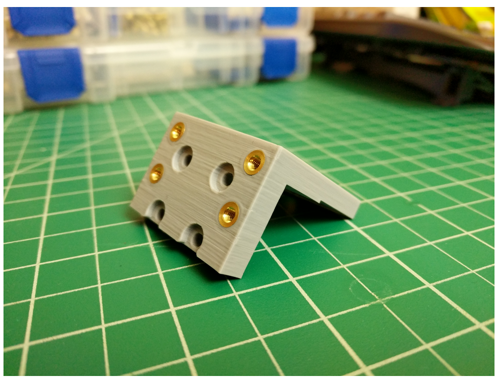


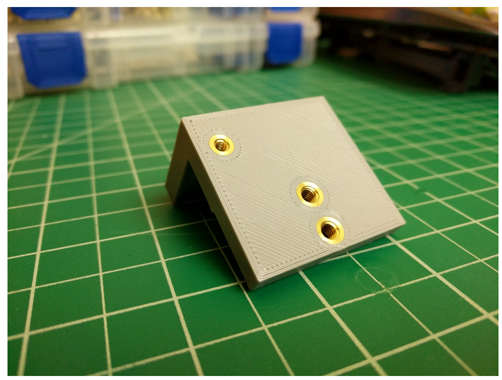
REFLECTION:

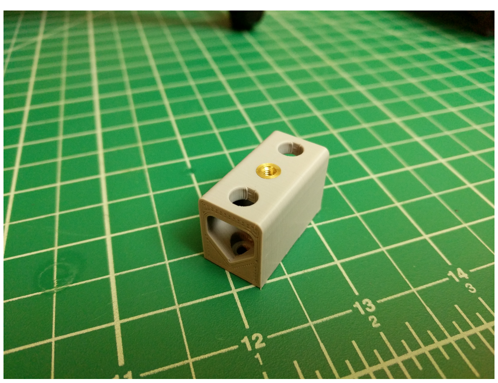
I imagine that tweaking both our iron temperature and insertion speed might reduce or eliminate this bulging effect if we practice installing these inserts under various conditions. But that hypothetical need for practice is exactly what makes the plate-press technique so valuable. Simply put, the plate-press technique gives us consistent results without the need for robot-levels-of-precision. We simply “smoosh” the insert into its final place and be done with it. The result is a flush insert with little effort and no practice. Admittedly, this technique is not how the industry folk do it for mass-production, but it sure is consistent — a hack even.

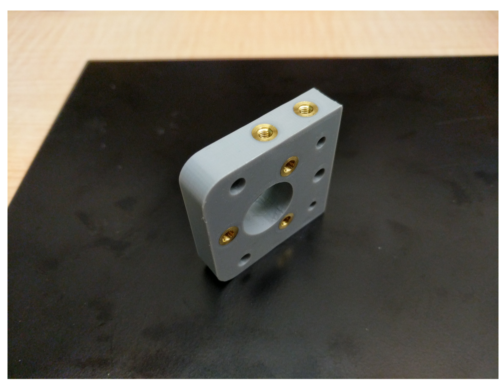
CONCLUSION:

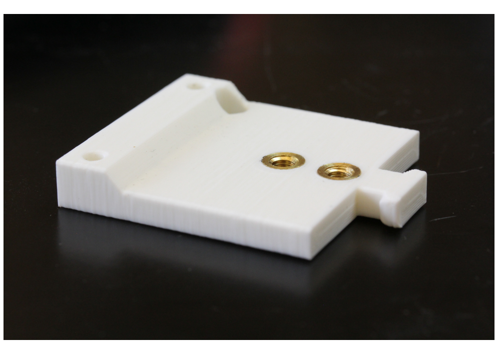
That’s it! I hope this guide serves you well in nailing beautiful flush inserts every time without too much hand hassle. Here’s a quick snippet of a few other parts I made to put some perspective on what to expect.

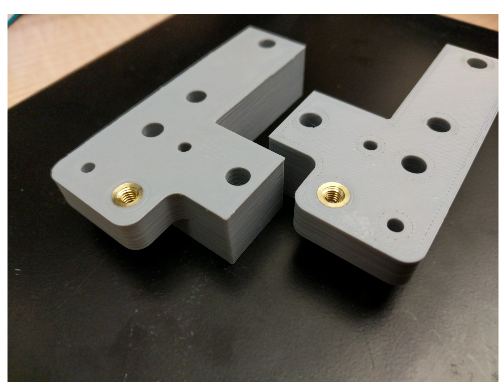












I've started posting my wares up with #beautifulinserts, and I'd love to see how this technique fares for you. If you make anything fun, why not inspire some fellow community members by joining the conversation?

REFERENCES:

1. https://markforged.com/blog/heat-set-inserts/
2. https://www.ptonline.com/articles/four-ways-to-tackle-threaded-inserts-for-plastics