Lessons in Manufacturing and Prototyping

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This blog series documents how I leveraged my manufacturing experience, materials science knowledge, mechanical engineering and prototyping skills to resolve real-life production or quality issues. The blogs are meant to crystallize the learnings, to educate, and to start conversations.

In the previous blog, we identified a weak point in the design of failing chair brackets and improved on the design (adding a filet), only to find out that producing these using established suppliers was prohibitively expensive. We were in the position similar to many hardware teams, with a need to create parts on a low budget.

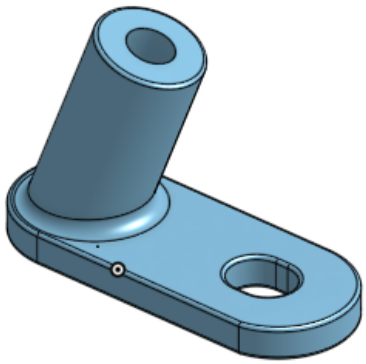

Figure 1. Improved chair brackets.

Because the part requires the hole of the top tube to be at a precise angle in two different planes, a fixture would be needed to accurately drill it in a solid block or metal.
One could think of welding a tube (instead of drilling the hole) at the correct angle on a plate. But the need for a fixture for repeatability is also needed.
Since that fixture would have to be designed and machined, we would incur additional costs which would be hard to amortize on a batch of 6 units.
One option to produce with reasonable accuracy, repeatability, in low volume, and at low cost is to cast in a Silicone or Polyurethane rubber mold. The pros and cons of each are well explained here. The first thought was to add the reinforcing features (fillet, ribs) to the CAD model and 3D print it. This would be the part to use to create a mold.
In our case, we already had parts of each design that had not broken yet. We therefore added the features with wax.

Figure 2. Original parts with wax reinforcing features added

Creating the mold can be done in a basic workshop. Before creating it, one should carefully choose the parting lines. Rubber is forgiving which makes drafts not always necessary and permits some undercuts. But too much of it and the part will not be removable without destroying the mold.
Also, when creating the second half of the mold, it is useful to cut out some alignment features (these do not have to be pretty) and to add a funnel (called a sprue) to be used to pour the material to cast the parts.

Figure 3. Two of the part prior to pouring the first half of the rubber mold

Figure 4. Setup is simple and it does not have to be messy

Figure 5. Ready to pour the second half of the rubber mold. Notice the wax sprue

After the mold is fully cured, the mold can be used to cast parts.
As a first try, we decided to cast them out of polyester (to which I added a little bit of iron powder with the intent to reduce friction wear and increase compressive strength). This was also the rationale behind adding ribs in addition to the filet (which most likely would have been enough had we chosen to cast them out of metal).
We could have decided to cast them directly out of metal but this was adding a layer of complexity for possibly no added benefit.

Figure 6. Modified part (top) and cast resin parts (bottom)

The first batch has a few too many entrapped air (more about that in another blog) but the parts had the desired form and fit. As for function, it worked. But since people could potentially get hurt if the parts were to fail, we decided to not claim victory yet and to test more extensively.

Testing and the lessons learned will be the topic of the next blog of the series.