Lessons in Manufacturing and Prototyping

Nicolas Avril - Enging.net - Blog 01 - May 2021

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.

This issue deals with metal brackets connecting the legs to the seat of some designer chairs. The customer decided to contact me when at least one bracket had broken on every one of his chairs, rendering them useless. The parts were custom made, the supplier was unwilling (or unable) to sell the brackets alone, and my customer (an average handyman) was feeling hopeless.

Figure 1. One of the failed chair brackets.

An investigation was in order. Was it poor control over the material properties (or maybe a deliberate attempt to cut costs by using a different alloy)? Was it an inadequate parameter of the casting process (maybe a cold shut)? Or was there a flaw in the design.

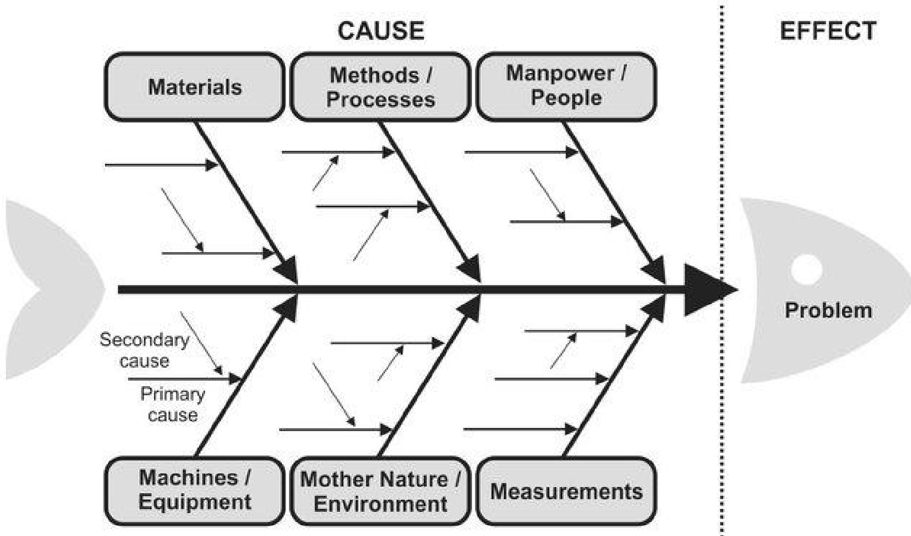

Figure 2. A fishbone diagram (aka Ishikawa diagram) is useful to structure the approach to root cause analysis (often following a brainstorming session)

Since microscopic evaluation of the fracture surface did not reveal a cold shut (and because I do not have easy access to a method to determine the chemical composition of an alloy) I started investigating the design. To that end I created a 3D model of the part. This allowed me to confirm a flaw in the design. The area where the brackets are failing is the area where the amount of material is the thinnest (to the point of almost not being present at all).

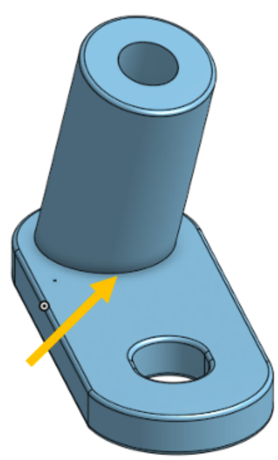

Figure 3. A 3D model of the part allowed identification of a weakness in the design.

It is important to note here that the root cause of the failure could still be related to the process parameter, to the material selection, or other branches of the fish-bone diagram. Only an analysis of the production history data in combination with test results could confirm it.

In our case, since we are looking at solving the problem for that specific set of pieces, we opted to change the design and to add material (a thick fillet) in that area.

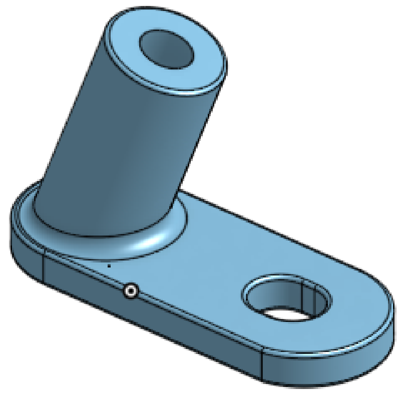

Figure 4. A 3D model of the part with a thicker fillet added

Having a 3D model, and not requiring any specific tolerances nor surface finish, we could now request quotes from the instant quoting tools now available on many distributed manufacturing platforms. This is a great way to not only produce small batches of parts (our case) but also to get an idea of the lowest price for a given combination of material and manufacturing techniques.

Unfortunately for my customer, when manufactured in batches of 6 units, the cost of the brackets exceeded that of the whole chair (manufactured in large batches). His situation was similar to that of a young company needing functional parts but not able to benefit from low cost production techniques. When the goal for producing these units is to learn something or confirm a hypothesis, the higher cost is the price to pay for the learning. But when it is to fulfill some early orders (priced on the basis of mass-production, and possibly even discounted), or for maintenance or repair, the higher price tag is often prohibitive.
From my experience, if one cannot afford the high manufacturing costs, the only option (which I have seen implemented very successfully by some robotic companies) is to manufacture the parts yourself.
This is what I offered my customer, and will be the topic of the next blog of the series.