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ADDITIVE FABRICATION

How and When to Choose Between Additive and Subtractive Prototyping

Both additive and subtractive processes can work, but you need to evaluate delivery, material, tolerance and cost.

By Dan Mishek

Your design is complete and now it's time to prototype! Which process should you choose? Before you decide, you need to do a little discovery. What are your needs? Do you desire speed, function or a specific material? What are your needed quantities and what is your budget? Only after you answer these questions can you choose the correct method of prototyping between (additive) rapid prototyping and (subtractive) CNC.

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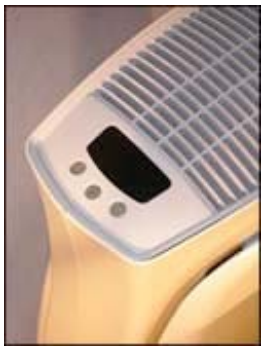
Speed

If speed is your top priority, additive is your best option. With an additive process you are not limited to design issues or complexities: SLA, Polyjet[1] , FDM and SLS technologies can all produce your parts consistently between one to four working days. Obviously, a larger part can demand a longer delivery. Note that within these four additive processes, each process offers different speed based on each individual project.

CNC deliveries typically take seven to 12 working days. This delivery varies based on available materials, complex geometries, number of setups and current workload. With the additional time needed for programming, setup and fixtures it is difficult to consistently keep faster leadtimes.

A hint for the wise, the actual time to produce your part for additive or subtractive is not actually the days quoted. The days quoted take into consideration the time for a machine or a programmer to be freed up. Oftentimes, the time is only a fraction of the quoted leadtime. To expedite the delivery, commit to your vendor in advance. Let them know when you will release the actual CAD data, so they can plan to work on it when it arrives. Without advance notice, typically that job will only get started when the next available person can jump on it. This notion is easier said that done. For this to work, engineering, marketing and management have to be on the same page. That's up to you.



Prototype whose top grill and buttons were painted SLAs, the black lens was a tinted SLA and the body was painted FDM. Images courtesy of Vista Technologies.

Function

Be careful, because function can be a loaded term. You can use SLA and Polyjet as a functional option for your transparent or clear needs. Those same materials will not maintain the same impact strength of a machined piece of polycarbonate.

Polyjet and SLS offer a soft durometer material. A special family of rubberlike flexible materials[2] offered in the Polyjet will flex and bend like a santoprene or rubber, but will not hold up when testing true tear strengths.

For functionality, let's look at tensile strength, robustness and impact strength. In the additive corner, FDM and SLS are the two main contenders. SLS[3] offers a Nylon and a GF Nylon powder blend. FDM offers spec material in ABS, PC, PPSF and an ABS/PC blend.

These materials can be very strong and tested to be proved out for production or used in production.
These materials will fall a little short compared directly to a subtractive material spec sheet due to the fact that these parts are built layer upon layer, which can create weak points in the material.

CNC does give you the most function because you are getting the actual material. Your choices are not limited to just ABS or polycarbonate. You can machine Delrin, Peek, Ultem, GF Nylon and metals.

Tolerance

Among the additive processes there are certain processes that are more precise than others. For argument sake, let's use the general +/- .005" for the first inch and +/- .002" every inch after. These additive processes can also vary in build layers. The ranges can be from .0006" to .010" a layer. If you want to go with an additive process, then you need to search within those options.

The CNC process can really hold any tolerance within reason. That being said, when was the last time you sent a print along to your supplier

when you ordered an SLA or FDM? Chances are you didn't. Prints are more important for machining, so accurate tolerances can be held. Hole dimensions, boss locations and overall flatness are industry standards for the CNC world.

Budget

Typically, quantities one to five will be more cost effective using the additive process. In machining, you have too much cost absorbed in the initial programming, setup and fixturing for small quantities. On runs larger than five, your unit price drops because all the upfront cost has been absorbed. CNC then lends itself to be a more cost-effective process.

It is rare to find anyone who can produce any prototype for under $200. This seems to be the minimum when you add the cost for technology, human programming and material cost. Your budget can be depleted quickly so make sure your need for cheap does not make you weep. Sometimes by only viewing the price, you are missing out on some great methods of prototyping that you can use for other applications. If you can use one prototype for multiple tests or functions, it should be worth more to you.

This is a medical model using the additive process called Polyjet. The model was built using a .001" layer thickness using VeroWhite material.

Quantities

In the subtractive world, programming has become easier and faster; better fixturing is in place with "3R" and two-sided tape; and, the cost for all-purpose CNC machining centers has dropped. This has allowed the CNC world to become more competitive in lower volumes and still maintain its competitiveness in higher volumes.

In the additive world, the materials have gotten better, the machines have gotten faster and the unit pricing has dropped. A new machine[4] designed for making production parts in an additive process called direct digital manufacturing (DDM)—whose niche is low volume, low cosmetic, functional parts—and another machine[5] for the SLS process allow the end user to eliminate tooling or fixturing. A new RP machine[6] has the ability to run multiple materials on the same platform, allowing people to build over-molded prototypes without any tooling. It permits the programmer to select different materials or blend materials to best fit the desired material requirements.

With the waters muddying between additive and subtractive processes, it is wise to be open to both methods. They both can work, but then you need to evaluate delivery, material, tolerance and cost first.

Some advice for moving forward includes researching multiple processes and getting multiple quotes. Do not fall in love with price unless you can fulfill more of your needs found during discovery. Speed is important, but do not shortchange function.

Summary

The earlier you are in your design stage, the more important it is to prove out your design with fit and form without wasting a lot of time. The additive process can be very helpful for you in this stage. When moving further down the line with proving out function and needing more quantities, you need to consider your options with both subtractive and additive technologies.

References

[1] Machine from Objet used to jet photopolymer material.
[2] Tango family of materials from Objet that enable models to closely resemble the feel of flexible target products.
[3] Duraform series.
[4] Stratasys' 900MC.
[5] 3D Systems' Sinterstation Pro for the SLS process.
[6] Objet's Connex500 for Polyjet technology.