Desktop 3DP vs "High end" 3DP

Taika3D

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3d printing (3dp), or additive manufacturing has been a valid option for commercial orthotics and prosthetics (O&P) production for some years now. It has not become mainstream yet but increasingly, we can find new products brought to the market. Clinicians and labs often ask us about these technologies and how they could be used in their operations. This paper aims to offer some background information and advice on these technologies and on what kind of systems are used in this industry already. In this paper we have only considered plastic part production.

Despite common misconceptions about 3d printing, you cannot buy a little machine that sits on the office desk and magically makes anything you throw at it, including orthotics and prosthetics.

It should be first noted that under the “3d printing” umbrella we are talking about a broad family of digital manufacturing processes, all of which work differently even if the broad principle of layer manufacturing is consistent across the board.

Fortunately, out of the plethora of 3dp processes out there, only a few are in commercial use today in the O&P industry. Only desktop Fused Deposition Modelling (FDM) systems and typically higher end powder based systems, such as Selective Laser Sintering (SLS) by 3d Systems and EOS and MultiJet Fusion (MJF) by HP are in commercial use at the time of writing. The new Selective Absorption Fusion (SAF) systems from Stratasys will no doubt soon follow.

Left (1) an Ultimaker 3 and right (2) Lulzbot Taz Workhorse desktop FDM systems.

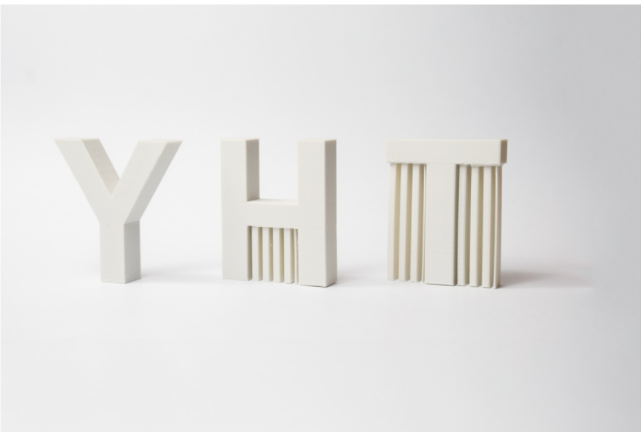
Left (3) a Stratasys H350 SAF machine and right (4) a 3D systems sPro60HD machine.

Desktop systems

What do we mean by desktop printers? Filament based low cost systems. There are hundreds of manufacturers around the world making them and/or the associated materials.
We can find higher end FDM systems also, primarily from Stratasys but in O&P, the lower cost systems have been used most often.

The systems work from a 3d model of the part you want to make, slicing that part to very thin layers (0.1mm for example) and then physically creating those layers. This is done by extruding a melted filament through a nozzle on a build platform. Once one layer is completed, the nozzle moves up by the thickness of one layer and the process repeats on top of the first layer so the second layer adheres to the first one. Repeat until your part is completed.

Certain structures will need support with additional "scaffolding" such as overhangs. These are typically built using water soluble materials to enable easy support removal.



Supports are required for overhangs and such structures in FDM systems (5).

Regarding materials, there is a growing range available for FDM. The most common ones used are PLA and ABS plastic but for example polypropylene, TPU, nylon and polypropylene are available. The choice for a specific product is typically dictated by how rigid the device needs to be and how easy/reliable the desired material is to process. The material used should always be considered when selecting the machines as not all machines are good with all materials.

Numerous websites, blogs, forums and youtube channels have been created by a vast community of enthusiasts over the years and there is probably an answer already somewhere out there to any question anyone might think about regarding FDM machines and their operation. This is very convenient as in most cases you will have to service and repair the machines yourself. This is something you may or may not have the affinity for.

If large capacity is required, larger platform machines can be obtained but the more common route appears to be to build a farm of smaller machines. This provides flexibility operationally and financially but multiplies the maintenance burden. A dedicated technician will almost certainly be required to reliably operate a farm used in regular production.

Finally, it should be noted that when operated by expert users, these systems can be reliable, a common experience for new users is the unpredictable nature of part manufacture and an almost constant need to supervise and/or restart the process when something goes wrong. In my experience this never really goes away completely and for a commercial setting your tolerance for risk and for example the impact of doing a rebuild in lead times should be carefully considered

Pro/contra

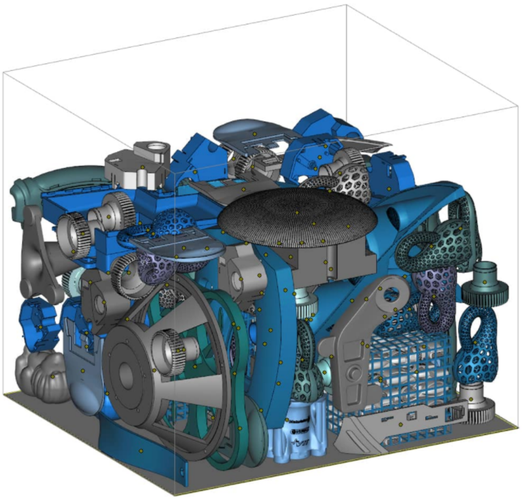
+ Low cost of systems - as low as $100
+ A substantial selection of systems and materials available
+ A lot of content/materials available on-line for support
+ Easy operation, simplicity of the machines

- Reliability of the machines
- The need for supports and their removal
- Productivity - typically one device/pair at a time for an overnight build or longer

Powder based systems

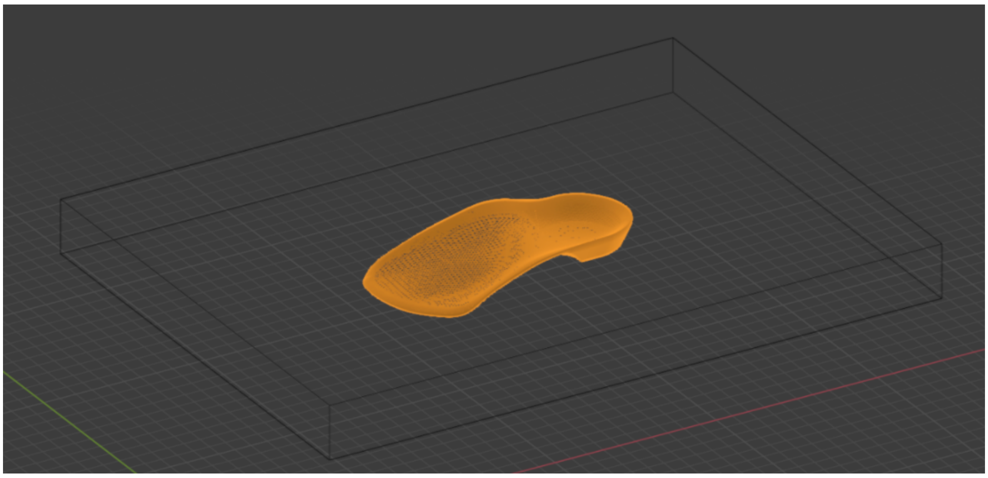
The high end powder based systems are similar to each other in terms of the physical machine size and the auxiliary equipment needed. This consists of the machine itself, a part breakout station and a bead blasting station for cleaning the parts. The HP material processing system is more automated and enclosed but has certain other limitations. All of the equipment is typically provided as a part of the system purchase. Additional extraction systems, electric lifters etc may also be included in the package. A vibratory tumbler polishing system commonly used for SLS parts for a final polish as they are simple and inexpensive.

The main difference between powder and filament based systems is that you can use the entire build volume more efficiently in the former case. No supports are required as the powder can support the parts. This enables parts to be nested anywhere in the volume in any orientation and parts can be stacked easily and any gaps between them utilised. Larger and smaller parts can be built together. This way a batches of > 100 foot orthoses for example can be easily created in an 10h build. The key to make the most of these systems is the efficient utilization of the build volume. The larger your product is, the more important this becomes and for example spinal braces may have to be produced in multiple parts.



An example of a build with many kinds of parts in terms of sizes and shapes (6).

The downside to this is that the whole build surface needs to be always covered in powder regardless of what you are building. So building for example just one small device is not usually very efficient.



When building a single product there is a considerable amount of unused space in the build volume (inside the black lines). For efficient manufacturing, this should be utilised.

In terms of operation, the high end systems are more complex and time consuming than a single desktop system. While most can learn how to do this, generally a dedicated technician will operate the machine and do all of the post-processing, prep the builds etc. For a single machine this is not a full time job.

In terms of materials, powder based systems have a more limited selection than filament systems and each process (MJF/SAF/SLS) has their own materials which cannot be used in the other processes. Nylon is by far the most common material used in O&P applications with the PA 11 and 12 variations available. The PA 11 has an advantage over the 12 in terms of mechanical performance and it is made from renewable sources (castor beans), but is more expensive. Polypropylene is also available as is TPU.

Pro/contra

+ Relative productivity and reliability
+ Consistent quality and reproducibility
+ Supports not required providing greater design freedom and less finishing work

- Cost of systems and materials requiring larger volumes of production
- Trained operators required for day-to-day operation and material processing
- Additional service costs

Conclusions

In conclusion we could summarise that desktop systems are less investment heavy and flexible than high-end systems but have their limitations in terms of reliability, consistency and productivity. The operator needs to be willing to roll their sleeves up and to take the time to maintain and repair the kit as needed. This may not be the obvious choice for a small clinic even if it may initially appear so.

The high end systems essentially require a steady volume of production to justify the investment and a single clinic is unlikely to produce this kind of volume. Even for a larger company, this is a significant strategic decision to for example switch from a thermoplastic product to a 3dp one. These systems are typically operated by central fabricators and for smaller clinics, outsourcing the production to large, industrial service providers is always an option. With the right manufacturing partner, the costs and lead times can be surprisingly competitive.

So, apart from this very brief summary, what is the advice we can give to clinicians who want to get into 3d printing? Regardless of whether it is high/low end?

1. Do your research. Don't just read one blog post or press release or listen to just one sales person. Speak to several. Ask for samples and compare them. Try to speak to people who operate these machines. There are many different perspectives out there and there are no short-cuts. Do the work or ask someone who you trust to do it for you.

2. Build your own operational/cost model. Only you know all the factors relevant to your business, not only from a direct manufacturing cost perspective but business-wide. Do you really want to manufacture in-house or is sub-contracting an option? How much risk can you tolerate? How can an all digital end-to-end process benefit you?

3. Think about where you want to spend your time and where it makes sense for you to spend your time. Is it in seeing patients, doing CAD, operating machines and/or in post-production (cleaning parts, adding liners), speaking to service providers etc?

4. Can you add value in the products through design or do you simply wish to reproduce existing products with different technology? Can this create new opportunities or create better products or address problems that you could not address before?

References

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