MANUFACTURING TOOLS

FORTUS 3D PRODUCTION SYSTEMS

Time Required Cost Skill Level

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OVERVIEW

Manufacturing engineering's daily challenge is to maximize production quantities while maintaining quality and managing costs. To keep operations at their peak, it relies on manufacturing tools that include jigs, fixtures, templates and gauges.

The applications for manufacturing tools range from machining operations to final inspection. They are used to align, assemble, clamp, hold, test and calibrate components and sub-assemblies (figure 1). Some are simple in form and easy to construct while others have sophisticated designs that are difficult to produce.

Manufacturing tools are commonly machined or fabricated from metal, wood or plastic. Like the items that they are used to produce, these tools go through the design, documentation and production process. For an elaborate or intricate tool, there may be a prototyping, evaluation and design iteration cycle to produce a jig or fixture that performs as needed. On average, production of a manufacturing tool takes one to four weeks.

Throughout the manufacturing operation, manufacturing tools are common, and yet, they are virtually transparent when production is running smoothly. However, when problems arise, their role becomes obvious. To avoid production halts or product defects, immediate solutions are needed and new manufacturing tools must be quickly designed, manufactured and deployed. However, the lead time can prove to be a barrier. So, manufacturing engineering may have to resort to short-term, stop-gap repairs.

FDM FOR MANUFACTURING TOOLS

Fortus 3D Production Systems with FDM (fused deposition modeling) technology provide manufacturing engineering a fast and easy alternative for production of manufacturing tools. Using FDM for direct digital manufacturing (DDM), new tools can be put into service just hours after the design is complete (figure 2). FDM also offers the advantages of design optimization, labor reduction and cost reduction.

In contrast to machined manufacturing tools, the FDM process requires fewer steps, fewer resources and less effort on the part of manufacturing engineering. With direct access to a Fortus system, the engineer converts the digital design into a production tool. There is no need for detailed engineering drawings (figure 3), requests for quote, negotiations with the internal machine shop or oversight of a supplier. The self-serve nature of the work flow makes the manufacturing engineer more productive and allows immediate response to problems on the production floor.

The manufacturing tools that are produced with FDM are free of design constraints imposed by traditional manufacturing methods. This promotes better designs that address the functional needs and ergonomic requirements of the manufacturing, assembly and inspection processes. Made from tough and durable thermoplastics, the FDM tools will withstand the abuse of the manufacturing environment. And when it is time to replace a worn or damaged manufacturing tool, simply call up the digital data and manufacture another one in only a few hours.

PROCESS

There are no process modifications required when producing manufacturing tools with FDM. It can be a simple substitution for traditional manufacturing methods. The only requirement is that the jig, fixture, template or gauge is designed in 3D CAD so that an STL file is available.

To maximize the performance and efficiency of a manufacturing tool, consider capitalizing on the freedom of design that FDM offers. The additive fabrication process eliminates constraints

TOOLS AND EQUIPMENT:
- Materialise RapidFit software
- Modular fixturing system

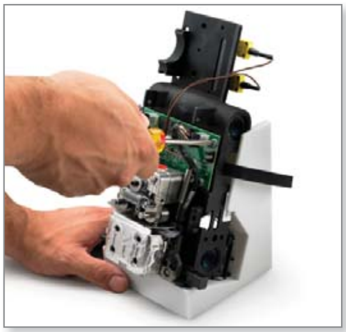

Figure 1: Assembly is one of many applications for fixtures. Show here is an FDM fixture supporting an electro-mechanical sub-assembly.

Figure 2: A roller arm fixture assists in assembly. Versus CNC and FDM, there was a 94 percent cost reduction when made with FDM:

Estimate using CNC method:
Cost $2,300
Delivery 3 - 6 weeks

Estimate using FDM system
Cost $300
Delivery 1 - 2 days

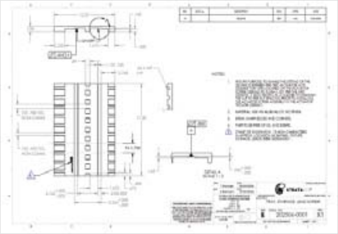

Figure 3: FDM eliminates the time-consuming process of detailing engineering prints (top). Instead, a simple work instruction diagram (bottom) can be used.

imposed by machining and fabrication. This allows manufacturing engineering to design a manufacturing tool with fewer parts, reduced weight and better balance.

DESIGN

In CAD, create the 3D design of the manufacturing tool. Where the tool makes contact with a component or sub-assembly, simply use a Boolean subtraction to create perfectly mated surfaces. Then, offset the surface slightly to avoid interference.

An alternative to manually designing fixture components is Magics RapidFit, a software module from Materialise. RapidFit, which is discussed in the "Manufacturing Tools: Modular Fixtures" application guide, automatically creates contact elements from the CAD data of the part that is held by the tool. This guide also details the construction of modular fixturing systems (figure 4), which are ideal for single- or intermittent-use applications.

If the manufacturing tool has tight tolerance specifications, add machine stock to the critical areas. After construction in the Fortus system, the tool can be milled to design specifications.

When designing a manufacturing tool that is made with FDM, try to break free of old design practices. Instead of designing to satisfy the constraints of the milling, turning or fabrication process, focus all efforts on designing the tool for the best performance. Make it as complex and intricate as it needs to be rather than trying to simplify the design to make it practical. Since FDM is an additive fabrication technology, design complexity will have no impact on time or cost.

Following are some design tips to assist in breaking from design traditions:

Reduce Weight:
A manufacturing tool constructed from a Fortus plastic will be lighter than a comparable tool made of metal or wood. However, further weight reductions are possible. Since the addition of features does not drive up manufacturing time or cost, remove material from the tool by adding pockets, channels and holes. Eliminating excess material will reduce worker fatigue when using a handheld assembly tool. For larger, stationery tools, the weight reduction will make it easier to move. In either case, reducing the material in the manufacturing tool will reduce FDM build time and cost.

Consolidate Parts:
Manufacturing tools are often constructed in pieces to allow them to be machined or fabricated. This is unnecessary for an FDM tool. Instead, consolidate all pieces of the tool into a single part. Part consolidation has many benefits. It will eliminate assembly of the tool, which decreases labor and time, while eliminating interference issues and improving accuracy. Single-piece construction also simplifies tool room operations as there are fewer items to inventory, maintain and track.

Design for Function:
Due to the limitations of fabrication and machining, manufacturing tools would have very linear designs with geometric shapes. This is no longer necessary. FDM encourages designs with freeform shapes and flowing lines (figure 5) that can improve the performance of the manufacturing tool. It also promotes ergonomic designs that improve the productivity of line workers.

Iterate the Design:
The first design does not have to be the final design. The initial version of a sophisticated manufacturing tool can serve as a functional prototype or bridge-to-production solution. Since there is little delay and minimal labor required to make subsequent tools, gather performance data from the first iteration; make design a revision; and produce a better manufacturing tool. Following the design of the ideal manufacturing tool, export an STL file and import that data into Insight build preparation software. Standard build parameters may be used. However, for large or bulky items, consider using sparse fill (figure 6) or double dense sparse fill. This build technique will reduce the volume of material within the part, which reduces weight, build time and cost.

MATERIAL SELECTION

All Fortus materials can be used when producing manufacturing tools (figure 7). For material selection, the primary factors will be the suitability to the mechanical and thermal conditions under which the manufacturing tool will operate. For example, if strength and rigidity are required, PC or PC-ABS may be ideal for the application. If temperature and chemical resistance are needed, PPSF may be the better choice.

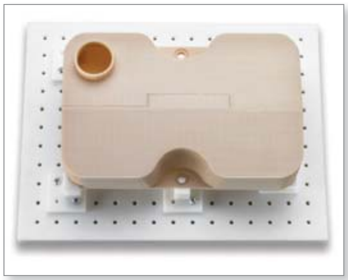

Figure 4: Modular fixturing systems are ideal for intermittent use. Pictured is an FDM-made modular system (white) used to support a gas tank while being bonded.

Figure 5: FDM manufacturing tools can have complex designs without driving up time or cost.

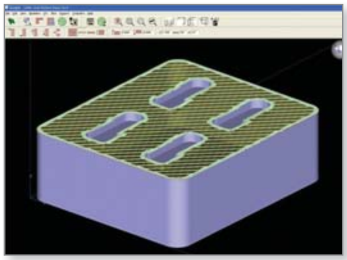

Figure 6: To reduce weight, build time and cost, consider sparse fill for thick-walled parts.

Figure 7: All FDM materials are suitable for manufacturing tools. Pictured is an ABS fixture for mounting a heat shield.

For complex and intricate manufacturing tools, consider using one of the ABS materials, including the PC-ABS blend, so that soluble supports can be used. The soluble supports will reduce direct labor and ensure that support material is completely removed, even from inaccessible features.

PRODUCTION

Producing manufacturing tools requires no special consideration. Prepare the STL file and build the tool in the same way as any model or part.

Following the build, the part is taken off of the Fortus system, and the support structures are removed. In most applications, no other finishing work is required. The manufacturing tool is ready to be deployed to the manufacturing floor (figure 8).

DIGITAL WAREHOUSING

If a manufacturing tool is damaged or lost, it can be replaced quickly and with little effort. Simply access the tool's design data in CAD, export an STL file and rebuild the jig, fixture or gauge.

Because replacement and duplication is so efficient, consider digital warehousing for manufacturing tools that are used infrequently. Instead of carrying an inventory in the tool room, dispose of the tool between uses and rebuild when needed. This new practice will eliminate warehousing issues such as spending an inordinate amount of time searching for the manufacturing tool.

CONCLUSION

Manufacturing tools are vital for the productivity of the manufacturing process and the quality of the products. Replacing machining and fabrication with FDM makes production of these tools a simple, flexible, affordable and fast process. Instead of waiting weeks for a manufacturing tool, it can be ready in a few hours, often with a cost reduction of 50 to 75 percent.

With FDM, the manufacturing tools are constructed faster and made better. The short lead time allows iteration of a tool's design. Combined with the freedom of design, manufacturing engineering can create manufacturing tools that are optimized for performance and ease-of-use.

Manufacturing engineers tend to gravitate to FDM when given access to the technology. It eliminates steps in the process, reduces dependency on others, expedites delivery and increases productivity. In many cases, this leads to more manufacturing tools on the manufacturing floor, which increases production quantities, product quality and financial gain.

Figure 8: After removing supports, manufacturing tools are ready for use. Cost estimate of part pictured:

Estimate via traditional method:
Cost: $3,000 - $4,000
Delivery 2 - 6 weeks

Estimate using FDM:
Cost: $600
Delivery 1 - 2 days

FDM PROCESS DESCRIPTION

Fortus 3D Production Systems are based on patented Stratasys FDM (Fused Deposition Modeling) technology. FDM is the industry's leading Additive Fabrication technology, and the only one that uses production grade thermoplastic materials to build the most durable parts direct from 3D data. Fortus systems use the widest range of advanced materials and mechanical properties so your parts can endure high heat, caustic chemicals, sterilization, high impact applications.

The FDM process dispenses two materials—one material to build the part and another material for a disposable support structure. The material is supplied from a roll of plastic filament on a spool. To produce a part, the filament is fed into an extrusion head and heated to a semi-liquid state. The head then extrudes the material and deposits it in layers as fine as 0.005 inch (0.127 mm) thick.

Unlike some Additive Fabrication processes, Fortus systems with FDM technology require no special facilities or ventilation and involve no harmful chemicals and by-products.

For more information about Fortus systems, materials and applications, call **888.480.3548** or visit **www.fortus.com**

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