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Production Tooling with Additive Manufacturing

White Paper

Production Tooling with Additive Manufacturing

This guide focuses on the business considerations for additive manufacturing (AM) usage in the production of tooling. Although traditional subtractive-based technologies for tooling fabrication continue to be heavily used, technology improvements and a better understanding of the adoption drivers and financials for AM have increased the number of uses in tooling applications. Due to the fact that tooling is often manufactured in low quantities and in complex shapes, AM is being utilized more often as a fabrication method.

Adoption Drivers

AM tooling currently covers a range of tooling applications from assembly guides on the manufacturing floor to test and inspection fixtures on CMM tables. While unique tooling use cases continue to grow every year, similar business drivers have become apparent for adopting AM. With such a broad range of applications currently being used and developed, many industries have begun to embrace the use of AM for their unique tooling needs including the aerospace, defense, automotive, industrial machinery, and even healthcare markets. The drivers for AM tooling adoption can be organized in four categories:

1. Economical Custom and Low-Volume Manufacturing
2. Supply Chain Realignment Advantages
3. Increased Part Functionality
4. Increased Operational Efficiency

Economical Custom and Low-Volume Manufacturing

The historic relation between volume and cost in traditional manufacturing does not hold true in additive manufacturing. Custom and low-volume tools become a viable and cost-effective option with AM. Tools can be designed per operator requests without paying a premium price for a single, highly customized tool. Due to the fact that tooling is often manufactured in low quantities and in complex shapes, AM is a great option as a fabrication method.

Supply Chain Realignment Advantages

Tooling supply chains become much more efficient utilizing additive manufacturing. The path for a traditionally manufactured tool includes multiple, labor-intense stages such as material procurement, fabrication, coating and final assembly. An additively manufactured tool can go from CAD model to processing software to building on the printer within hours. Lead times that once were weeks are now down to days or hours. Figure 1 shows how the supply chain differs between traditional and additive manufacturing.

AM also allows factories to reduce their tooling footprint. Rather than storing physical tools, a digital inventory of tooling can be stored on servers and distributed to factory locations for printing as the tool is needed. This methodology can greatly reduce the lead times and shipping costs associated with central manufacturing of tooling.

Increased Part Functionality and Geometric Complexity

1. Design Freedom

Design for manufacturability is a critical consideration that tooling designers take into account when beginning the design on a new tool. This usually places constraints on the design in terms of the types of geometries and functionality that can be built into the tool. One of the biggest advantages of additive manufacturing is the design freedom that tooling designers can leverage. Using computer aided engineering (CAE) software, designers can perform finite element analysis (FEA) and topology optimization on tools so they can be designed for optimum performance and functionality rather than for traditional manufacturability. Increased geometric complexity in AM does not equate to increased cost as it does with traditional subtractive-based technologies.

2. Part Consolidation

This design freedom also allows tools that were previously assembled from multiple components to be consolidated and printed as one piece.

3. Internal Structure Control

As mentioned above, the use of CAE software allows designers to optimize designs for minimal material use while still fulfilling design requirements. The internal structure of the tool can be modified with different infill patterns to satisfy certain rigidity, strength or weight requirements all while using the least amount of material possible. Weight reduction is crucial for tools that are used in high repetition processes on the manufacturing floor since it greatly reduces operator fatigue.

Operational Efficiency

The "lights out manufacturing" methodology to producing tooling is nearly achievable with additive manufacturing. There is not a huge labor commitment required to keep AM systems running around the clock. In most cases, current

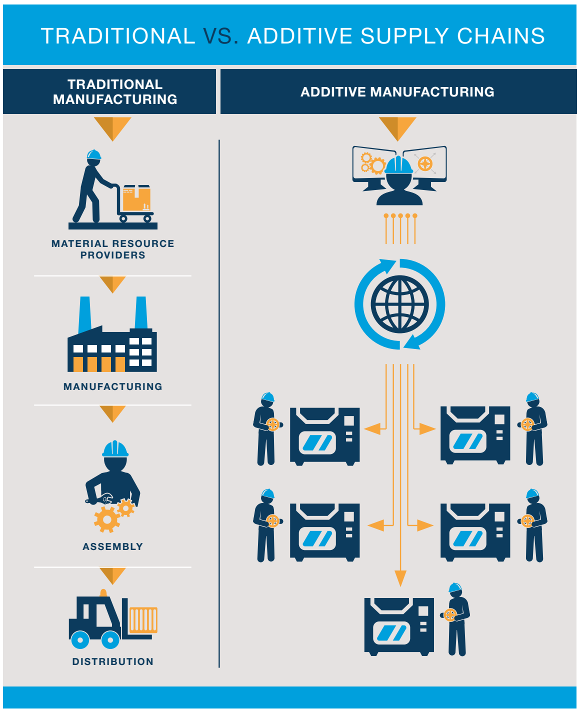

Figure 1

shop personnel can handle keeping systems printing while running other equipment in the shop. AM is not for all tooling applications since there are many times that traditional tooling is more practical and cost-effective. However, using AM for tooling applications that fit the technology can free up time on other machines like mills and lathes needed to produce metal

Increased Part Functionality and Geometric Complexity

tooling. Over the course of a new product development program, the tooling design phase often can't start until the product has reached a certain point near the end of the design phase. This often leaves a compressed time frame for tooling design and fabrication. Using traditional manufacturing doesn't allow adequate time for multiple tooling design iterations and testing. As mentioned previously, AM removes multiple steps from the tooling supply chain, thus reducing the lead time greatly, allowing tool designers to try different concepts and multiple design iterations before choosing a final design.

Incorporating Additive Manufacturing

Tooling Applications

Stratasys offers both FDM® (Fused Deposition Modeling) and PolyJet™ technologies for additive manufacturing systems. For tooling applications, FDM has become the technology of choice and fits a broader range of applications although there are certain applications where PolyJet also works well for tooling.

Stratasys FDM Printers

Printer	Build Volume	Materials	Tooling Application Examples	Price
Stratasys F170™	10x10x10 in	PLA, ABS-M30™, ASA	Assembly Fixtures, Drill Guides, Work Holding, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures,	↓
Stratasys F270™	10x10x10 in	PLA, ABS-M30, ASA	Assembly Fixtures, Drill Guides, Work Holding, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures,	
Stratasys F370™	14x10x14 in	PLA, ABS-M30, ASA	Assembly Fixtures, Drill Guides, Work Holding, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures,	
Fortus 380mc™	14x12x12 in	ABS-ESD7™, ABS-M30, ABS-M30i™, ASA, FDM Nylon 12™, PC, PC-ABS, PC-ISO™, ULTEM™ 9085 resin	Assembly Fixtures, Drill Guides, Composite Layup Tooling, Metal Form Tooling, Thermoform Tooling, Machining Fixtures, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures, End of Robotic Arm Tooling	
Fortus 450mc™	16x14x16 in	ABS-ESD7, ABS-M30, ABS-M30i, ASA, FDM Nylon 12, FDM Nylon 12CF™, PC, PC-ABS, PC-ISO, ULTEM 9085 resin, ULTEM 9085 resin	Assembly Fixtures, Drill Guides, Composite Layup Tooling, Metal Form Tooling, Thermoform Tooling, Machining Fixtures, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures, End of Robotic Arm Tooling	
Stratasys F900™	36x24x36 in	ABS-ESD7, ABS-M30, ABS-M30i, ASA, FDM Nylon 12, FDM Nylon 12CF, PC, PC-ABS, PC-ISO, ULTEM 9085 resin, ULTEM 9085 resin	Assembly Fixtures, Drill Guides, Composite Layup Tooling, Metal Form Tooling, Thermoform Tooling, Machining Fixtures, Hand/Wrist Guards, Hand Tools, Check Gauges, Inspection Fixtures, End of Robotic Arm Tooling	

Capital Investment

The intended tooling application will be the key driver to finding the system that best suits your needs. Table 1 shows build volumes and material capabilities of each FDM system. The Foruts 3D Printers and the Stratasys F900 are best suited for larger tools and tooling intended for rigorous manufacturing environments. These printers can print high temperature, chemical resistant and durable thermoplastics such as ULTEM and FDM Nylon 12 Carbon Fiber that are ideal on the shop floor due to their toughness to withstand repetitive use and handling. For smaller assembly fixtures and check gauges, the F123 Series is a more economical option for producing tools that don't require high-performance thermoplastics. For an entry-level cost, Mojo and uPrint 3D Printers can make similar tooling to the F123 Series but on a smaller scale.

Once the tooling application is determined, the price point at which companies are willing to enter the market will be the next biggest driver for the selection of a system. Multiple price points within each series of printers allow opportunity for businesses large and small to invest in AM technology. If a capital investment is not possible, Stratasys Direct Manufacturing (SDM) offers a full lineup of additive manufacturing technologies. In addition to Stratasys technologies, FDM and PolyJet, SDM also offers direct metal laser sintering (DMLS), laser sintering (LS), HP Multi Jet Fushion and Stereolithography (SLA). Using a service bureau to introduce AM into your business gives you the flexibility to try multiple technologies and machines without the financial commitment of a machine purchase.

Conclusion

Traditional subtractive-based technologies for tooling fabrication continue to be widely used today; however businesses are realizing the benefits of using AM for tooling production. Understanding the adoption drivers is the first step for any business considering using AM for tooling fabrication. If the benefits of these drivers present a business case favorable for investment in AM technology, the next step is to determine the intended tooling application and price point at which they are comfortable entering the market. From there, a system that satisfies both application and price requirements can be selected.

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