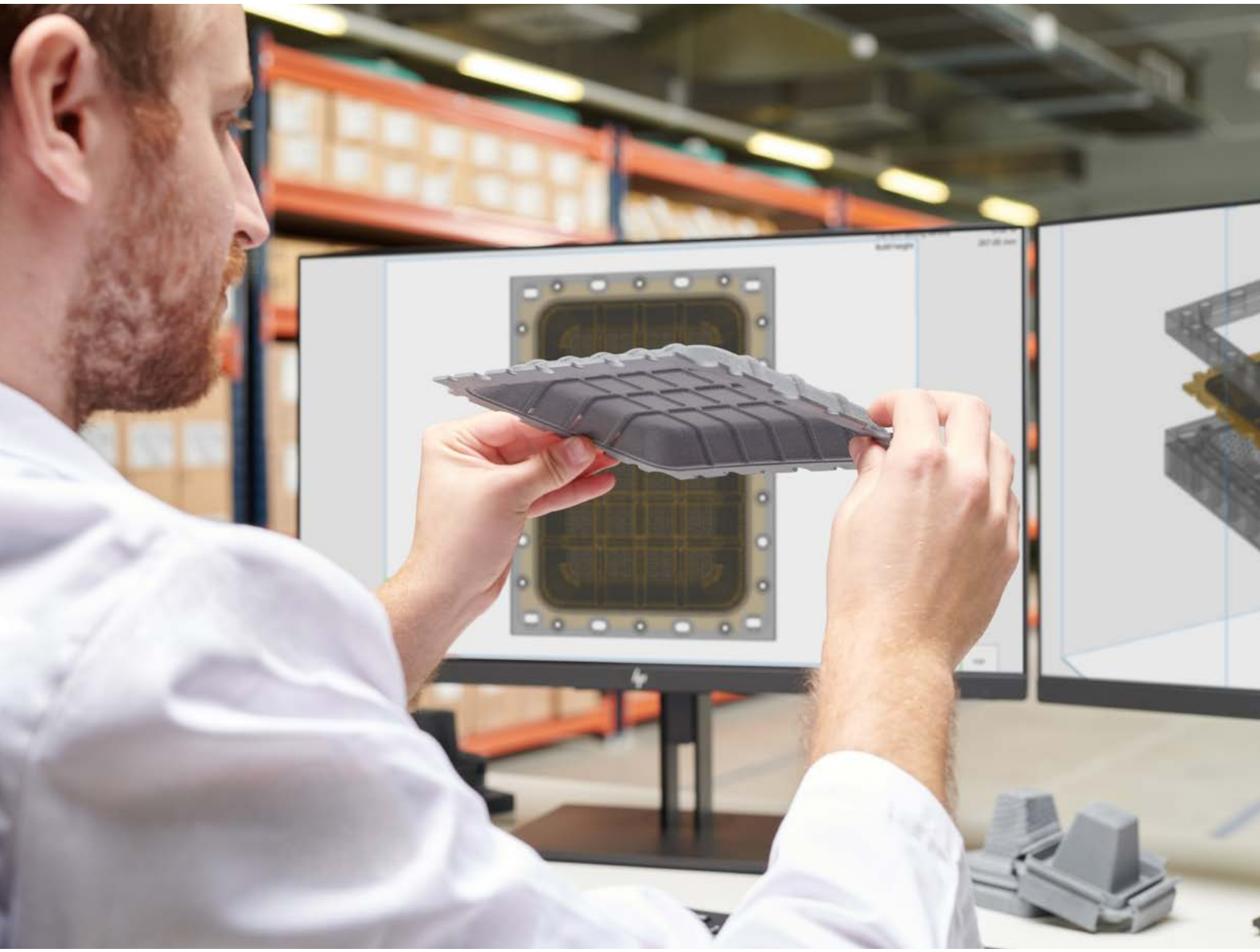
White paper

The HP Molded Fiber Advanced Tooling Solution



Macrotrends driving the packaging market

The packaging market is transitioning from foam/plastic to molded fiber (also known as molded pulp) packaging for sustainability reasons, with environmental packaging (i.e., replacing foam with paper) favoring the growth of this segment.

The molded fiber packaging market is a worldwide industry, valued at $8 billion, and is the fastest-growing segment in the packaging market, with growth being fueled by growing consumer demand for sustainable and environmentally friendly packaging solutions, as well as the increase in take-out food and e-commerce.[1]

Asia-Pacific countries (APAC) are the biggest geographical market, especially China, Hong Kong, and Taiwan. The region is experiencing the highest growth and is expected to be the largest market by 2024. This growth can be attributed to the rising importance of disposable packaging,[2] as well as the lower cost of tooling production in these areas, which presents a significant price advantage over other regions.

The primary segments currently are food and beverage and electronics, which are estimated to have the highest growth. The increasing use of molded pulp products for the packaging of various electronic products (including mobile phones and accessories, computers, printers, modems, trimmers, and projectors, among others) due to its convenience, improved sustainability, and low cost are some of the factors contributing to the growth of this segment.[2]

Molded fiber manufacturing

The thermoformed tooling segment is expected to outgrow other segments, propelled by increased consumer demand for high-quality molded fiber packaging and ongoing innovation driving down thermoforming-packaging manufacturing costs.

Ongoing operational improvements will drive down the cost of packaging production and minimize barriers for new entrants.

Large manufacturers of molded fiber products are vertically integrated; but beneath them, players are rather fragmented, with the majority residing in Asia as regional and local players. Major players lean heavily toward insourcing machining and tooling, considering it to be a source of competitive advantage; others are more likely to outsource, leaning on those with global expertise to provide tools and machinery.

Molded fiber products are largely commoditized, with little differentiation between different products of the same type, and currently custom short runs are not economically viable. This presents a barrier to adoption of personalized molded fiber products in the packaging industry.

Market trends and challenges

In the last 20 years, the industry has not experienced many changes, but manufacturers of molded fiber products are looking for ways to improve operations and enhance current efficiencies.

Tooling is an important factor impacting operational efficiency, with current key pain points including downtime (planned and unplanned), tooling replacement time (stops and starts), rejected products (worn out screens leading to bad parts), and semi-skilled labor costs for maintenance.

Today, manufacturers of molded fiber products typically produce screens manually, which can be time consuming and somewhat limiting, due to intrinsic design constraints. Some manufacturers are also trying to optimize the screen production process using robots; but highly skilled laborers are required for programming tasks, which in turn has a significant impact on labor costs.

Outsourcing CNC tooling services can be a cost-effective option when using low-cost suppliers, typically located in Asia, but this also results in long delivery times.

Manufacturers of molded fiber products have already tried to improve tooling production efficiency by searching for new capabilities, such as 3D printing. However, there hasn't been an optimal solution yet that delivers on key requirements, and a feeling of disappointment prevails in the sector.

Limited 3D printing adoption for molded fiber tooling

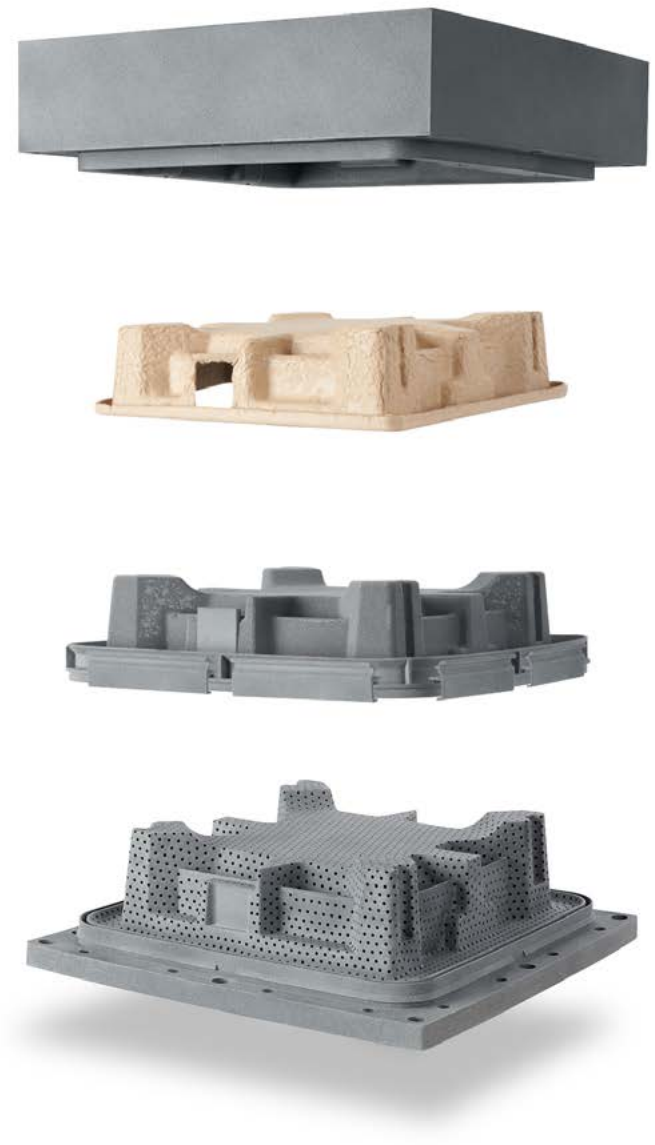
Manufacturers of molded fiber products have been using 3D printing technologies—mainly fused deposition modeling (FDM)—but with little success to date. The lack of an optimal 3D printing technology to help solve some of the molded fiber industry's major pain points has created skepticism that 3D printing can serve as anything useful beyond prototyping.

FDM tooling is used primarily for prototyping, and other techniques have been applied for this purpose, from machining of porous materials to temporary castings, among others; but these are not production solutions.

A new solution to address tooling pain points

When HP researched the market and learned about its pain points, it became clear that existing 3D printing technologies were not being adopted for fabrication of production tooling in the molded fiber industry, because they could not accomplish two important goals: eliminating the labor and other issues associated with the screens and remaining functional long enough to support mass production quantities. As such, HP pursued a different approach—one that mimicked the tool architecture that has worked for decades, while taking advantage of HP's unique 3D printing capabilities to replace woven wire screens with HP Multi Jet Fusion (MJF) printed screens.

By taking advantage of digital design and HP MJF capabilities, we have been able to provide advancements in the molded fiber product manufacturing industry, with expanded tooling capabilities for both molded fiber manufacturing efficiencies and product performance. For example, HP's SmartScreens are printed in one piece that maintains its shape, which means your parts won't show seams or wrinkles common with wire screens. They also have integrated features, such as deckles, block-outs, and part markings that improve part quality over traditional tools, as well as features that reduce production downtime such as snap-fit hold-downs that allow in-machine replacement of screens. Moreover, the consistency of HP's 3D printed tools eliminates the tool-to-tool performance variation common with manual and labor-intensive traditional tools. And the HP Molded Fiber Advanced Tooling Solution addresses common tool sourcing and maintenance challenges, allowing manufacturers to focus on production efficiencies instead of tooling operations.



Delivering quality molded fiber products, faster[3]

Traditionally, the tooling manufacturing process is necessarily sequential: first, the form is CNC-machined and manually drilled; then a screen is manually cut, shaped, and secured over the form. However, with the HP Molded Fiber Advanced Tooling Solution, leveraging HP's digital manufacturing process, none of these operations are necessary as the forms and screens are printed at the same time, enabling production-ready tooling in as little as 2 weeks.[4]

Manufacturing molded pulp parts efficiently means sucking the fibers in the slurry onto the screen (i.e., forming) and removing the excess water from the formed part as quickly as possible while avoiding clogging the tool with fibers. Good through and lateral flow of water is essential. This means less clogging, that would typically require downtime for in-machine cleaning, resulting in an increase in productivity.

HP's team of experts leverages HP's proprietary digital technology, and applies a design process to engineer toolsets with fluid pathways that make the best use of the most important fibers in the slurry. This allows efficient quality part production.

Further efficiency gains are enabled via HP's secure online platform,[5] as having a digital tooling design stored in a digital warehouse allows for quick design changes and iterations. The platform offers password-protected intellectual property and encrypted access control.

Increased OEE and reduced downtime[3]

Because HP molded fiber tooling screens are not subject to corrosion[6] or calcification[7] in water (a common problem with metal tooling), manufacturers can keep their machines up and running by reducing the need for time-consuming maintenance.

Molded fiber tools produced with HP 3D High Reusability nylon polyamides were tested over 5 days at 50° C (122° F) using four different solvents (tap water, a $CaCO_3$-saturated solution, a 5% wt solution of aluminum potassium sulfate, and DI water as a test negative control) and presented no visual signs of corrosion.

A complementary study was conducted to test signs of calcification. Other molded fiber tools produced with HP 3D High Reusability nylon polyamides were tested over 17 days at ambient temperature using 3 different solutions (super-saturated $CaCO_3$, tap water, and DI water as a test negative control). No visual signs of calcifications were found.[7]

Both studies were conducted under conditions representative of extreme (and non-extreme) corrosive or subject-to-calcification environments at molded fiber manufacturing facilities.

Aside from reduced maintenance, the HP solution also helps increase operational efficiency with smooth part release and fewer hang ups that can cause parts to catch on the form tool, and by reducing stoppages with enhanced flow tooling. Hang-ups can occur when fibers get caught on seams, broken wires, and interfacial spaces between the screen and the deckle ring or block-outs. HP's SmartScreens reduce this possibility because they have no seams and because they integrate features such as a deckle ring and block-outs, which are common striking points. Thus, unlike for traditional tooling, virtually no chemical bath time is required to dissolve the fiber build ups.

With traditional tooling, periodic equipment maintenance is required, most of which is related to the screen. However, screens made with HP's Molded Fiber Advanced Tooling Solution require virtually no maintenance, freeing up semi-skilled labor time. If you want/need to replace an HP SmartScreen (e.g., for rapidly converting a commodity production run into a higher value custom production run, with a premium paying customer's logo) they can be replaced in minutes[8] without removing tools from the machine. This is possible, because they hold their shape, are assembled from the top down, and use integrated snaps to hold securely to the form tool. In contrast, if a traditional tool's screen needs replacement, the entire tool must be removed from the machine, disassembled and reassembled by workers trained in the craft of making screens. This can take days, which gives HP's technology a competitive speed advantage compared to traditional tooling.

There are also more operational efficiencies to gain from the HP Advanced Tooling Solution. One is the benefit of reduced need for inventory of safety stock replacement tooling to avoid production delays that would otherwise occur when a traditional tool is removed for screen maintenance. And with HP's hot-swap SmartScreens that require no hardware to attach to the tool screen, replacement is accomplished even faster than with the standard SmartScreens. Furthermore, HP's Molded Fiber Advanced Tooling Solution delivers a lightweight plastic toolset that translates into efficient tool changeovers for production of other products.[9] Moreover, HP relieves your resources of the task of designing tools to meet your needs; and production ready tooling can be delivered as quickly as 2 weeks after finalizing design specs with HP's engineering team.[4]

Improved fiber retention for positive productivity impact

A comparison of productivity when using the HP solution versus traditional tooling was performed by an independent research and testing company, Innofibre.[10] A multivariable experiment was conducted, using, as constants, recycled newsprint pulp at 45ºC and 0.8% consistency in a production rotary reciprocating machine. The variables were the vacuum intensity, forming time and drainage time, apart from the tooling itself (our HP MJF vs a 50-mesh). The outcome was the dry product weight, its moisture content after drainage, and the resistance to compression at 10% deformation (to measure pulped parts' strength).

The results were very positive for HP tooling, showing improved performance and better fiber retention in general, and significantly higher retention of the most important fibers for pulp part mechanical properties. The findings indicate that using the HP Advanced Tooling Solution offers flexibility for a molder to achieve significant process efficiencies and cost reduction in the fibers used, and cycle time and energy consumption associated with drying operation. The solution is also optimized for different priorities such as:

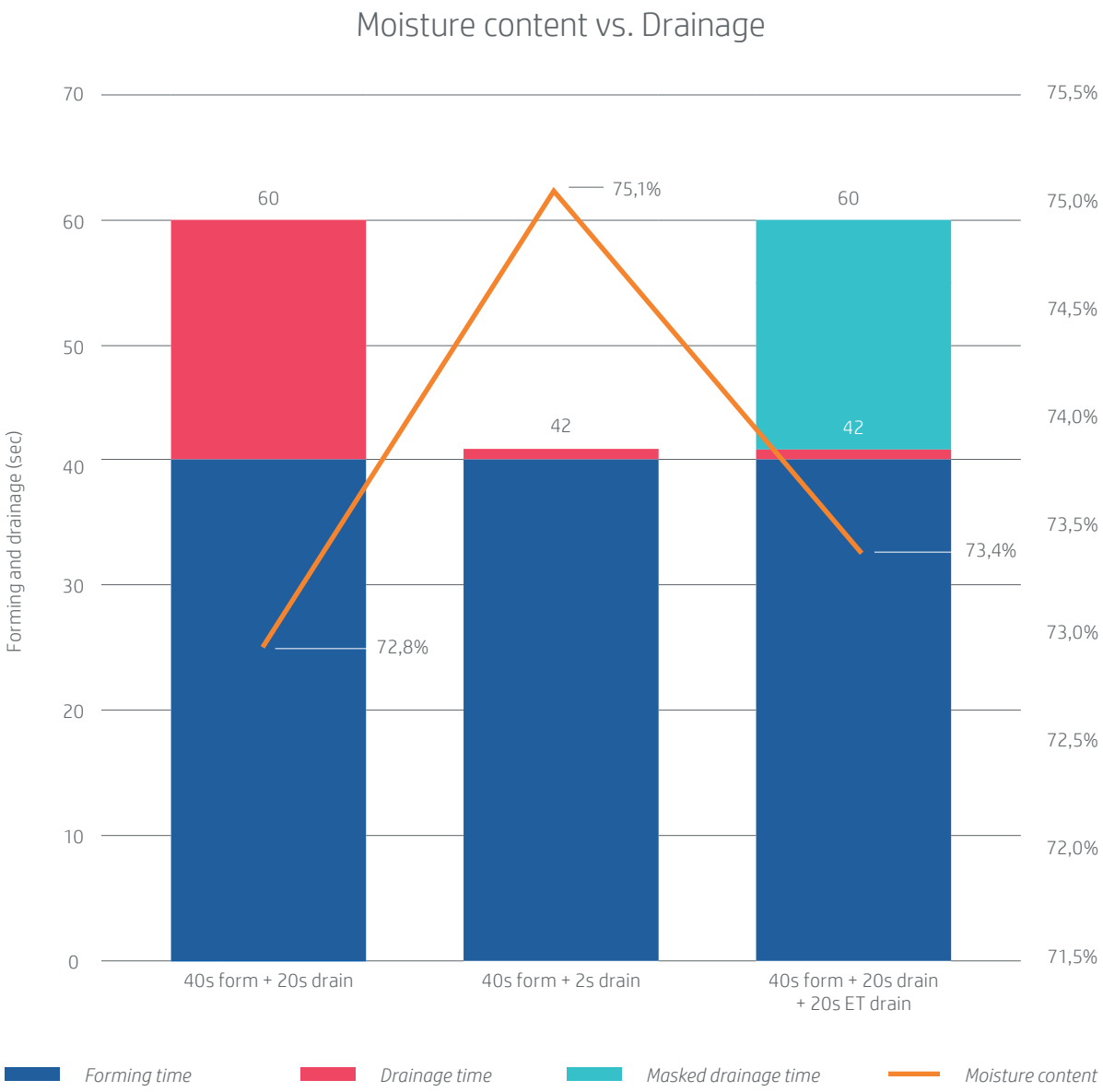
- Process efficiency: HP tooling made use of 15% less material (9.72g), 15% less water to be dried per part (29.2g) and more than 10 seconds shorter cycle time (8.25 forming time + 2.5 drainage time) while achieving the same compression strength of the pulped part.
- Part strength: Using HP tooling resulted in >10% stronger product, 2.6 seconds shorter cycle time (3.26 less forming time but 0.6 more drainage time) and a trade-off of 1.6% more moisture in the product (14.1g), while achieving same dry weight of 60g.

Further productivity enhancements with the AdvancedPro Transfer Tool

The productivity enhancement for molded fiber manufacturers goes one step further with the HP AdvancedPro Transfer Tool. By incorporating more perforations into the transfer body and covering it with an HP MJF screen in the same manner as is done on the form tool, the manufacturer has the ability to obtain equivalent finishes on the transfer side of Type II molded fiber parts, without after-pressing, and produce parts with low draft angles. These features are particularly suited for OEMs/brands, as having transfer-side part markings means having the opportunity to have a strong brand differentiator.

The HP AdvancedPro Transfer Tool is also aimed at producers that want to bring productivity to the next level by reducing forming time and/or reducing the moisture content of the parts when they leave the wet process thanks to better de-watering. This has a clear OEE improvement effect. For this purpose, an experiment using BCTMP pulp (0.3% consistency) at 45ºC was conducted, with a constant forming time of 40 sec but variable drainage time with and without the AdvancedPro Transfer (and variable vacuum intensity). The output was the cycle time and moisture content after drainage (see graph).

In the typical molded fiber process, minimizing cycle time is limited by needing to wait for the form tool drainage to achieve optimum moisture content before returning it to the slurry to make the next part. With the AdvancedPro Transfer tool, the vast majority of that delay in returning the form tool to the slurry can be eliminated or masked by using the enhanced transfer. In our study conditions, this meant a 30% reduction in cycle time (60 sec to 42 sec).



Graph 1: Increase of productivity with the HP AdvancedPro Transfer Tool

Opening new revenue streams with economically viable short runs

Traditional tooling typically requires production runs above 50,000 or 100,000 parts to make it economically viable. In addition to the cost of tooling, the cost of developing new products is also a key factor (e.g., time spent on packaging design and business development, semi-skilled labor resources to assemble and maintain tools, fixed costs of logistics, etc.). It also can take time to set up a new product, which may not be worth the cost if the parts are pulped in a few hours.

The speed and the ease of changeovers that the HP Molded Fiber Advanced Tooling Solution provides, finally helps make higher value customized production short runs economically viable. HP's secure online platform (digital warehouse),[5] helps enable new levels of agility and versatility for tooling design and fabrication. Changing customer requirements can be easily accommodated with fast design iterations and quick modifications of the same toolset, enhanced even more with the HP AdvancedPro transfer.

Our digital workflow makes changing screen designs to convert a commodity into a high-value branded product quick and easy. Manufacturers can offer additional value to their customers with quick and cost-effective custom features such as embossed brand logos, model numbers, traceability information, or even custom artwork. We are now able to deliver such markings on both sides of the molded fibre part, and those markings can be either embossed or debossed.

Reinventing production tooling for the molded fiber industry

The HP Molded Fiber Advanced Tooling Solution provides manufacturers of molded fiber products with expanded tooling capabilities for greater production efficiencies and design opportunities. HP's end-to-end service can enable additional profitability by combining proprietary tooling technology and engineering expertise to help cut lead times, reduce maintenance time, and enable customized short runs.

Learn more at
hp.com/go/MoldedFiberTooling

1. See futuremarketinsights.com/reports/moulded-fibre-pulp-packaging-market.
2. See marketsandmarkets.com/Market-Reports/molded-pulp-packaging-market-36997090.html.
3. Compared to traditional CNC and manual tooling processes as of June, 2020. Based on internal HP analysis and testing including expert interviews and a review of published market reports. 4-6 weeks average fabrication lead time when producing in CNC.
4. Delivery as quickly as 2 weeks after HP receipt of design file, detailed specs, the tool design quotation approval, purchase order, and receipt of first payment. Shipping time not included.
5. Secure online platform offering password protected intellectual property and encrypted access control.
6. Polyamides in HP 3D High Reusability PA 11 material do not corrode with water (a common problem with metal tooling). Based on internal HP testing, August 2020. HP tools produced with HP 3D High Reusability PA 11 material were tested over 5 days at 50° C (122° F) using different solvents (DI water - control, tap water, $CaCO_3$ saturated, and 5 wt% aluminum potassium sulfate), and presented no visual signs of corrosion.
7. Polyamides in HP 3D High Reusability PA 11 material do not present calcification signs with water (a common problem with aluminum tooling). Based on internal HP testing, November 2020. HP tools produced with HP 3D High Reusability PA 11 material were tested over 17 days at ambient temperature using 3 different solvents (DI water - control, tap water, $CaCO_3$ super-saturated), and presented no visual signs of calcification or weight changes.
8. HP hot swap SmartScreens can be replaced in seconds.
9. No machining, drilling, or manual screening needed.
10. Compared to traditional CNC and manual tooling. Based on testing commissioned by HP and performed by Innofibre, February 2021.

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