Fyous™

POLYMORPHIC MANUFACTURING.

The Critical Factor for Mass Customisation

ITCH INNOVATION LTD

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Executive Summary.

> Driven by new expectations and rapid technological advancements, today's consumers are shifting away from generic, mass-produced products toward flexible, tailored alternatives that better fit their unique needs and preferences.

This shift necessitates a complete overhaul of traditional production infrastructure. Hampered by rigid process economics, current production technologies, including injection moulding and 3D Printing, are structurally inadequate for delivering true customisation at an industrial scale:

These inadequacies include:

- Prohibitive Upfront Costs: Vast capital expenditure required for tooling and mould creation.
- Protracted Lead Times: Weeks or months are required to transition from design approval to production tooling.
- Unsustainable Waste Streams: Significant material waste and scrap rates generated by subtractive methods.

Polymorphic manufacturing is a revolutionary digital-to-physical process that utilises reconfigurable pins to form the precise shapes required for production tooling automatically, in minutes.

This foundational technology has the potential to deliver affordable mass customisation across multiple industries, and delivers immediate, quantifiable advantages:

- Cost Savings: Eliminates the foundational need for conventional, expensive fixed tooling.
- Time Savings: Agile tooling accelerates time to market by enabling mould reconfiguration and validation in minutes, not months.
- Innovation Agility: Zero-cost iteration removes the innovation bottleneck, allowing manufacturers to prototype rapidly and adapt designs in real-time.
- Waste Reduction: Cuts material waste by up to 96% compared to traditional production processes, delivering significant sustainability improvements.

Fyous is pioneering this transformative technology by developing advanced, reconfigurable tooling systems and partnering with innovative manufacturers, from high-performance footwear to critical medical devices, to reshape their production economics.

Introduction.

Imagine a world where every shoe is sculpted to each foot exactly. Where dental aligners are produced faster, cheaper, and without millions of kilograms of plastic waste.

Where new aircraft parts can be developed and enhanced without waiting weeks and wasting tens of thousands of pounds for new tooling that the manufacturer might only use once.

And where patient care is enhanced by the rapid, cost-effective production of custom-fit medical devices, such as prosthetics and radiation therapy supports.

Until now, the ability to produce such bespoke products was a distant dream, hindered by prohibitive costs and complex processes. But that dream can now become reality.

Welcome to the future of manufacturing...

Changing How the World Manufactures

Polymorphic manufacturing is a new paradigm in manufacturing technology, where moulding and forming systems automatically reconfigure their shapes to make producing custom products not only possible, but also economically viable at near-mass production prices.

Say goodbye to rigid, single-purpose tooling.

This is the next generation of manufacturing, pioneered by Fyous. It's poised to transform footwear and numerous other industries.

FOOTWEAR
Shoemakers can turn customers' 3D foot scans into temporary moulds to produce millimetre-perfect lasts for shoes to be built around.

DENTAL
Producers of dental aligners no longer need to waste time, effort and plastic 3D printing single-use moulds for each customer.

AEROSPACE
Aerospace manufacturers can reduce tooling costs and lead times when producing and refining new components.

MEDICAL
Medical manufacturers can reduce wait times and improve patient outcomes by quickly and cost-effectively producing devices tailored to each patient's anatomy.

The Challenge.

Overcoming the Tooling Bottleneck

Mass customisation is the ability to deliver unique, personalised products at competitive prices and in industrial volumes. It has been a goal for manufacturers seeking to capture greater market share and build lasting customer loyalty for decades.

The history of attempts to achieve this standard demonstrates that the demand for these products is robust, driven by informed and discerning consumers who require products tailored to their needs. This history also shows that tooling agility within manufacturing processes is a key barrier to overcome in meeting that demand.

Case 1: Adidas Speedfactory

Launched in 2016, the Adidas Speedfactory represented a major investment in automated, localised production. It aimed to cut lead times, bring manufacturing closer to key markets and support mass customisation of athletic shoes[1].

THE AMBITION: The goal was to fully automate the production of footwear, so that Adidas could produce a unique shoe based on customers' data (including foot measurements, running style and preferences) without the long lead times or high costs of traditional customisation.

MASS CUSTOMISATION CHALLENGE: The advanced automation within Speedfactory was optimised for a specific production workflow and component set, but it did not solve the fundamental tooling bottleneck for true mass customisation.

THE SIZE LIMITATION: Speedfactory automated assembly and upper creation, but still relied on moulds and tooling for the midsole and bonding process. The need to create a unique physical mould for each customer's feet meant the factory was better suited to high-speed runs of single designs rather than to bespoke manufacturing for individuals.

Case 2: SmileDirectClub

SmileDirectClub (SDC) sought to disrupt the orthodontics industry by selling dental aligners and retainers directly to consumers at prices it said were up to 60% lower than traditional options. In 2019, it announced a major investment in 3D printing to produce the custom mouth moulds required to make these dental products at scale.

THE AMBITION: To provide dental aligners and retainers at a lower cost than conventional options. SDC invested in 49 HP Jet Fusion 3D printing systems, a move that was claimed to make it the largest user of such systems in the US, providing capacity to produce 20 million moulds per year[2].

FAILURE TO SCALE: High advertising spending, combined with significant expenditures on 3D printers, post-processing equipment, labour, and the specialist materials needed to produce multiple moulds for each customer, meant that SDC was unable to achieve profitability, despite serving over 2 million customers.

THE OUTCOME: SDC filed for bankruptcy in 2023 after years of mounting debt and closed its operation[3]. SDC's bankruptcy filing cited multiple operational and manufacturing challenges, including delays in obtaining raw materials and substantial increases in input costs, as well as a decline in consumer spending[4].

These historical examples underscore a crucial principle: To achieve mass customisation without compromise, manufacturers require a technology that makes the production of a truly unique tool (such as a last or mould) significantly faster and more cost-effectively than producing a standardised one.

The Tooling Bottleneck

> Traditional manufacturing systems are not merely inefficient; they are fundamentally structured to resist customisation at scale. The cost of tool creation and validation acts as a bottleneck for both innovation and profitability.

Challenge	Traditional Injection Moulding	Traditional Additive Manufacturing
Tooling Cost	Prohibitive. Costs range from £20,000 to over £80,000 for hardened steel tooling[5]. Research indicates that at low to medium volumes, tooling expenditure can account for between 84.6% and 97.7% of the total per-part cost[6].	Uneconomical. High per-part cost and slow speed render it economically unviable for medium- and high-volume runs[7].
Lead Time	Protracted. Fabrication and validation for production tooling require substantial time, with industry sources suggesting timelines ranging from 8 to over 20 weeks[8], which can hinder innovation. Tool rework further compounds delays.	Slow Cycle Time. Slower production speeds than those of conventional methods inherently limit speed to market[9].
Material Waste	Significant Scrap. Subtractive processes for components can result in approximately 90% of the original material being discarded as waste[10].	High Waste. Studies suggest 34.6% of material used in some 3D printing processes is wasted due to failed builds and discarded support structures[11].

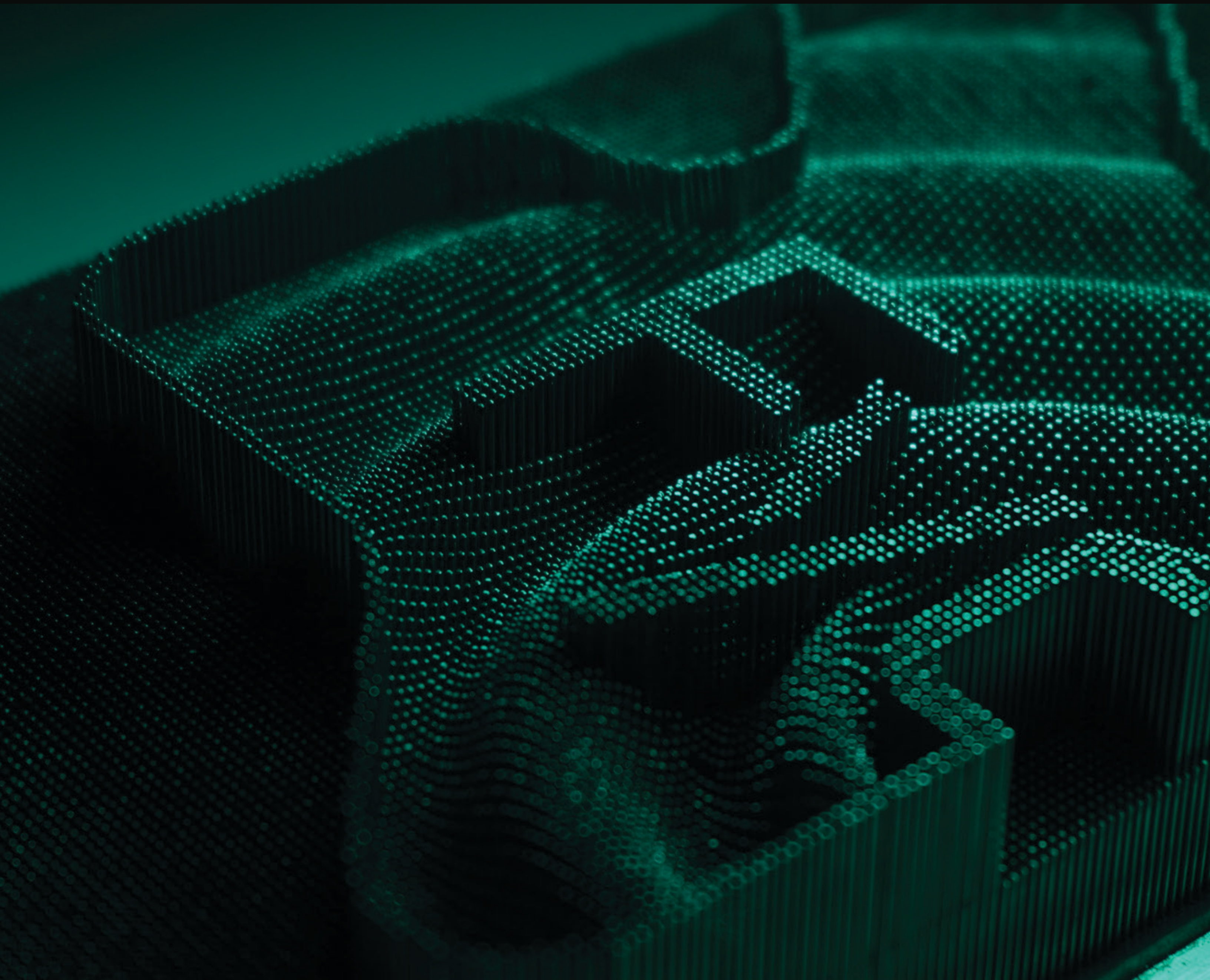
There is a clear need for a new approach to moulding and forming — one that combines the ultimate flexibility and speed of digital manufacturing with the superior material performance, surface finish, and scalability of traditional injection moulding.

Polymorphic Manufacturing.

A Paradigm for Agility

Designed to unleash unparalleled flexibility and efficiency in manufacturing environments, polymorphic manufacturing is a revolutionary digital-to-physical process that rapidly and automatically crafts custom tools and moulds within minutes.

THIS IS NOT AN INCREMENTAL IMPROVEMENT.
THIS IS A NEW CATEGORY OF PRODUCTION CAPABILITY.



The Technological Core: A Reconfigurable Actuation Bed

> The technology is centred on machines featuring tens of thousands of precisely controlled, reconfigurable pins — a high-density actuation bed — that are controlled by 3D CAD software.

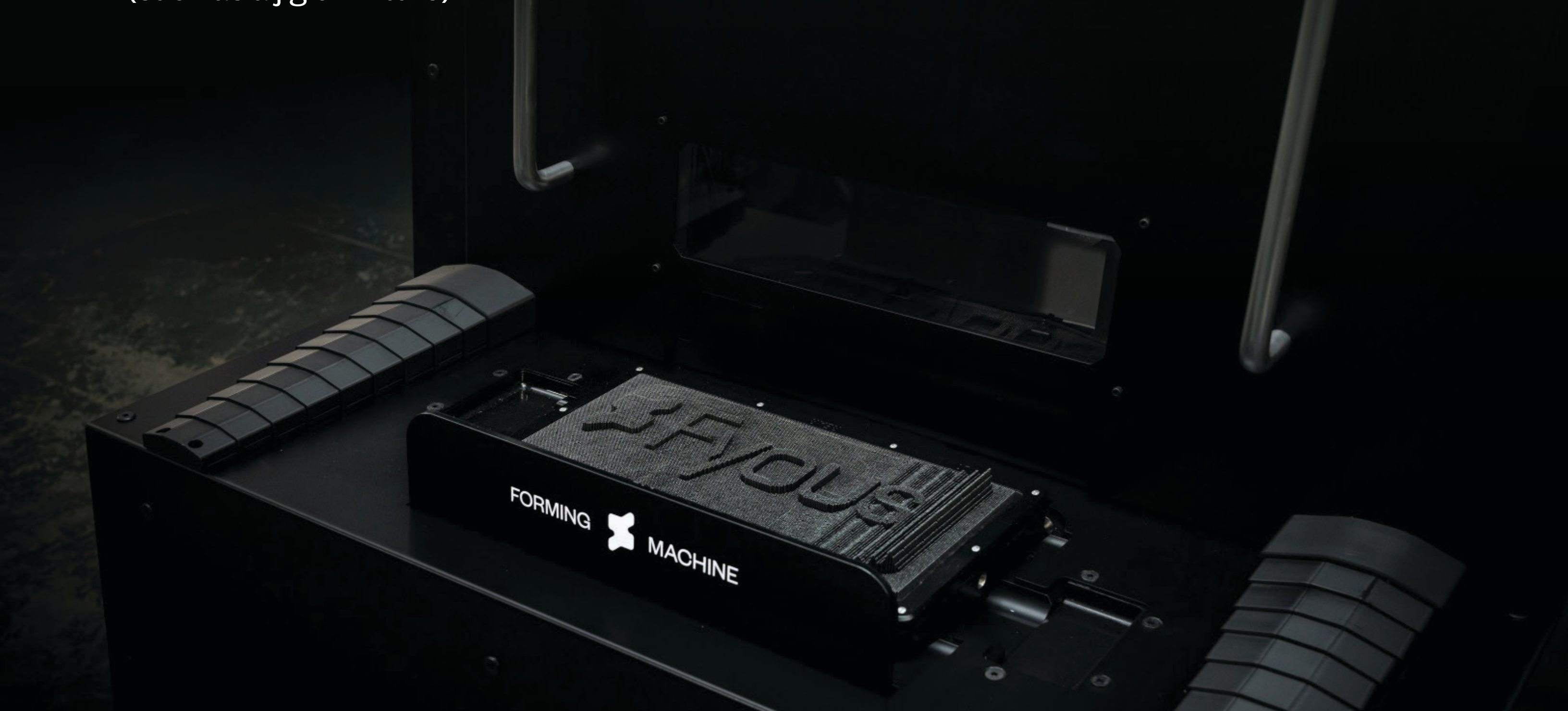
HIGH-DENSITY ACTUATION
Uses an actuation bed with infinitely reconfigurable pins to create the desired shape geometry. The density of these pins helps to determine the surface resolution and complexity that can be achieved.

DIGITAL INTEGRATION
The physical pin configuration is dynamically controlled by the digital blueprint, enabling the system to act as a digital-to-physical interface for tool creation.

FUNCTIONALITY
A single machine can serve as a mould for injection, a forming tool for thermoforming, or even a reconfigurable work-holding device (such as a jig or fixture).

SURFACE DELIVERY AND MATERIAL PERFORMANCE
A durable, heat-resistant membrane wraps around the pins. This membrane delivers material injection and ensures the necessary smooth surface finish and structural integrity required for high-volume injection moulding.

UNDERCUTS
The use of multiple actuation beds, each operating at a different angle, enables the creation of undercuts. Traditionally, these complex features required specialised, expensive and multi-part fixed tooling.



The Polymorphic Process: Production Agility in Minutes

> Polymorphic manufacturing replaces the weeks-long tool fabrication cycle with a digital-first workflow that brings moulds to life in minutes.

1 DIGITAL BLUEPRINT
A product design is sculpted in 3D CAD software, tailored to a customer's exact needs and specifications, or generated automatically from a body scan (e.g. a foot or dental scan).

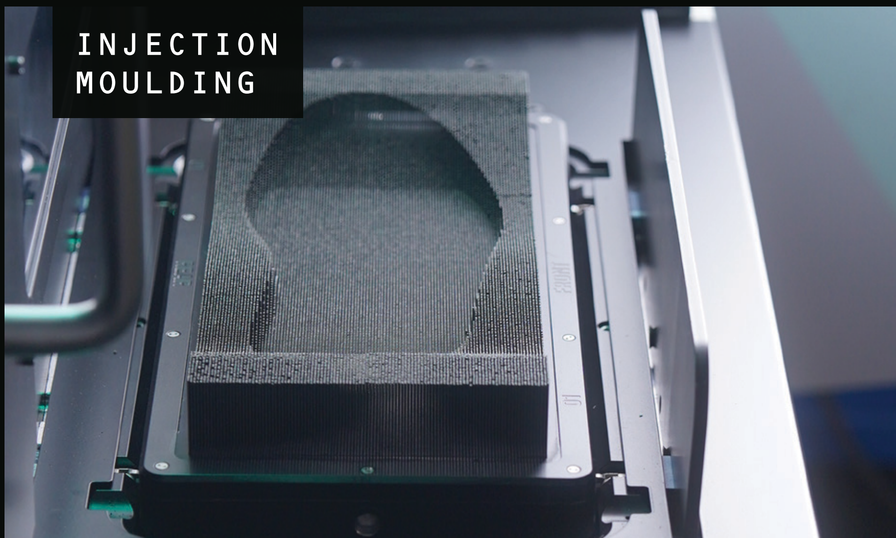
2 INSTANT TOOLING
The digital blueprint directly interfaces with the machine's controller, enabling the reconfigurable pins to lock into the exact required production shape in minutes.

3 DYNAMIC PRODUCTION
The polymorphic mould creates a custom component and automatically shape-shifts for the next unique order on the line. The machine can then immediately begin a production run for a completely different variant or component size.

Applications

> The flexibility of polymorphic manufacturing is poised to reshape a multitude of manufacturing processes, providing unprecedented agility.

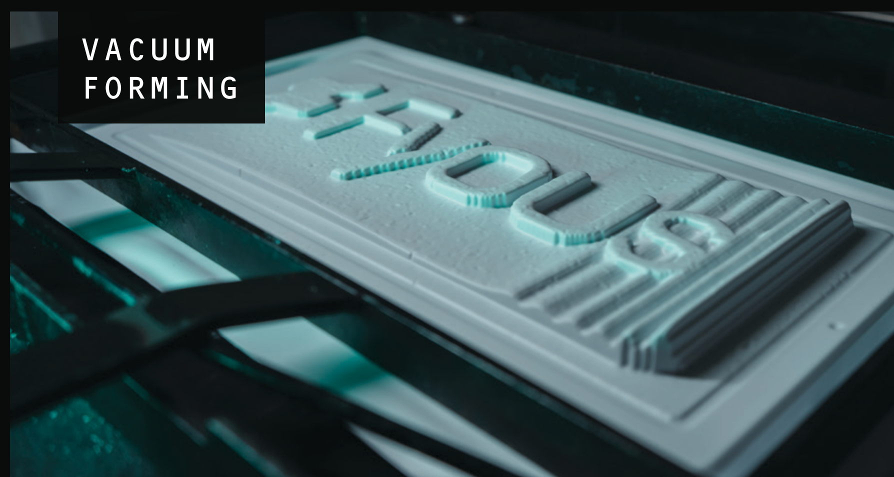
INJECTION MOULDING



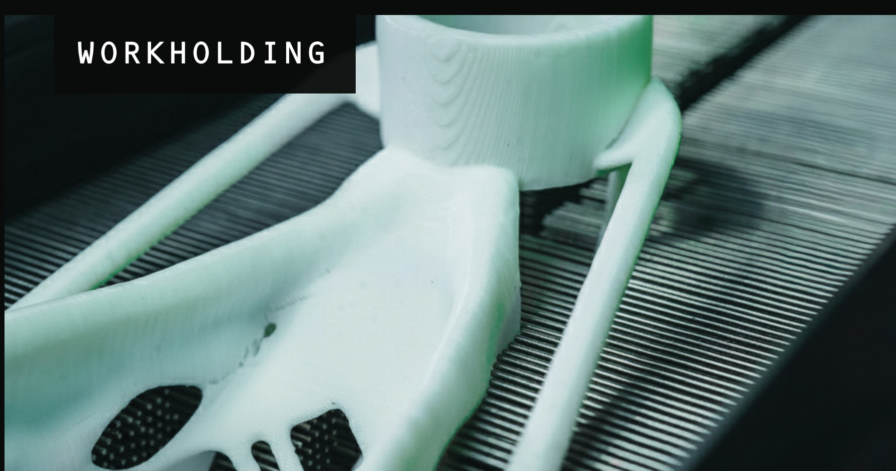
A single polymorphic moulding machine reconfigures itself for each design, enabling endless variants, customised patterns, or unique batch sizes without the prohibitive costs and delays of conventional tooling. Flexible membranes separate the material from the pin surface and improve the surface finish.

VACUUM FORMING

A polymorphic forming machine can produce custom forms for products such as patient-specific orthotics, medical devices, and bespoke packaging in minutes, eliminating the need for vast inventories of physical moulds.



WORKHOLDING



Polymorphic tools provide a precise, customised grip for complex, irregular parts, streamlining operations and eliminating the need to invest in bespoke fixtures and jigs for each product iteration.

The cost of design changes or switching between product variants is effectively zero, as no new permanent physical moulds, tooling or fixtures are required. This eliminates the primary barrier to customisation and supports integration into smart factory environments, enabling custom products to be created on demand with minimal human intervention.

The Total Cost of Ownership (TCO) Advantage.

> For manufacturers, the decision to invest in new technology involves considering the TCO. The advantages of polymorphic tooling are clear when compared to traditional tooling, particularly in industries where frequent product variants and rapid iteration are common.

Scenario Comparison: Traditional fixed tooling Vs dynamic polymorphic tooling.

Consider a manufacturer aiming to produce 50 unique product variants (e.g. 50 different sizes, widths, or designs).

Cost Factor	Fixed Tooling (Traditional)	Polymorphic Tooling
Tooling Investment	50 individual tools at £20,000 each: £1,000,000	One Polymorphic Machine: The cost depends on size and pin density, typically between that of 5-10 individual tools.
Tooling Storage	High. Requires significant warehouse space, security, and maintenance.	Zero. The mould is software-defined. No physical storage is required.
Time-to-Tooling Approval	Months. 8 to 20 weeks per variant.	Minutes. The tool is reconfigured instantly via CAD data. All variants are available immediately and are brought to life by the polymorphic tool.
Design Iteration Cost	High. Any minor design change requires scrapping or modifying the fixed tool, which can cost thousands and delay production by weeks.	Zero. Design changes are implemented instantly in the CAD file. The polymorphic machine adapts automatically.
Waste Rate	High, especially in subtractive finishing.	Low and predictable.
Financial Risk	High. If a market trend shifts or a product variant fails, the fixed tool investment is lost and cannot be repurposed.	Minimal. The hardware is fully reusable for any product variant, mitigating sunk costs from design failure.

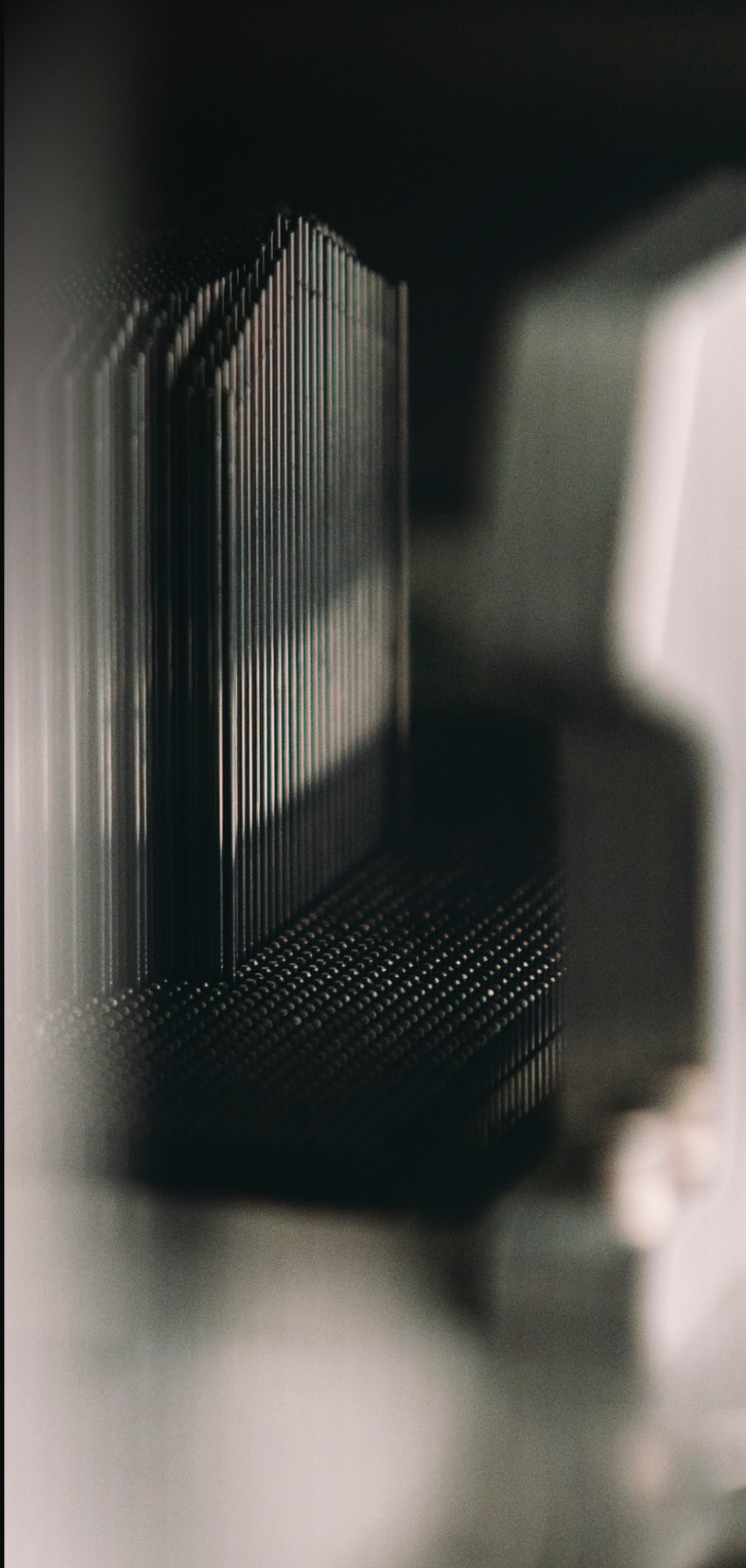
The Role of Polymorphic Manufacturing in Mitigating Risk

> Manufacturers are operating in an environment that is more complex, interconnected and volatile than ever before, and where technology and customer tastes are evolving rapidly. As a result, mitigating risk in production has become as much a strategic priority as an operational one.

DE-RISKING PRODUCT DEVELOPMENT
Polymorphic manufacturing allows manufacturers to invest primarily in design data rather than physical moulds. If a pilot batch of a custom variant underperforms, the manufacturer has lost only the material cost of the small batch, not the cost of the fixed tool.

ENABLING LOT SIZE OF ONE
By eliminating setup time and fixed tooling costs, the technology makes the production of a "lot size of one" (a single, unique item) profitable. This is essential for bespoke services, specialised spare parts, and patient-specific medical devices where production runs are naturally small.

SUPPORTING SUPPLY CHAIN AGILITY
Relying on single-source, fixed overseas tooling creates immense supply chain risk. Polymorphic manufacturing enables local, on-demand, and flexible production, reducing reliance on lengthy and potentially vulnerable international supply chains.



SWOT Comparison.

Evaluating Manufacturing Agility

Aspect	Subtractive	Additive	Polymorphic
Strengths	Achieves tight tolerances. Excellent surface quality. Established processes and standards. High throughput at single-part, high volume.	Supports complex geometries. Ideal for low-volume, personalised parts. Fast CAD-to-part iterations	Custom products at near mass-production cost. Zero-cost design iteration. Single machine for multiple tooling types. Shifts variants in minutes. Significant environmental and cost savings.
Weaknesses	Requires extensive, costly fixed tooling. Poor material efficiency (substantial scrap). Long setup times make small runs uneconomical.	Uneconomical for high-volume production. Slower speed than conventional methods. Lower strength parts. Extensive post-processing.	Upfront capital investment in advanced machinery. New technology with limited industry validation. Certification for regulated sectors may slow uptake.
Opportunities	Hybrid manufacturing for high-precision parts. Automation and robotics could improve efficiency.	Supports local, on-demand production. Less inventory and supply chain risk. New tech may enable medium-volume production.	Practical, affordable mass customisation for previously uneconomical products. Reduced tooling costs and lead times in industries that depend on subtractive processes. Seamlessly fits into smart factory environments.
Threats	New regulations and sustainability demands. Rising material and energy costs. Limited availability of skilled operators.	Part-to-part variability and certification challenges limit adoption. Digital part files create new IP risks. Advances in subtractive tech create competition.	Advances in other manufacturing tech could limit unique advantages. Resistance from industries accustomed to conventional tooling may slow uptake.

Real-World Applications.

Unlocking the Value Proposition

> Polymorphic manufacturing enables the production of affordable, on-demand, fully personalised products, opening new market segments and addressing core industry challenges.

Footwear

CHALLENGES

Each size and style requires dedicated, expensive fixed moulds and lasts.

Traditional last-making is a wasteful moulding and milling process, where over 50% of material is cut away to create a desired shape[12].

KEY BENEFITS

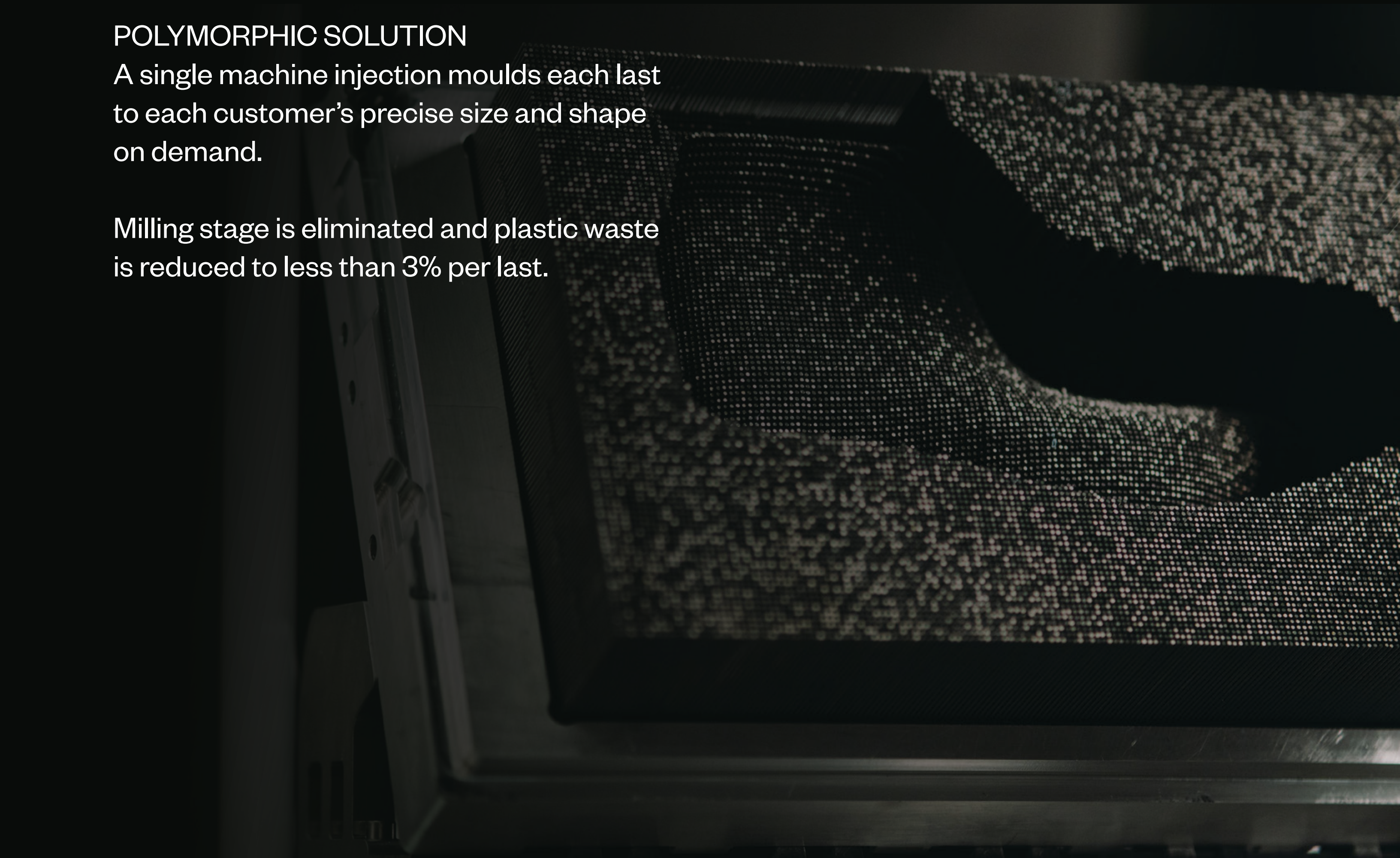
Enables true custom-fit shoes for every customer, overcoming the limitations of the Adidas Speedfactory model.

The cost of producing lasts decreases by more than 75% due to automation and material efficiency.

POLYMORPHIC SOLUTION

A single machine injection moulds each last to each customer's precise size and shape on demand.

Milling stage is eliminated and plastic waste is reduced to less than 3% per last.

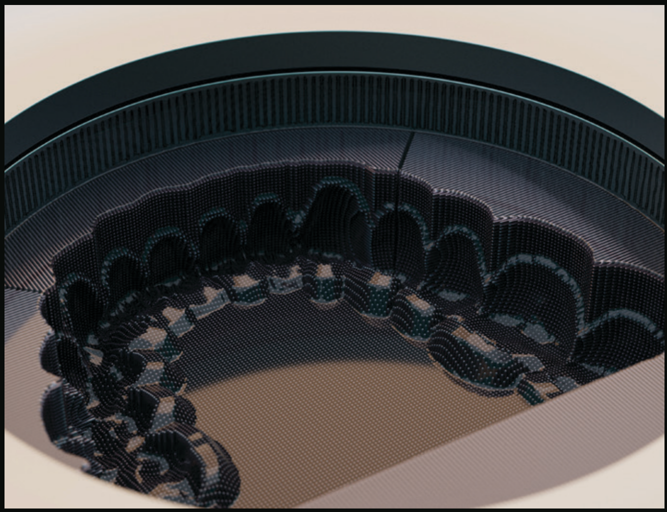


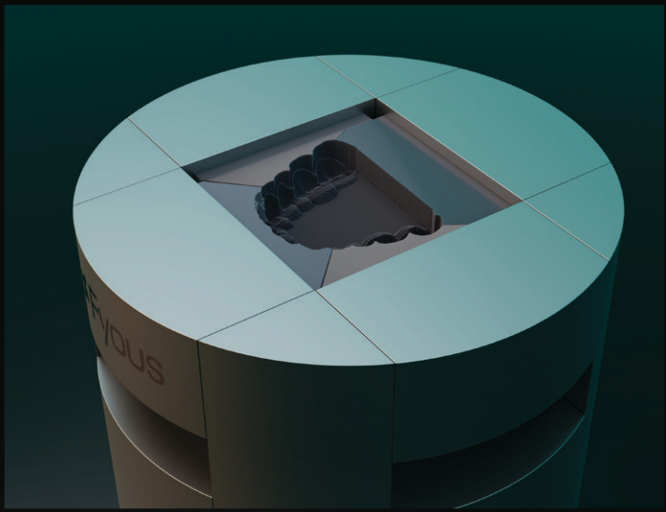
Dental

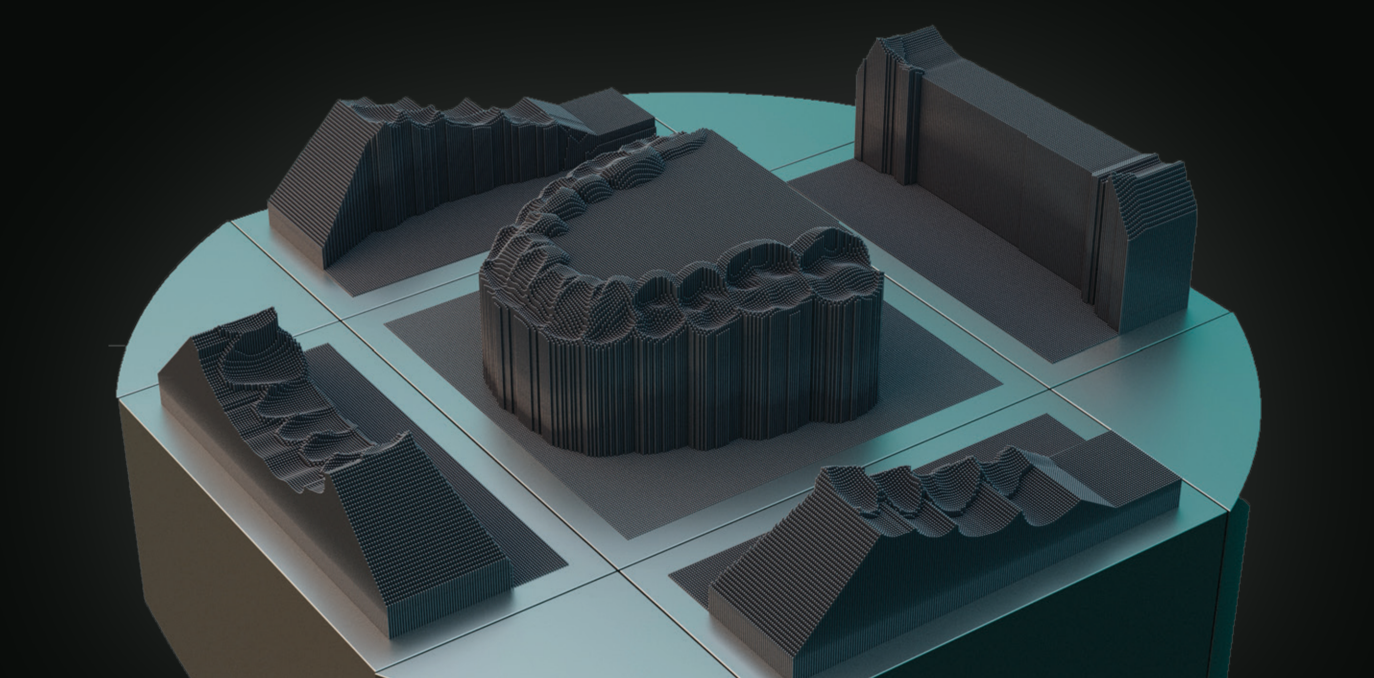
CHALLENGES
Aligner production relies on disposable 3D-printed moulds (up to 80 per customer)[13], generating significant plastic waste and high material costs.

POLYMORPHIC SOLUTION
Reconfigurable pins allow for the direct creation of custom, temporary moulds in minutes, eliminating the need for disposable 3D prints. 5-sided tools enable undercuts with minute pins for maximum resolution.

KEY BENEFITS
The process is faster and cleaner. Mass adoption would avoid millions of kilograms of plastic waste, eliminate 14,000 tonnes of CO2 emissions, and save an estimated £1 billion in production costs annually[14].





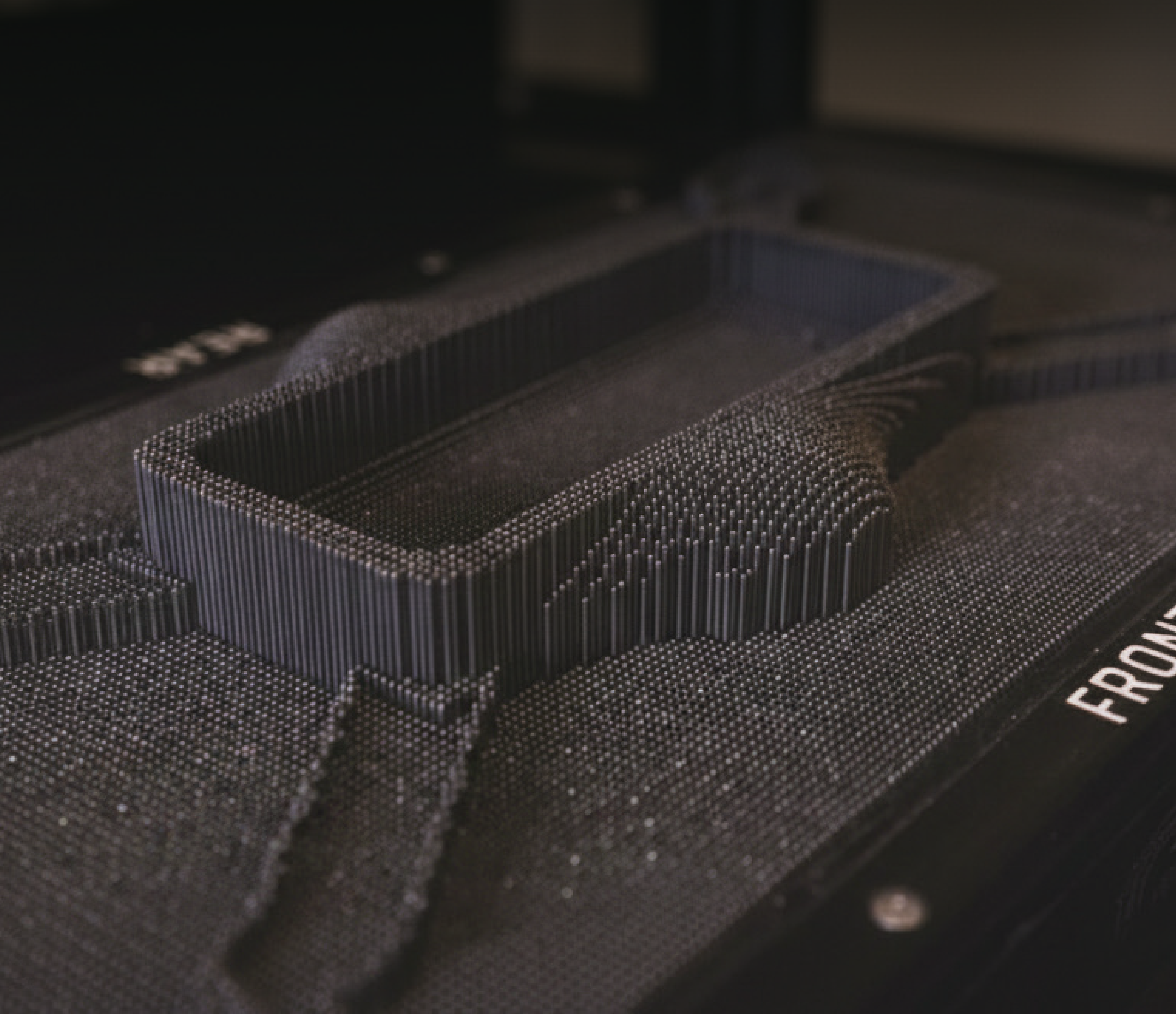


Aerospace

CHALLENGES
Frequent design changes require unique, costly tooling and long lead times for certification.

POLYMORPHIC SOLUTION
Rapid reconfiguration of tooling supports agile development and significant cost reductions in fixture creation.

KEY BENEFITS
Supports the faster development of complex structures with minimal waste and enhanced cost efficiency, which is critical for low-volume, high-value components.



Medical Devices

CHALLENGES
Patient-specific devices (e.g. prosthetics, orthotics) require high customisation, leading to high costs, long lead times, and sub-optimal care.

POLYMORPHIC SOLUTION
Patient-specific devices can be produced quickly and affordably, starting with a 3D scan.

KEY BENEFITS
Improves patient outcomes and supports rapid design iteration in a regulated industry, making bespoke solutions accessible and affordable.

Partner with Fyous.

Shape-Shift Your Future

> Polymorphic manufacturing is redefining what's possible in production and addresses the key challenges facing modern manufacturers.

MASS CUSTOMISATION: Enables the production of premium, personalised products at near-mass production costs, unlocking new markets and fostering customer loyalty.

COST: Delivers substantial cost savings by eliminating the need for expensive, single-use moulds and storage, transforming CapEx into OpEx.

TIME: Offers transformative time savings by converting new designs into production-ready tools in mere minutes, a key factor in gaining a competitive edge.

WASTE: Reduces material waste by up to 96%, supporting critical sustainability goals.

Fyous stands at the forefront of this revolution. We are pioneering polymorphic manufacturing with advanced, reconfigurable tooling systems that accelerate time-to-market, reduce production costs, minimise waste, and enable true mass customisation to be both possible and economically viable.

We invite you, as manufacturing innovators, to engage with us and explore how polymorphic manufacturing can deliver a better future for you and your customers. Fyous is not just imagining the future — we are building it.

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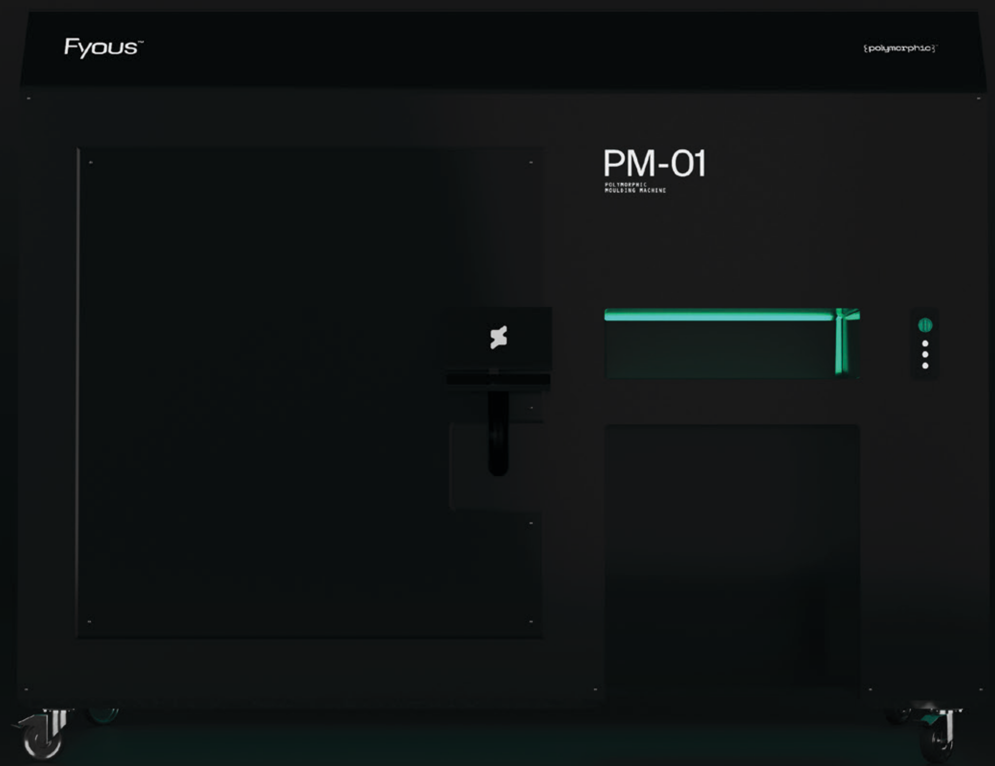

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