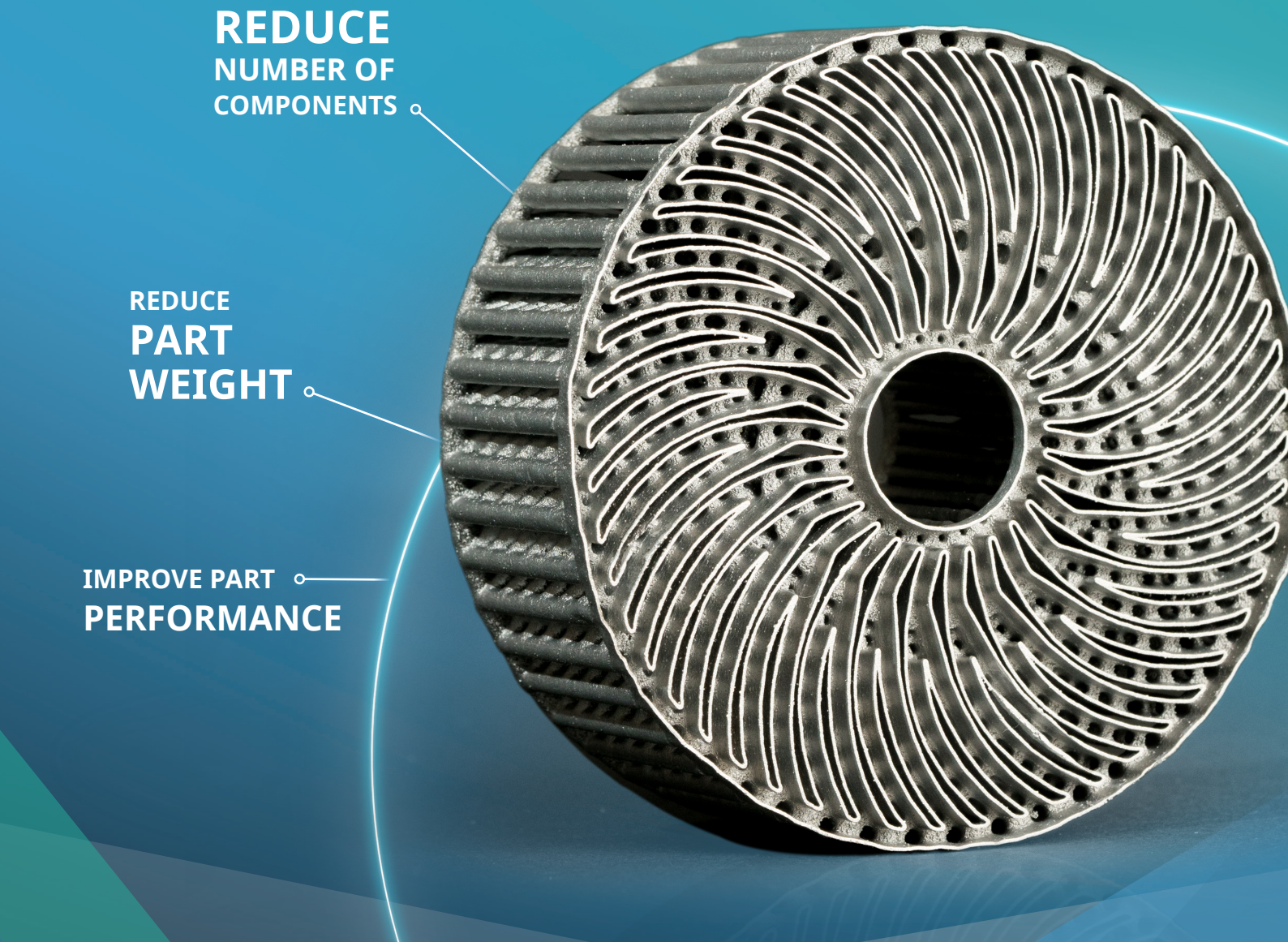
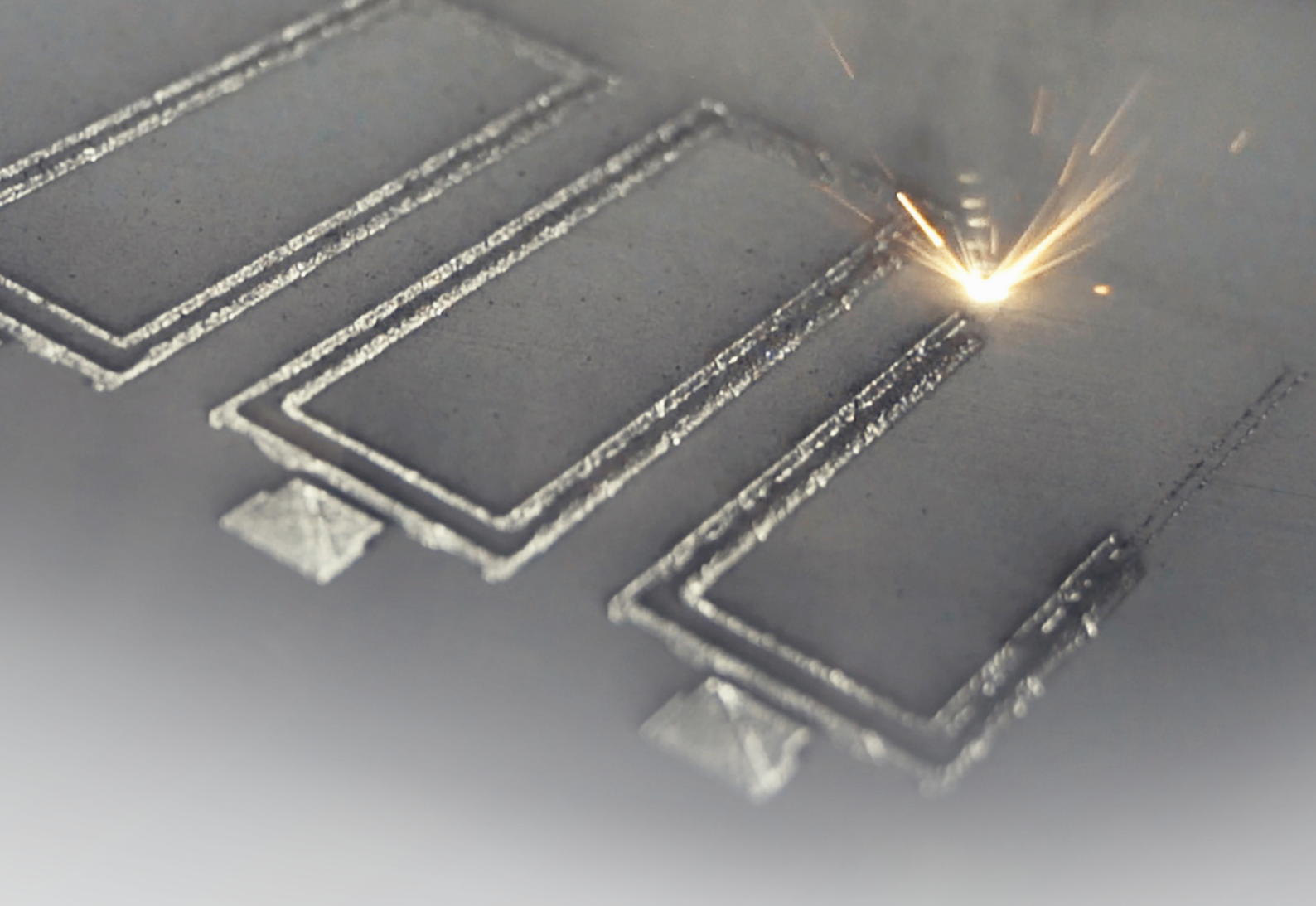
3D SYSTEMS®
Additive Manufacturing Solutions

Executive Brief

Discover the Fifth Wave: Metal Additive Manufacturing



Contents



Metal additive manufacturing is revolutionizing how parts are designed and produced, offering solutions that were impossible just a few years ago.

This new world is not only delivering better quality components at lower cost but is offering whole new design possibilities, new business models and new markets. The key is to know when to use metal additive manufacturing instead of or complementing conventional milling or casting.

Read this executive brief to learn about the transformative value of the fifth wave of metal 3D printing, as well as compelling use cases for direct metal printing from the aerospace, automotive and industrial sectors.

AT A GLANCE

- Know when to use metal additive manufacturing instead of conventional milling or casting
- Find out how one automotive client reduced part component count from 20 down to one
- Learn how you can improve strength-to-weight ratios
- Achieve up to 50% part weight reduction and faster production times
- Improve part lifetime and reduce material degradation

Metal additive manufacturing and the new era of 3D production

The history of 3D printing in manufacturing is a story of transformative value arriving in five waves. Just as television did not replace radio or movies, each new wave of value from 3D printing did not replace previous usage, but opened up new possibilities.

Rapid prototyping changed expectations regarding design iteration processes with lower cost of multiple prototypes and faster time to product. Indirect manufacturing introduced the creation of master patterns or tools with 3D printing. Custom manufacturing offered complex individualized products based on 3D scan data or other bespoke input. Complex manufacturing used 3D printing technology and advanced materials to create specialized or custom final parts in low volume.

Now 3D printing has arrived at the fifth wave, 3D production.

Depending on factors including the product, the industry, the production run and the materials required, it is now physically and cost-effectively possible to fully design for functionality and create effective manufacturing production runs, leaving the limitations of traditional manufacturing behind.

The transformative opportunities of 3D production ripple through the entire manufacturing ecosystem, affecting both manufacturing and economics.

3D production opens the door to agile manufacturing processes, reducing the lead time from conception to production and decreasing time to market.

THIS IS WHAT METAL ADDITIVE MANUFACTURING CAN DO: DRAMATICALLY SIMPLIFY DESIGN, IMPROVE FUNCTIONALITY AND REDUCE WEIGHT ALL IN ONE.

IT IS REVOLUTIONARY.

Design flexibility and end-to-end workflows

Specifically for metal production, this new wave offers previously unknown design flexibility.

Because metal additive manufacturing overcomes the constraints of traditional manufacturing, it's ideal for producing compact components with highly complex organic shapes, internal channels, complex surface textures and high levels of detail.

Moving to metal additive manufacturing is a big step, perhaps a bigger leap than moving into the previous four waves of 3D printing. It more directly connects design and manufacturing. It requires updated end-to-end workflows. But the benefits described in this report are immense and not achievable using traditional methods.

The 3D Systems Direct Metal Printers (DMP) metal additive manufacturing line is the most mature metal 3D printing line available anywhere. It is factory-tested and continuously improved with constant input from customers and a team of leading scientists and engineers. It is scalable, and applicable for initial production run testing to large scale 24/7 production runs.

Setting new standards for cost, speed and part performance

In metal additive manufacturing, consistent repeatable mechanical properties are key, delivering cost reductions, speed and part performance for your business.

These benefits are well documented in tests using 3D Systems' ProX DMP 320 printers. See the results in the Appendix of this report.

THE BENEFITS OF 3D PRINTING DESCRIBED IN THIS REPORT ARE IMMENSE AND NOT ACHIEVABLE USING TRADITIONAL METHODS.

Compelling use cases for metal additive manufacturing

Metal additive manufacturing brings multiple advantages to manufacturers looking for new paradigms in production costs, speed and part performance.

Customers mentioned in the use cases below achieved the following metrics:

- Part count reduction of 20 down to one
- 50% part weight reduction and faster production times
- 3x improved part lifetime through combination of Inconel materials and internal cooling channels to reduce part degradation
- Maintaining and improving part strength-to-weight ratios

USE CASE: PART CONSOLIDATION

That light bulb moment

Consider the light bulb – if you want to make one from quartz glass, you have to heat it under a gas flame to extreme temperatures. The engineering team at lighting equipment manufacturers Havells Sylvania had a problem: their gas burners were burning out. Not just that, the 20 individual steel and aluminium parts were costly to manufacture and assemble.

A whole new approach was needed, but what?

3D Systems' Customer Innovation Center took a radical approach: the recommendation to use Inconel, an alloy used in jet engines, was the first step, because it can take extreme temperatures. Then use it to make a consolidated unit – one single part to do the job of 20 assembled parts. It would have been unthinkable once, but now possible thanks to metal additive manufacturing. This radical approach worked and the engineers delivered a new burner which was 60% more cost-effective.

But metal additive technology meant they could go even further. For a start, they cut the volume of material actually used in half. Then, they were able to create internal cooling channels, something that was impossible to do using traditional methods The new alloy, the single component, the huge drop in volume used and the cooling channels meant a tripled product lifetime.

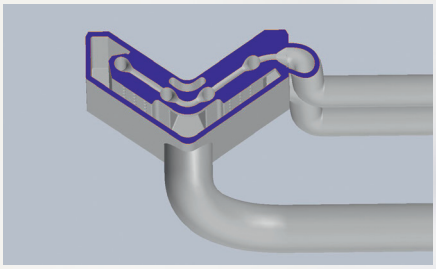


Image above:

A scaled-up model of the internal, integrated gas and cooling channels that can only be produced using additive manufacturing.

"TOGETHER WITH 3D SYSTEMS WE HAVE ACHIEVED A MAJOR TURNAROUND ON THE LEVEL OF THE BURNER DESIGN. EXPLOITING THE DESIGN FREEDOM ASSOCIATED WITH AM ENABLED US TO REALIZE OPTIMUM BURNING CAPABILITIES, EFFICIENT INTERNAL COOLING AND REDUCED WEIGHT."

Frank Broeders, Project and Equipment Design Manager, Havells Sylvania

Image right:

The completed single-part burner, printed in Inconel, cuts heat variance across the part, produced in half the time and has tripled reliability.

The original burners required careful assembly of 20 parts.

USE CASE: PART CONSOLIDATION

Less really is more

Traditional manufacturing delivers many limitations on a part design due to the need to assemble many parts together, increasing risk of assembly errors, and increasing weight through the use of fasteners, glues and so on. Metal additive manufacturing enables significant assembly consolidation into a single part, reducing weight, costs of assembly and assembly errors.

Metal additive manufacturing means making just one piece from the start: less weight, less cost, fewer errors. And that translates into much smoother supply chains, faster and cheaper manufacturing and the opportunity for startling design innovations.

Engineering consulting firm MTI is a pioneer in the use of metal additive manufacturing. One recent project was a valve component that needed several intricate internal passages.

Traditionally, the valve would be manufactured in pieces that would be welded or brazed together. Using 3D printing, MTI worked with the customer's team to create an equivalent design in one single piece. In addition to saving the time and labor associated with assembly, developing a single-piece print enabled MTI to deliver a better quality product that will require less maintenance and have a longer lifespan.

Now lets look at our light bulbs again – or rather the burners that made them. Havells Sylvania's new monolithic Inconel burners are a textbook example of part consolidation because they used one part for every twenty previously – that meant not just better performance, but way fewer unpredictable break downs and a much longer lifespan.

DIRECT METAL PRINTED EXHAUST - KEY BENEFITS

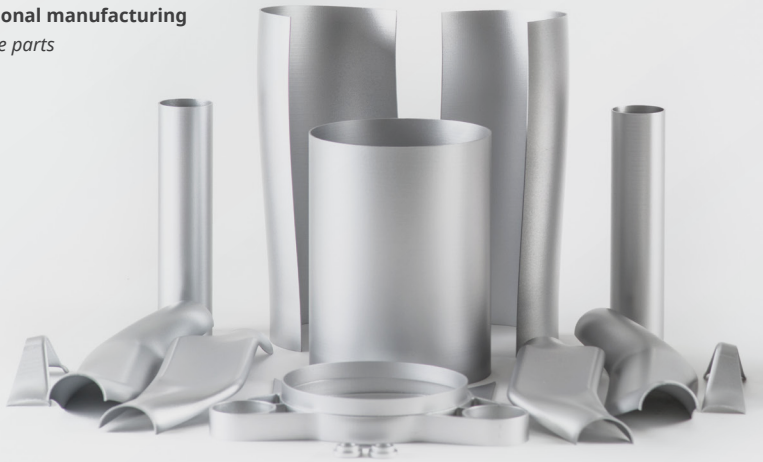
- Geometry optimization
- Component consolidation (from 20 individual parts, down to a single component)
- Increased complexity
- Typical wall thickness = 0.6mm
- 23hrs to produce in LaserForm® Ti Gr23 (A)
- Huge reduction in manufacturing time – 23 hours vs. several weeks
- Eliminate the need for tooling, fixturing, and multiple welding and inspection processes

Direct metal printed exhaust

One automotive client was able to reduce 20 individual parts down to one single piece with metal additive manufacturing.

The image on the left shows the number of parts needed to produce this exhaust using traditional methods, the image on the right shows the exhaust in a single part. The benefits of part consolidation for this particular use case are listed in the fact box above.

Traditional manufacturing
Multiple parts



Additive manufacturing
One single part

Weight-loss for aerospace

New design methods in computer aided design (CAD) are making it easier to create parts that can only be built by metal additive manufacturing.

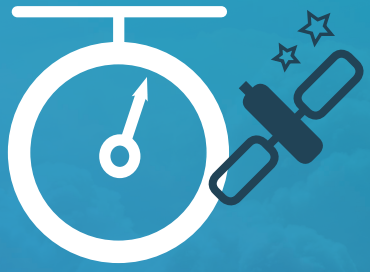
Every ounce reduced from the weight of an aircraft means less fuel burned on each flight. But aircraft are full of components that are solid blocks of material that don't have to be solid as long as they're strong.

They can be 3D printed to be even stronger (and safer) by creating lattice structures for what used to be solid areas. Titanium and expensive alloys become more feasible, since there is no waste and parts are no longer solid. Load-bearing components can be redesigned to optimize strength-to-weight ratios.

Airbus Space and Defence, in partnership with 3D Systems, received the first-ever certification for satellites on metal 3D printed radio frequency (RF) filters and frequency waveguides.

By consolidating the parts into a single-build assembly, the part achieved 50% weight reduction and faster production times.
Read the story

1KG = $22,000



When it pays to travel light

It costs up to $22,000 to send 1kg into space so for satellite manufacturers, it's a constant battle against weight. 3D technology is helping them to win it. Today 80% of metal parts in satellites are produced using 3D printing.

Metal 3D printing enabled Airbus Defence and Space to design and build a consolidated RF filter assembly based on a super-ellipsoidal cavity that efficiently channels RF currents.

USE CASE: LIGHTWEIGHTING

Printed parts in orbit

When global aerospace manufacturer Thales Alenia Space needed to shed weight in the antenna brackets of its satellites, it turned to 3D Systems for help.

Using metal additive manufacturing, Thales Alenia Space and 3D Systems came up with a design that improved stiffness-to-weight ratio, but, crucially, cut weight by 25%. And it cut production time in half, too.

The collaborative partnership worked together to produce four topologically-optimized brackets for the satellite, requiring an individualized design, as they are mounted on the antenna's reflector edges and screwed onto a shaped surface.

Production costs have been reduced considerably and total time from order to shipping – including file preparation, 3D printing, heat treatment, finishing, CNC milling, quality-control analysis, cleaning and data traceability – was four to five weeks, compared to 10 weeks using traditional methods.

"TOPOLOGICALLY-OPTIMIZED METAL PRINTED SATELLITE BRACKET REDUCED PART WEIGHT BY 25%, WAS PRODUCED IN HALF THE TIME OF TRADITIONAL ALTERNATIVES WHILE MAINTAINING STIFFNESS-TO-WEIGHT RATIOS."

BETTER
STIFFNESS-TO-WEIGHT RATIO

TITANIUM BRACKETS
25%
LIGHTER

Topologically-optimized metal printed satellite bracket

USE CASE: LIGHTWEIGHTING

Tipping the scales in favour of additive manufacturing

Research engineers were able to use additive manufacturing to produce a manifold that was over half the weight, included complex channels, and reaped the benefits of component consolidation.

The image to the right compares the weight of the manifold, first produced as a cast aluminium part, then compared to a 3D printed titanium version.

The cast aluminium part with SLA prints of the throttle bodies weighed 951.6g, while the 3D printed titanium version weighed 474.6g – a saving of just under 50%.

USE CASE: MOLD DESIGN

Cut mold design time by up to 75%

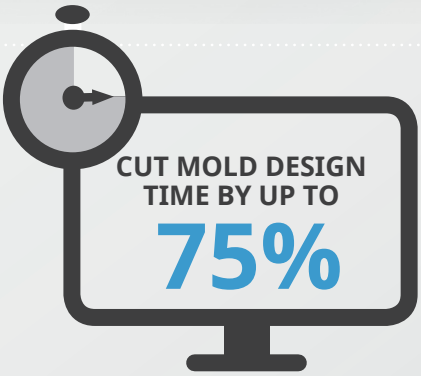
Heating, cooling, hydraulics systems are just the start.
Now let's see how 3D printing is changing the world of mold design.

Intricate internal channels that get coolant to the different parts of the mold are hard to make in the traditional way. With additive manufacturing, mold makers can create precise conformal cooling channels that are a consistent distance from the part geometry. This cools the parts faster and dramatically speeds up the injection molding cycle.

With 3D printing, engineering consulting firm BasTech has cut the time it takes to design a mold by 75%.

Not just that. The results include cutting injection molding cycle times by 22% and mold production costs by 18%.

Thanks to the integration of design software and printers, the molds are faster and cheaper to make, too.



CUT INJECTION MOLDING CYCLE TIME BY UP TO
22%

CUT COSTS BY UP TO
18%

Integrating software, printers and materials for manufacturing innovation

3D Systems is the original 3D printing company and the leader in research and development for production printers, advanced materials, and additive manufacturing factory production methods.

For a quality 3D print, it takes more than just a CAD model and printer. 3DXpert software from 3D Systems bridges the gap between model and printer giving you an all-in-one integrated solution that streamlines and optimizes the design, simulation, printing and post-processing of metal parts.

With two Customer Innovation Centers (CICs) and a new factory production solution, 3D Systems is a trusted partner for metal additive manufacturing innovation. Customers have access to a thoroughly developed and tested database of print parameters from 3D Systems' expert material process team.

A partnership with 3D Systems offers a one stop shop of benefits: reduced risk, lower operating costs, better quality and higher productivity.

3D Systems' metal additive solutions are known as Direct Metal Printing (DMP) a high-performing alternative to earlier Direct Metal Laser Sintering (DMLS) metal additive platforms.

From the largest metal printer (DMP Factory 500) to the entry level product, 3D Systems' direct metal printers are a proven solution with years of production experience.

They offer uniform, repeatable quality suitable for the most demanding factory operations. The vacuum chamber of ProX DMP 320 and DMP Factory 500 for part build ensures material purity throughout the process, while the RPMs (Removable Print Modules) provide constant powder control and short set-up times.

The 3D Systems DMP line of printers are designed for low cost of ownership and built for use in a production environment. They are factory tested for advanced manufacturing applications.

3D Systems uses its DMP printers to produce more than 500,000 challenging aerospace and industrial parts annually, in-house.

The learnings and expertise from this work informs product development teams and enables fine-tuning of workflows to ensure consistent and quality parts.

When traditional build methods are not possible or cost-prohibitive, metal additive manufacturing from 3D Systems offers a wealth of possibilities. The combined and integrated solutions for metal additive from 3D Systems reduce risk, decrease waste, increase production speeds, shorten set up times, deliver the best Total Cost of Operation (TCO) and produce dense metal parts.

500,000+ AEROSPACE & INDUSTRIAL PARTS PRODUCED IN-HOUSE EVERY YEAR

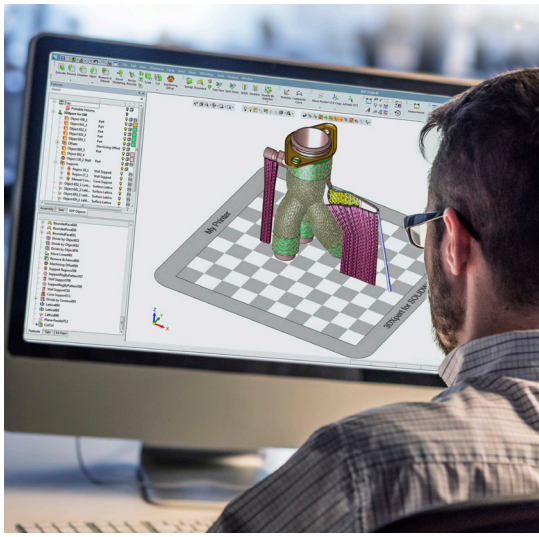
3DXpert™ – the all-in-one design for metal additive manufacturing software

3D printing, in particular metal additive manufacturing, does not start and finish with a printer. To achieve the best workflow and quality, the right software is key.

3D Systems delivers end-to-end solutions for metal additive manufacturing, including 3DXpert design for additive manufacturing (DfAM) software. An industry first, this software innately understands metal 3D printing and works with existing CAD models to eliminate conversion errors and deliver greater part accuracy than can be achieved with neutral 3D file formats.

The 3DXpert software brilliantly evaluates and redesigns existing models for strategic light-weighting (through, for example, the intelligent application of lattice structures), texturing of surfaces, optimization of supports, zoning for finish, reduction of stress in the parts and for material use reduction. And then it follows through into production and plan for post-processing.

Using 3DXpert alongside existing design tools reduces the total cost of operation and opens the door to extraordinary innovations in engineering workflow. That means the preparation of a build is streamlined, leading to an overall faster print process with better results.



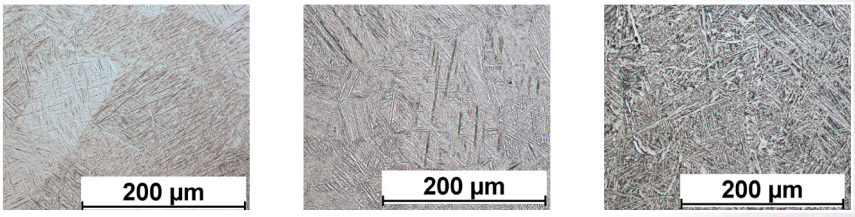
Manage risk with certified materials and established processes

3D Systems Customer Innovation Centers (CIC) in Leuven, Belgium and Denver, USA work closely with customers on fine-tuning processes and sharing best process parameters.

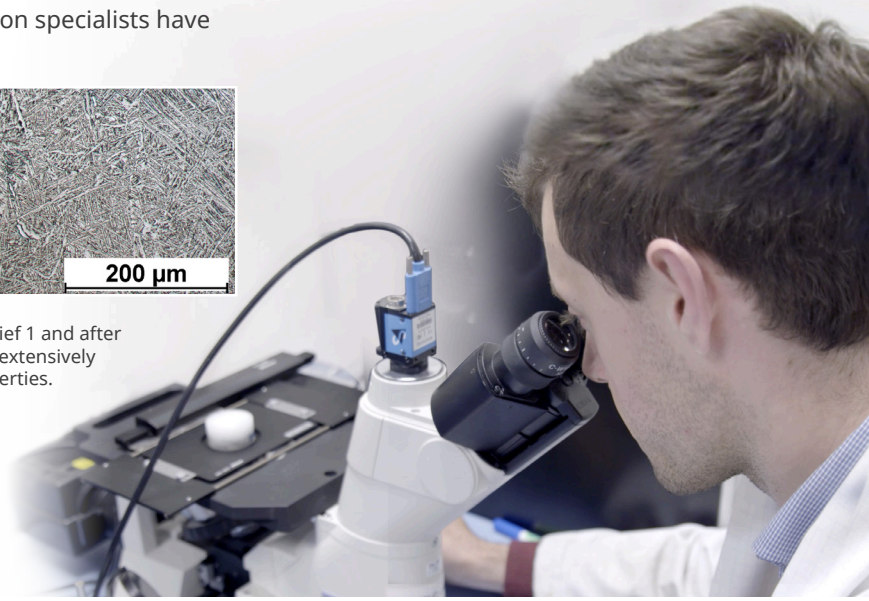
3D Systems offers a wide array of its ready-to-run LaserForm materials, with each material extensively tested and fine-tuned for the DMP line.

The expertise of the CICs is also useful in managing risk when certifying materials and establishing processes. It can take an engineering team months to vet materials for metal additive manufacturing properly. Often, those doing the in-house material review are not materials science experts.

An expert team of 3D Systems material scientists and metal AM application specialists have developed and tested an extensive database of material properties for every LaserForm material, data which is shared with customers. Using the database can significantly shorten the time it takes to get metal part production up and running.



Excellent microstructure LaserForm Ti Gr23 (A) as-built, after stress relief 1 and after stress relief 2. A team of material scientists and application engineers extensively develop and test print parameters to achieve consistent material properties.



ProX DMP printer line: designed for consistently high quality and productivity

In the ProX DMP 320 printer, the lowest possible oxygen content in the build chamber protects chemical composition and moisture content of the LaserForm metal alloys during manufacturing.

This means that the operating conditions don't affect the desired material specification. Working with a vacuum chamber eliminates material waste and reduces the Total Cost of Operations (TCO).

This process also reduces consumable usage, leading to shorter setup and fewer change overs compared to competitive products.

IT IS NOW PHYSICALLY AND COST-EFFECTIVELY POSSIBLE TO FULLY DESIGN FOR FUNCTIONALITY, LEAVING THE LIMITATIONS OF TRADITIONAL MANUFACTURING PROCESSES BEHIND

On Demand Manufacturing

Providing full manufacturing lifecycle technology and production support services

The On Demand Manufacturing Services of 3D Systems offer a broad range of processes and technologies, including direct metal printing.

It is an ideal way to start using 3D printing to quicken the pace of product development and to create completely new products and parts.

3D Systems On Demand Manufacturing is set up to comply to ISO quality management system standards, ITAR and AS9100C specifications.

What's next?

Interested in learning more about metal additive manufacturing? Our experts know how to integrate metal additive manufacturing into your production environment.

Get in touch today - we will be right with you.

Get in Touch

Appendix

SETTING NEW STANDARDS FOR COST, SPEED AND PART PERFORMANCE

In metal 3D printing, consistent, repeatable mechanical properties are key. This graph shows documented test results on 2 ProX DMP 320 printers using LaserForm Ti Gr23 (A). The test sample consisted of 40 print jobs, each including 120 traction samples over a test period of 3 years.