Desktop Metal

CASE STUDY

Hybrid Manufacturing of Surgical Instruments

—

BAK Kohler Medical combines metal binder jetting and CNC machining

—
BAK Kohler Medical uses Shop System, a metal binder jetting system from Desktop Metal designed to enable machine shops to 3D print metal parts cost-effectively.

Customer
BAK Kohler Medical KG

Location
Neuhausen ob Eck, Germany

Industry
Surgical instruments

Application
Dental forceps for large animals

Machine
Shop System™

Material
17-4PH

Website
www.kohler-med.com

Challenges in the conventional production of surgical instruments

Established in 1989 in Germany, BAK Kohler Medical manufactures surgical instruments using CNC milling and turning/lathing machines. Like many manufacturers worldwide, BAK Kohler Medical has faced its share of challenges in recent years, prompting a re-evaluation of the viability of its conventional manufacturing process.

The production of surgical instruments using CNC machines has certain limitations — complexity limitations, for instance. While CNC machining can produce highly intricate parts, there are limitations to the complexity of shapes and features that can be machined. Parts with highly complex geometries, like bionic structures, internal passages, or undercuts, are even impossible to machine.

Moreover, CNC machining of surgical instruments typically produces waste material in chips or scrap metal. Machining complex or intricate parts generates even more material waste, making this production method economically inefficient.

"Surgical grips, for instance, the rear areas where the fingers go through are usually the same. However, milling and machining the handles' front area is lengthy and costly as this is where customization with a more complex design is required. Up to 80 or 90 percent of the metal block must be machined, which is a huge material waste," explained Jörg Vollmann-Schipper, Business Director of SolidCAM Additive, which supports machine shops in making operations more efficient through additive manufacturing.

Moreover, the conventional production of complex parts like surgical instruments with CNC machining requires a high degree of manual preparation before executing the actual production, for instance, in CNC programming and producing jigs and fixtures. Additionally, labor-intensive human intervention is needed during production (e.g., re-clamping, mounting components on jigs and fixtures). This skilled labor requirement can also add to operational costs.

In addition to those factors, SolidCAM Additive has seen the market among surgical instrument manufacturers becomes more challenging both local and global competition. Many of BAK Kohler Medical's major competitors, especially from countries like Pakistan, sell products at a lower price. Although the competitors' product quality is perceived as less than that of BAK Kohler Medical's, price-sensitive customers have welcomed this price reduction. BAK Kohler Medical must also maintain the high costs of skilled labor in a high-wage country like Germany.

"All these factors drove BAK Kohler Medical to search for a more efficient and cost-effective solution alongside its milling machine processing. But this alternative way must be able to process the same material (17-4 PH) that BAK Kohler Medical has used for many years in its production," added Vollmann-Schipper. New material would require a new validation process for the surgical instrument production, which is both costly and tedious, especially in a highly-regulated market like Germany. Additional product validation may be necessary for sales in other global markets as well.

Andreas Kohler, Founder and CEO of BAK Kohler Medical, emphasized the things that he wanted to change in his company: "First, we want to reduce our long machining times and free up our machines for other production. Second, we want to be able to produce other surgical instruments which we have never produced before because of their geometric complexity."

> "BAK Kohler Medical was interested in 3D printing technology because they wanted to be prepared for the new industry trends and innovations of next generation of surgical instruments."
>
> **Jörg Vollmann-Schipper, Business Director, SolidCAM Additive**

Metal binder jetting offers a solution

BAK Kohler Medical thrives on being excellently equipped for future demands despite constantly changing market conditions and customer requirements. With this vision in mind, BAK Kohler Medical sought advice from SolidCAM Additive, the additive manufacturing business line of SolidCAM, a leading developer of CAM software used by BAK Kohler Medical since 2002 for efficient CAM programming of its advanced Sim5x, Mill-Turn, and Swiss CNC machines. SolidCAM Additive recommended BAK Kohler Medical integrate additive manufacturing using metal binder jetting into its existing CNC machining process.

Vollmann-Schipper of SolidCAM Additive recalled this moment: “BAK Kohler Medical was interested in 3D printing technology because they wanted to be prepared for the new industry trends and innovations of next generation of surgical instruments.”

However, BAK Kohler Medical needed to examine results to overcome its initial adoption hesitations about binder jetting. “Initially, we were skeptical of 3D printing and even against it,” Kohler explained. But we printed a few tests and were satisfied with the results. Our machining times were significantly shorter when we combined 3D printing and CNC to produce a few parts. If we continue producing this way, we hope to use our machines more efficiently and free them up for other productions. And thereby, we would reduce our production costs too,” he stated.

“Moreover, 3D printing would enable us to produce certain contours that are impossible to produce with the conventional CNC process. And that means we would be able to produce new surgical instruments that we have never made before,” Kohler added.

Convinced by the capabilities and benefits that metal binder jetting could bring to the company, BAK Kohler Medical invested in Shop System™ in 2023, an easy-to-use metal binder jetting system from Desktop Metal. The Shop System is designed to enable machine shops to 3D print metal parts cost-effectively. A second Shop System owned by SolidCAM Additive for benchmarking was added inside BAK Kohler Medical’s site.

—
BAK Kohler Medical, SolidCAM, and SolidCAM Additive on the Desktop Metal Shop System installation day at BAK Kohler’s production site in 2023.

—
SolidCAM Additive helps BAK Kohler Medical integrate metal binder jetting into its established CNC machining process.

—
BAK Kohler Medical combines AM and CNC to produce surgical instruments.

Dr. Emil Somekh, the founder and CEO of SolidCAM, shared his company's effort to couple metal binder jetting and CNC machining: "It took us more than one year of study and practical R&D with our Desktop Metal 3D printers and CNC equipment at our hybrid technology centers to figure out how to best combine metal 3D printing with CNC machining, so we can present it as a viable and cost-effective solution to our more than 20,000 CNC machine shop customers worldwide, like BAK Kohler Medical."

Somekh added: "BAK Kohler Medical was our best potential candidate for the Desktop Metal Shop System. It is a 20-year veteran and a happy customer of SolidCAM. The company uses all our CNC machining technologies for CAM programming of advanced CNC machines including the Sim5x and Mill-Turn Swiss."

Dental forceps for large animals

BAK Kohler supplies the global medical technology market with a wide range of surgical equipment, diagnostic tools, and specialized devices for various medical specialties tailored explicitly to medical professionals' needs.

Dental forceps for large animals is one product manufactured by the company. Veterinarians use these specialized instruments to perform dental procedures on horses, ponies, cows, and other large mammals.

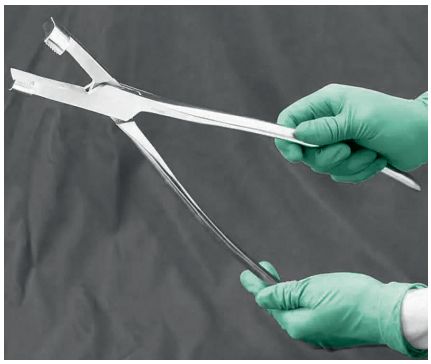
Some standard dental forceps for large animals are extraction, equine dental floats, dental elevators, and rongeur forceps. These instruments are usually made from high-quality stainless steel to ensure durability, corrosion resistance, and ease of sterilization. Proper selection and use of dental forceps are crucial for ensuring the success of dental procedures in large animals and minimizing discomfort or complications for the animals involved.

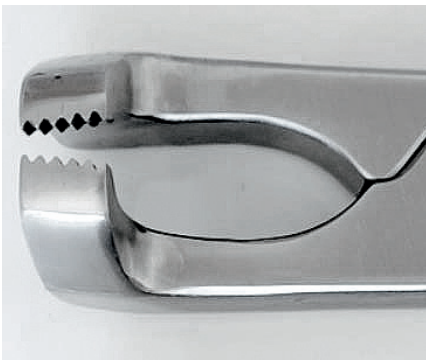
BAK Kohler Medical produces two different variants of dental forceps for large animals. Some customers prefer a welded version, whereas others a version with interchangeable forceps.

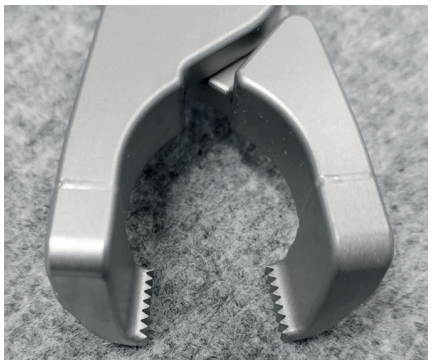
—
BAK Kohler Medical's stainless steel dental forceps with a 38 cm length

The handles are manufactured at the BAK Kohler Medical CNC milling center. A pocket for a tool head is located at the front end of each handle. Every tool head serves a different purpose in dental procedures. These tool heads are either welded to the handles (variant #1) or interchangeable (variant #2) by combining 3D printing and CNC machining.

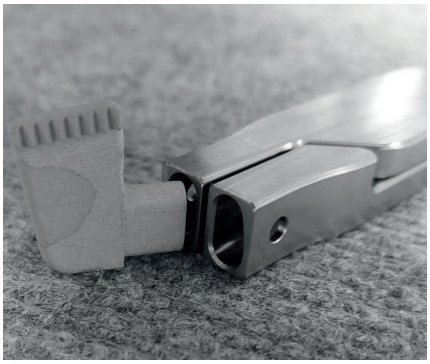
—
Variant #1:
Welded dental forceps

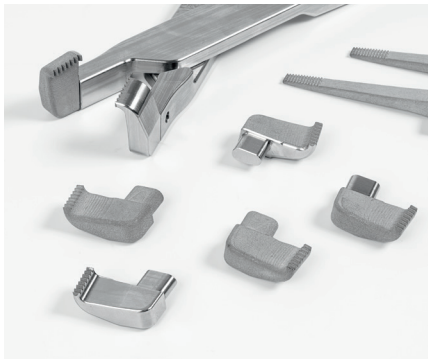






—
Variant #2:
Dental forceps with interchangeable tool heads



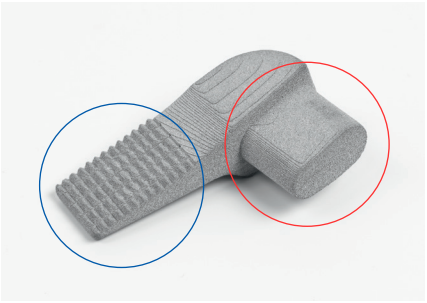


According to Vollmann-Schipper of SolidCAM Additive, the welded variant is easier to disinfect. However, machining this welded variant is very resource-intensive. It also requires end users to purchase many forceps with different inserts, which is very costly and impractical when performing dental procedures.

Regardless of the variant, the tool heads should be manufactured separately. If the handles are fabricated together with the inserts for the welded variant, a large amount of framing material is required, as the metal block must match the height of the tool head.

"The tool heads and handles have always been manufactured separately for both variants," Vollmann-Schipper said. While the handles are easy to manufacture from a bar material due to their shape, the tool heads were sometimes machined by up to 70%, making less sense from an economic point of view. That is why BAK Kohler wanted to avoid using a bigger material block for the CNC machining of the forceps to reduce its production costs.

And for this reason, we had an idea to make the handles separately from one metal block on a CNC milling center and 3D print the tool heads on the Shop System," he shared.

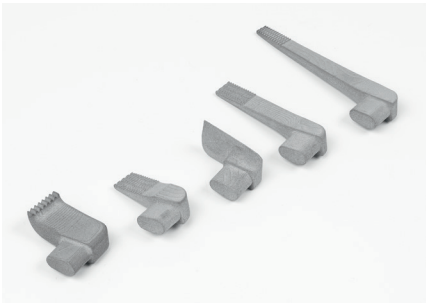


Machining the tool heads' pyramid-shaped structure, circled in blue, is complex and requires a very long machining time. The design freedom of the digital metal binder jetting process enables the production of complex components at ease and speed.

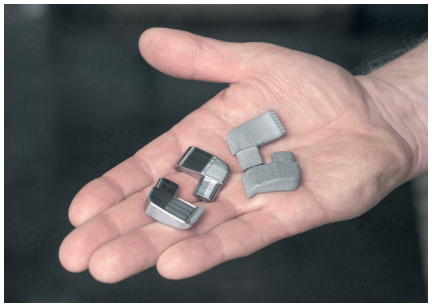
The connection geometry, circled in red, is an area with high shape and position tolerances. The near-net shape still needs subsequent milling to ensure that the required tolerance for the connection with the handle is achieved and the tool heads fit perfectly into the grippers.

To date, BAK Kohler Medical has implemented this hybrid manufacturing process to produce extraction forceps for molars, primarily for horses and secondarily for other large animals. Veterinarians use extraction forceps to grasp and apply controlled force to remove a tooth from its socket. They come in various sizes and shapes to accommodate different tooth types and locations within the mouth.

BAK Kohler Medical manufactures four types of extraction forceps and two types of cutting pliers. The handles on the left and right sides and the mounting pocket are identical for all versions. Customers who choose the variant with the interchangeable tool heads buy only one handle and can switch between the gripping pliers and cutting pliers tool heads on-site, as required.



—
Grasping tool head #1



—
Grasping tool head #2 in raw material

—
Grasping tool head #3 in raw material

—
Grasping tool head #4 in raw material

—
Tool head for cutting pliers

Hybrid manufacturing of other medical applications

BAK Kohler Medical has also started to explore the feasibility and discover the advantages of hybrid manufacturing for other surgical instruments, such as:

- Bite plates for the top and bottom teeth of horses
  "We got a request from a veterinarian to make bite plates for large animals. Usually, these instruments needed a lot of machining. But now we can produce them faster by combining 3D printing and CNC machining," said Kohler of BAK Kohler Medical.
- Dental forceps for the left and right upper jaws of horses
- Dental forceps for the left and right fragment jaws in 20 mm and 40 mm variants
- Left and right spreader in 5 mm

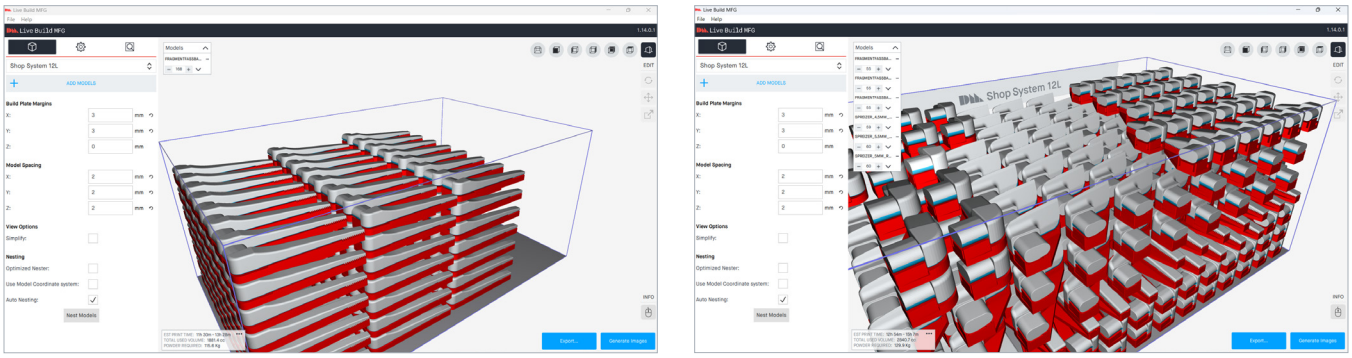
Hybrid manufacturing processes

Hybrid manufacturing combines traditional CNC machining to produce the handles while the end tool variations are 3D printed using metal binder jet technology. There are four main steps to producing the tool ends with additive manufacturing.

1. Design

The first step is to design the tool heads using CAD modeling software or prepare the file for printing when the digital design already exists. BAK Kohler Medical usually creates the CAD data for the tool heads and the grip design.

The next step is to import the CAD file to Desktop Metal Live Build™ MFG software. The platform generates and optimizes binder jetting builds for printing and sintering success. The tool's automatic nesting, support generation, and slicing capabilities enable BAK Kohler Medical to configure part-specific settings. The tool then automatically transfers the print job to the Shop System.



—
Generating and optimizing binder jetting builds for printing dental forceps inserts using Live Build MFG software for Shop System.

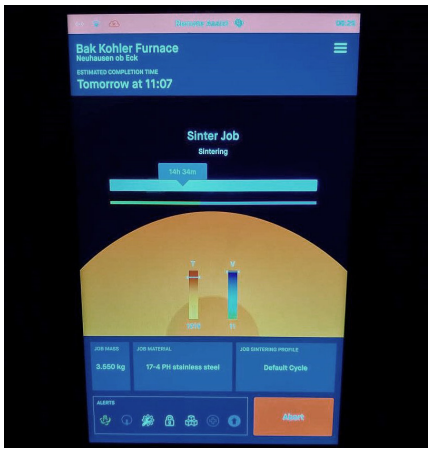
2. 3D Printing

The 3D printing process on the Shop System is a software-guided workflow. Layer by layer, the printer spreads metal powder across the build bed and precisely jets a binding agent to bond loose powder and define part geometry. This process is repeated until the entire build volume is packed with bound parts and surrounding loose powder. After printing, the parts are removed from the printer and transferred to a drying oven. Then, unbound powders are removed from the parts.

3. Sintering

The next step is to sinter the parts in a Desktop Metal Furnace. BAK Kohler Medical uses Desktop Metal's Live Sinter™ software to eliminate the required trial and error to achieve accurate parts without deformation. After sintering, the parts are removed from the furnace.

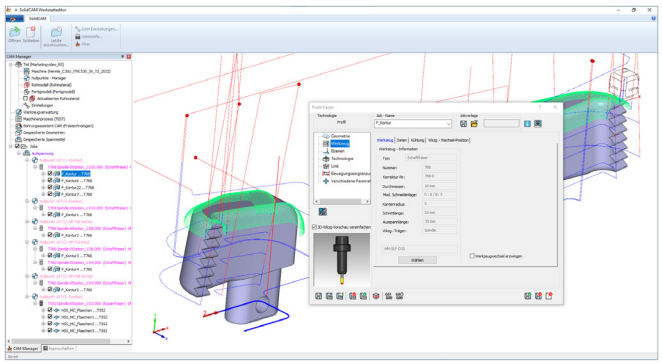
—
Sintering the printed parts using the Desktop Metal furnace, a shop-safe high-temp sintering oven built for cost-effective high throughput of 3D printed parts.



4. CNC-Machining

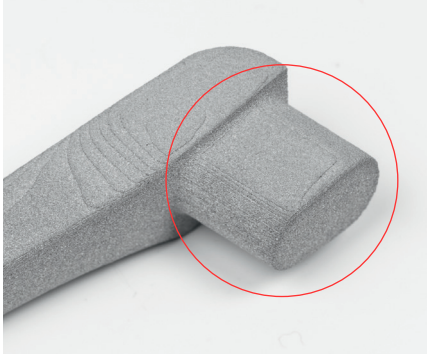
CNC tool paths are created with SolidCAM software to prepare the parts for the subsequent machining process.

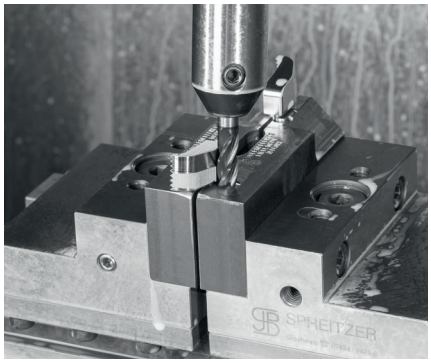
—
Preparing CNC tool paths for subsequent machining process using SolidCAM software.



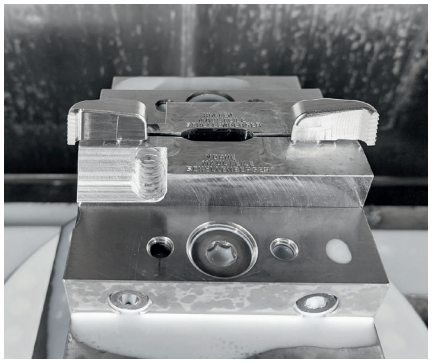
Mechanically reworking the connection geometry of the printed tool heads ensures that the required tolerance for the connection with the handle is achieved.

After securing the tool heads into the grippers with grub screws, both handle halves and the tool heads are hardened and polished until they have achieved a particular surface finish or texture required in medical applications. This additional post-processing is also a common step required in CNC machining. Lastly, all components of the forceps are assembled.





—
Milling fixture for machining two components



—
Reverse side processing

Hybrid manufacturing gives multiple advantages

The production of several surgical instruments using a combination of near-net metal binder jetting and subsequent minimal reworking on the CNC milling machine has enabled cost savings and relieved the burden of resource-intensive CNC production at BAK Kohler Medical.

Cost-effective at any scale

BAK Kohler Medical and SolidCAM Additive believe metal binder jetting is a cost-effective commercial solution for this application because of the annual demand fluctuations in the quantity if interchangeable tools required. By printing the tool heads for the dental forceps with the Shop System, BAK Kohler Medical can minimize costly material waste and a machine-intensive process, thereby reducing the price of the tool heads by 20 to 40 percent.

Reduce costs for milling tools

Roughing and rough finishing is a machining process with high wear on the milling tools. On average, a milling cutter can be used for around ten components of the above-shown tool head. With a production batch size of 1000 components, around 100 such milling cutters are required. Combined with AM and postprocess CNC machining, such cutting tools are unnecessary. The components are only fine-finished. This saves BAK Kohler Medical around € 2,000 in milling cutter costs.

Reduce machining times

Compared to conventional tool heads for dental forceps, the hybrid production method has significantly reduced the machine's workpieces' running times at BAK Kohler Medical's milling centers. The shown clamped component has the following milling times:

- Conventional CNC production: 25 minutes
- Combination of AM and CNC: 8 minutes

By combining AM and CNC, BAK Kohler Medical can save 17 minutes of milling time per tool head. The total time savings for 500 sets (one set = left and right side tool head) are 17,000 minutes or 283 hours. These considerable time savings have generated free capacities on the milling center which the company can leverage to mill other products.

Ability to manufacture new, complex products

Realizing complex component designs is a particular challenge for CNC machining. As the digital design for 3D printing has no boundaries, BAK Kohler Medical can now create, optimize, or modify the CAD design of complex surgical instruments geometries and easily print them. For BAK Kohler Medical's customers, this means that from now on, they will get optimized products that are better tailored to their needs. "Because there is no design constraint in 3D printing, now we can produce other surgical instruments which we could never make before," said Kohler of BAK Kohler Medical.

Vollmann-Schipper of SolidCAM Additive also agrees with the significant advantages of 3D printing's design freedom: "3D printing enables manufacturers to offer more design customization, design their components

differently or freely, even in the direction of complex bionic structures that cannot be machined. It also eliminates the disadvantages and barriers to innovation inherent in conventional manufacturing."

> "Because there is no design constraint in 3D printing, now we can produce other surgical instruments which we could never make before."
>
> Andreas Kohler, Founder and CEO, BAK Kohler Medical

Drive business growth

SolidCAM Additive believes that machine shops like BAK Kohler Medical must constantly attract new customers with machining needs to grow. BAK Kohler Medical can expand its business operations into a new growth area by bringing more product variants to the market, like these dental forceps with interchangeable, 3D-printed tool heads.

"So far, we have received positive feedback from our customers about using the combination of 3D printing and milling for future products," mentioned Kohler of BAK Kohler Medical.

—
BAK Kohler Medical adds 3D metal printing to its list of competencies

The future will be hybrid manufacturing

SolidCAM Additive believes that manufacturing in the future will be hybrid and the combination of AM and CNC is the answer to most challenges of today's manufacturers. "We are here to help machine shops upgrade their manufacturing with metal binder jetting so that they can address today's manufacturing challenges," said Vollmann-Schipper of SolidCAM Additive. The company also supports medical technology companies working through the rigorous qualification process in Germany for introducing 3D printing to produce medical instruments that meet the industry's extremely high requirements.

Kohler of BAK Kohler Medical pointed out: "We are still at the beginning of a long process, both locally and globally, for qualifying the hybrid manufacturing of surgical instruments for humans. We must conduct more tests to qualify our new production process. But we want to pursue this and will do it step by step."

About BAK Kohler Medical

Established in 1989, BAK Kohler Medical in Germany manufactures and sells various medical instruments globally explicitly tailored to the needs of medical professionals. In 2023, BAK Kohler Medical decided to enter the world of additive manufacturing to increase the efficiency of its production.

Learn more: www.kohler-med.com

About SolidCAM Additive

SolidCAM Additive is the additive manufacturing business line of SolidCAM, a global leader in innovative CAM software for CNC machining. With its extensive machining knowledge, SolidCAM Additive guides and educates manufacturers on how to best leverage the advantages of combined 3D metal printing and CNC machining.

Learn more: www.solidcam.com/solutions/solidcam-additive

About Desktop Metal Inc.

Desktop Metal is driving Additive Manufacturing 2.0, a new era of on-demand, digital mass production of industrial, medical, and consumer products. Our innovative 3D printers, materials, and software deliver the speed, cost, and part quality required for this transformation. We're the original inventors and world leaders of the 3D printing methods we believe will empower this shift, binder jetting and digital light processing. Today, our systems print metal, polymer, sand and other ceramics, as well as foam and recycled wood. Manufacturers use our technology worldwide to save time and money, reduce waste, increase flexibility, and produce designs that solve the world's toughest problems and enable once-impossible innovations.

Learn more about Desktop Metal and our #TeamDM brands at www.desktopmetal.com