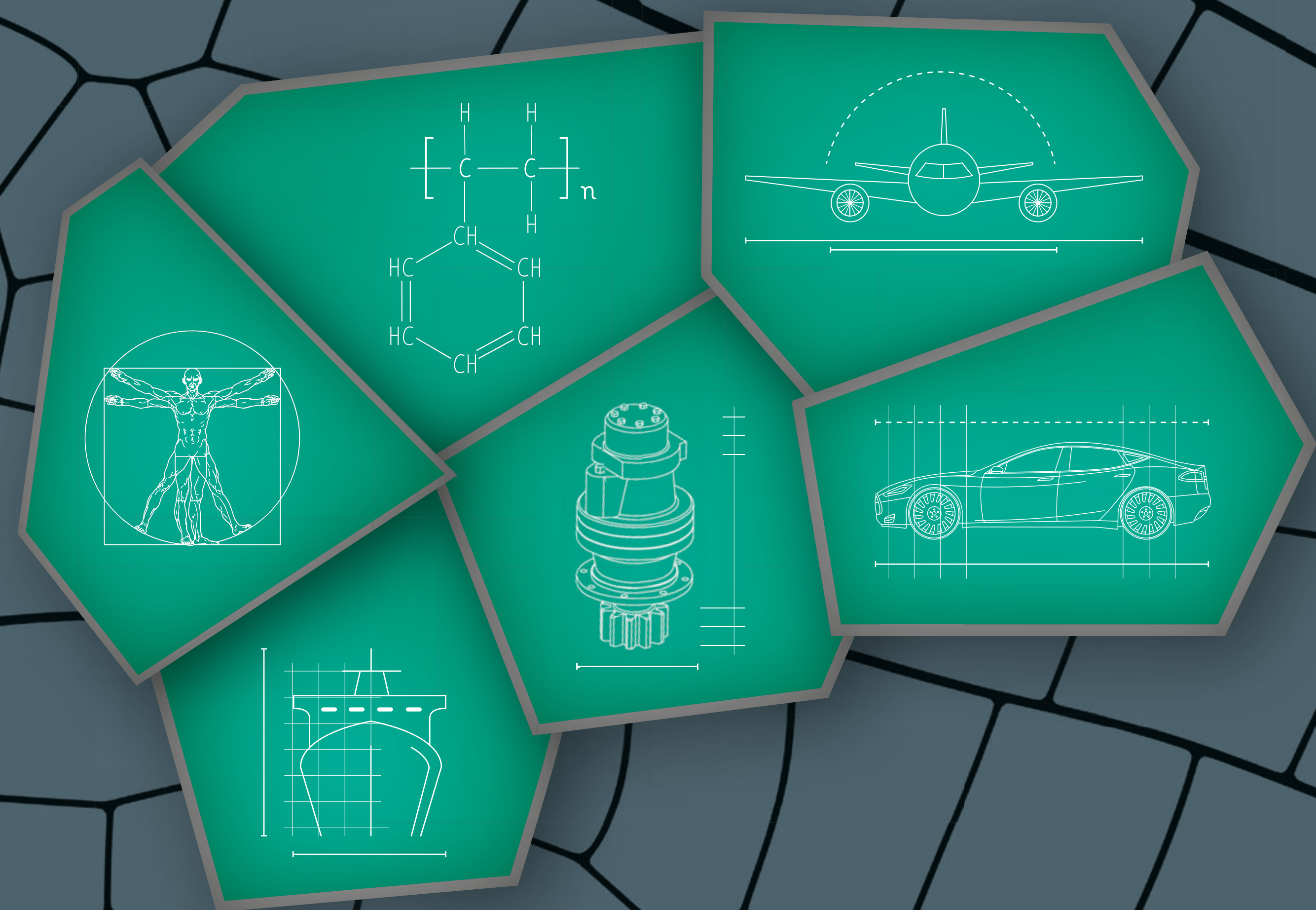
Fraunhofer
IAPT

FRAUNHOFER RESEARCH INSTITUTION FOR ADDITIVE MANUFACTURING TECHNOLOGIES IAPT

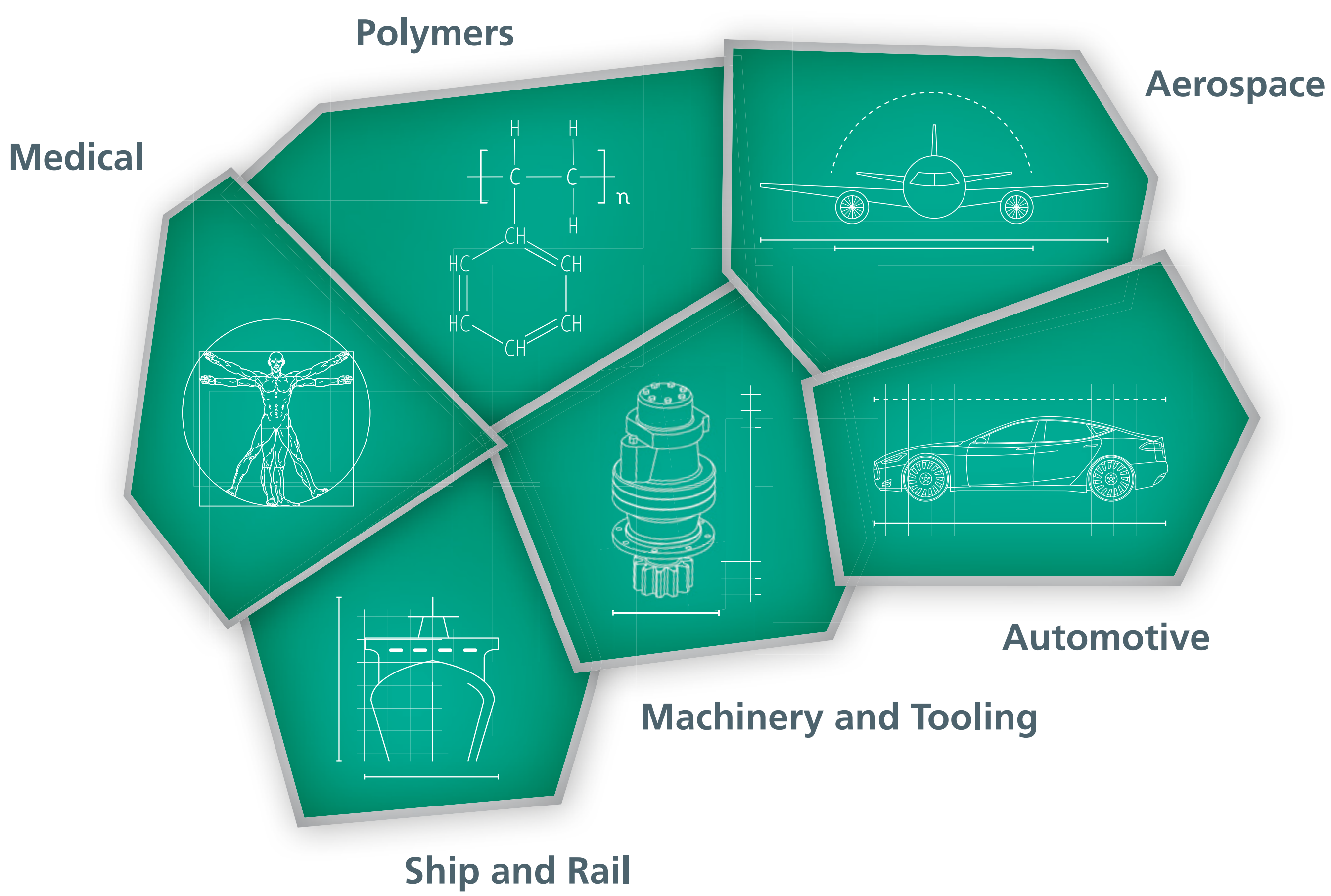
YOUR INDUSTRY’S ADDITIVE FUTURE



INDUSTRIES

BENEFIT FROM OUR EXPERTISE ACROSS A WIDE RANGE OF INDUSTRIES

At Fraunhofer IAPT, we use our knowledge gained from over 15 years of research and development in the field of additive manufacturing and transfer it to your industrial application. We achieve this by helping you to accumulate knowledge along the entire value chain, shape innovation, and gain a competitive advantage. Whether training newcomers to the technology, designing bionic parts, developing complex additive processes, or planning the layout of quality-assured factories, you can benefit from our multidisciplinary experience in a wide range of technologies. Our experienced key account managers speak your language. From dental implants to large structures in shipbuilding, we know the relevant industry requirements and standards.



AEROSPACE

WE HELP ADDITIVE MANUFACTURING TO REACH NEW HEIGHTS

The wide-ranging possibilities of additive manufacturing are particularly well suited for the aerospace industry. Weight-optimized parts, for example, have a positive effect on the overall mass of your aircraft. Flow-optimized parts improve the performance of rocket and aircraft engines. In addition, hydraulic components can be designed to be much more efficient, creating advantages not only within the part itself, but also in conjunction with the overall system.

Development times for prototypes can be reduced and downtime minimized by the availability of spare parts. In this way, additive manufacturing can be of great importance to you, especially when conventional manufacturing processes reach their limits because of component complexity or when time plays an overriding role due to the associated costs.

Additive manufacturing in aviation

The potential for additive manufacturing in aviation is huge and will also continue to grow in the future. There will be significant challenges in the areas of Industry 4.0, quality assurance, and design over the coming years. Together with you, we will confront these challenges and support you with new and innovative development approaches as we master them.

Fraunhofer IAPT has been a strategic partner to Airbus for over ten years, as it manages change processes for additive manufacturing. Our key areas of expertise here include optimizing topology, integrating parts and functions, processing new materials, and cutting production costs.

We have been able to continuously improve our expertise in the field of component design thanks to diverse research activities involving design guidelines and new design methods. Our knowledge went into producing perhaps the best-known part ever made using 3D metal printing, the so-called Airbus A350 FCRC bracket. Other examples include the A380 fuel connector and the helicopter bell crank.

In 2014, we devised a customized training program for our partners, aimed at teaching company employees the theory and practice of 3D printing. Fraunhofer IAPT is now regarded as a pioneer in this field and has trained over 1,200 engineers and skilled personnel at its Additive Academy – 600 of them in the aerospace industry alone.

Additive manufacturing in space travel

While the story of space travel began with achieving the impossible and exploring outer space, nowadays it is more about observing the earth, conducting research on the effects of weightlessness, and improving navigation and telecommunications. Money was originally no object, because the focus was on the spirit of discovery. Things are different today. Production and operating costs have to be cut, while simultaneously increasing payload capacity.

Both can be achieved with the help of additive manufacturing technologies. The increased design freedom makes it possible to create weight-optimized geometries for structural components. At the same time, the functionality of flow-dependent components – such as those found in engines or heat exchangers – can be optimized. The small production runs involved and the rapid reaction times also make additive manufacturing technologies the ideal choice for space travel.

Collaborating with our partners allows us to identify a number of different issues and challenges and incorporate them into productive research projects. Fraunhofer IAPT is also extensively involved in the Aviation Research Program (LuFo) run by the German Federal Ministry for Economic Affairs and Energy (BMWi) and in ESA projects. The project partners from the aerospace industry include Airbus, Liebherr Aerospace, Premium AEROTEC, GE Additive, the German Aerospace Center, OHB Systems, and many more besides.

With our comprehensive product portfolio and long-standing experience, we can offer you innovative solutions and work with you to tap the potential associated with your challenges. Advanced technologies allow us to make reliable statements about the quality and the life cycle of your component.

AUTOMOTIVE

3D PRINTING FOR AUTOMOTIVE ENGINEERING

The automotive industry is facing considerable challenges: electromobility, connectivity, autonomous driving, car sharing require shorter product life cycles and a wide variety of different versions with new demands made on parts and production processes. Ever stronger competition makes it necessary to respond flexibly and individually to the latest developments and requirements. We can help you to react precisely to these new market demands with additive manufacturing. Together with us, you can unlock the potential in all areas of motor vehicle production, from prototyping to printed spare parts.

Faster and more flexible prototyping

We can use CAD data to print prototypes for product developers. Alternatively, for testing design spaces and assembly configurations, we make parts that can be used quickly and flexibly tested in vehicles on the road, on the test stand, or in vehicle crash tests. In doing so, we can focus on specific requirements, such as mechanical resilience, temperature requirements on the engine test stand, and the deformation properties of prototypes in crash tests. Expensive tools for conventional casting, injection molding, and deepdrawing processes are no longer necessary thanks to additive manufacturing. In addition, multiple unique versions can be produced simultaneously at no extra cost, significantly cutting development times.

Further services for your prototyping:

- Development of metal and plastic materials in line with requirements for direct incorporation in full-scale production
- Establishment of the additive manufacturing process for prototypes within your company
- Development of quality standards and qualification of suppliers for 3D printing

New design concepts through additive manufacturing

Additive manufacturing allows us to overcome previous design limitations and create completely new component concepts. Intelligent cooling concepts can be economically produced for electric vehicles, for example, and lightweight chassis parts for high-performance vehicles can also be made in line with the respective load category requirements. New functions and even lighter parts can thus be produced. Furthermore, the latest additive manufacturing processes and the associated advances in productivity have made it possible to make the first massproduced parts using this method.

We can help you with the following:

- Screening and development of concepts for new automotive applications
- Design of lightweight structures and integrated parts in the context of overall vehicle requirements, such as fatigue strength, crash, and corrosion requirements
- Validation of parts by means of simulation and component testing on the test stand and in crash tests

Production resources and tools

In the area of car manufacturing, costs can be significantly cut, production processes optimized, and work simplified using 3D printing. Simple plastic printers, for instance, allow workers to optimize the ergonomics of their equipment by themselves. The efficiency of expensive tools used for hot sheet metal forming or injection molding processes can also be optimized by means of 3D printing thanks to faster and more precise temperature control. This minimizes cycle times and cuts costs.

Examples of services:

- Identification, design and production of jigs, tools and gauges
- Simulation, design, and production of conformally cooled tools optimized for injection molding and hot sheet metal forming
- Repair or modification of tools by means of deposition welding

Materials and processes

The automotive industry is placing new demands on materials and production processes in the form of crash requirements, highly automated production, and quality expectations from customers and manufacturers. In addition, there is also an extensive qualification process based on automotive standards. We are familiar with these requirements and can help you to start using innovative materials and processes successfully:

- Development of new materials with a focus on needs-based mechanical properties, cost-effective processing, the ability to withstand a crash, and much more besides
- Qualification and quality assurance of additive manufacturing processes such as selective laser melting, deposition welding, and new processes such as binder jetting for use in mass production
- Qualification of post-processing techniques, including painting and joining technology, for integrating additive parts into the overall vehicle concept

Spare parts

You can minimize costly warehouse stock by introducing additive manufacturing for spare parts. Print spare parts on demand with our support. The warehouse inventory of conventional spare parts can thus be reduced once a series has been discontinued, thereby minimizing the amount of capital tied up in stock. Parts no longer available for classic vehicles can also be reproduced in this way.

Examples of services provided in the area of spare parts management:

- Digitalization, (re)designing, and printing of spare parts
- Development of data, material, and logistics concepts for your additive spare parts management
- Qualification of printing and post-processing techniques for equivalent part and surface properties

MACHINERY AND TOOLING

PARTS FOR MAXIMUM PERFORMANCE

Machine construction and toolmaking are areas where maximum quality is demanded, but at the same time, cost pressure is also high. Conventional processes can be complemented – or in some cases replaced – by the new additive manufacturing techniques. Intelligent cooling concepts produced by means of additive manufacturing enable machines to operate at their maximum load on a permanent basis, while tools can achieve outstanding cycle times with minimal energy. Additive manufacturing can also revolutionize your spare parts management by allowing cost-effective spare parts to be produced on demand over the long term.

Additive manufacturing in hydraulics

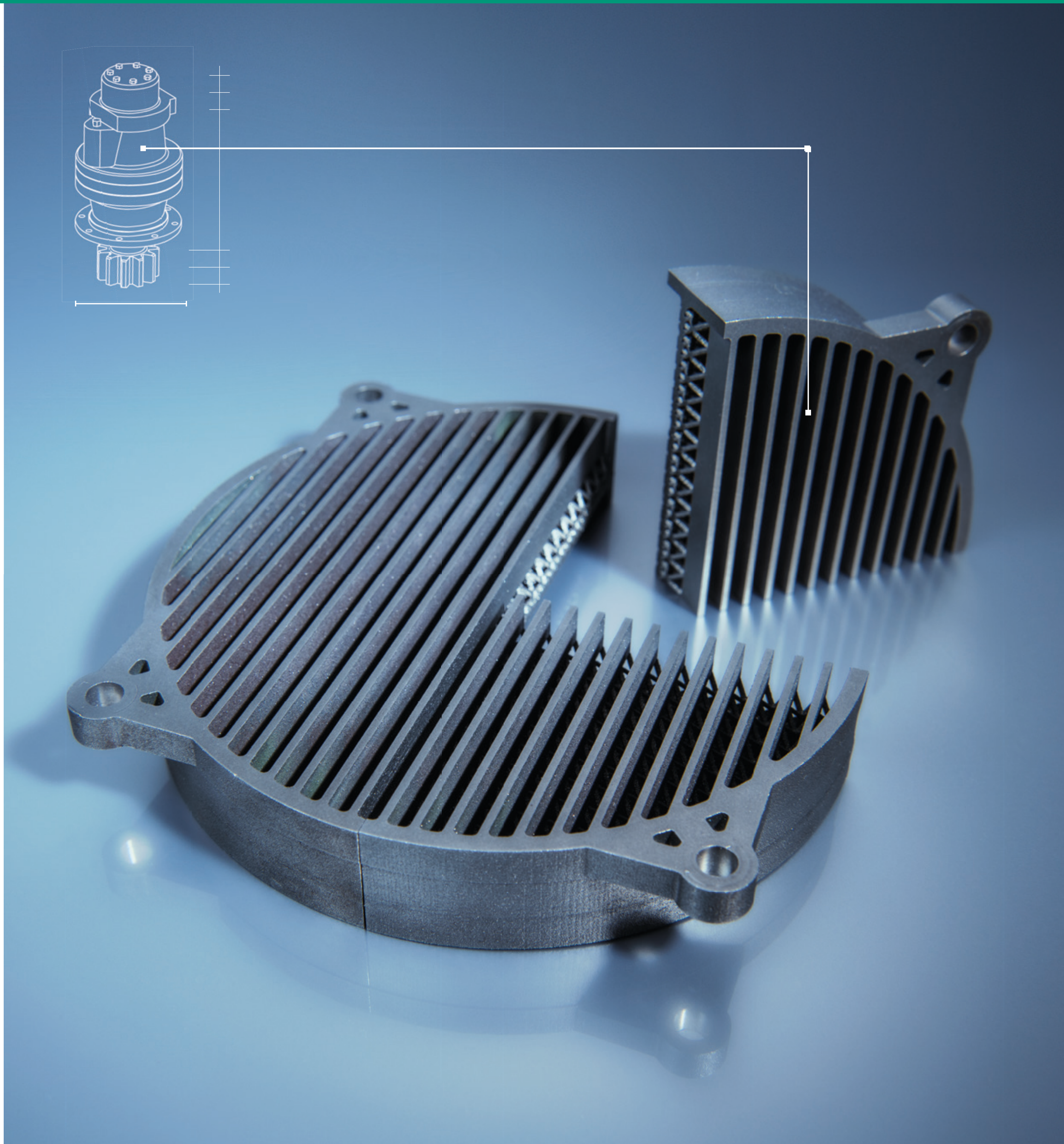
When designing hydraulic parts, the key constraints in the past were minimizing the volume of metal removed by cutting (and thus also minimizing costs) and taking into consideration production restrictions. Completely new approaches to design can be taken with additive manufacturing. One successful example of this is the hydraulic manifold designed and produced at Fraunhofer IAPT. The corresponding design with homogenous junctions and variable channel sections reduces pressure losses by over 40 percent and the weight of the part by 80 percent. This not only results in benefits at part level, but also improves the performance of the system as a whole, because smaller pumps and heat exchangers can be used.

Additive tools for EPP processing

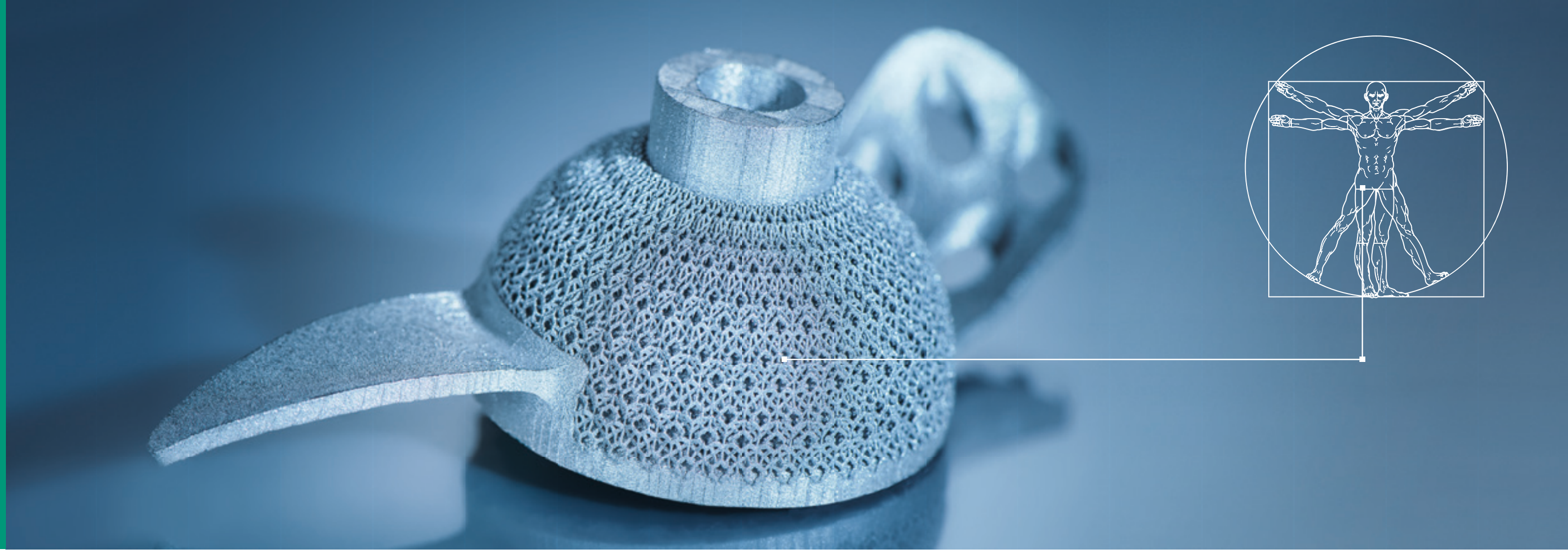
A revolutionary tool concept for processing expanded polypropylene has been developed by project partners Werkzeugbau Siegfried Hofmann GmbH, WSVK GmbH & Co.KG, and Fraunhofer IAPT as part of the LaEPPFo (laser additive-produced EPP mold) project funded by the German Federal Ministry for Economic Affairs and Energy (BMWi). Traditionally, tools used for processing EPP have been produced by machining an aluminum base, subsequently incorporating steam nozzles, and creating the desired surface structure. It has now been possible to combine these steps using additive manufacturing. The mold was created, the steam nozzles were optimally positioned, and the surface structure was directly integrated during CAD modeling. With the subsequent heat treatment, the CAD model was turned into the finished tool with an integrated steam chamber. No further machining was necessary and the tool could be immediately used. This resulted in a 97 percent reduction in steam consumption and an almost 50 percent reduction in the cycle time – increasing productivity while also saving a huge amount of energy.

Additive manufacturing of spare parts

Machine construction involves very long product life cycles. Efficient spare parts management is therefore of the utmost importance for being able to supply customers with the necessary spare parts at all times without tying up large amounts of capital in stored parts or risking considerable downtime. It has been possible, for instance, to deliver a quality-assured individual machine part after just 12 days instead of several months. The original part design was directly adopted and all manufacturing tolerances were met. Integrating additive manufacturing into spare parts management can open up completely new avenues, leading to a profitable aftersales market.



MEDICAL



A REVOLUTION IN MEDICAL TECHNOLOGY

In recent decades, advances in image and graphic processing have changed medical imaging into something far beyond traditional, two-dimensional visualization. Special software approved for medical applications can be used to turn a group of two-dimensional images into a virtual 3D model, and adapt the geometry in line with requirements. This results in specifically adapted 3D models that can be used as a blueprint for producing medical structures by means of additive manufacturing.

Additive processes provide innovative solutions for your medical applications. The elimination of design restrictions makes it possible to produce geometrically complex parts for individual patients. Besides implants, increasing numbers of medical tools and demonstration models are also being made. These are suitable for preoperative planning and intraoperative visualization, while also simplifying communication with the patient. As a result, the operation can be planned in detail beforehand, significantly reducing the actual operating time. Tools made for individual patients by means of additive manufacturing allow surgeons to perform precise operative procedures such as bone transplants and reconstructive surgery. Patient-specific spare parts and implants made from a wide range of materials can be quickly produced thanks to additive manufacturing.

Demonstration models

A two-dimensional image of the “area of interest” was previously regarded as sufficient for medical applications. However, adjoining structures can only be removed to a certain extent or sometimes not at all, restricting the field of vision. Even though there are already imaging techniques that produce a three-dimensional image, these are generally based on two-dimensional pictures that are taken along the third dimension, thereby producing a three-dimensional visualization.

For simple, physical visualization, however, it is possible to use additive manufacturing to develop a three-dimensional model based on the two-dimensional images. These physical models make it possible to provide a quick demonstration of the “area of interest.” This significantly simplifies communication with the patient and intraoperative visualization of the area. Additive models are also used for preoperative planning and for simulating complex operations.

Individual prosthetics

A paradigm shift is currently taking place in the field of medicine. There is a move away from mass production towards custom-made items; away from one-size-fits-all approaches towards personalized treatment plans. In this context, structures and customized implants produced by means of additive manufacturing have proven to be especially valuable in the area of oral and maxillofacial surgery, due to the large number of complex bone geometries in the skull. Furthermore, even slight dislocations in the facial area can have a profound impact on the patient’s physical function and aesthetic appearance. In such cases, it has been shown that patient-specific models produced by means of additive manufacturing improve patient care as well as communication between doctors and patients.

Drilling and sawing templates

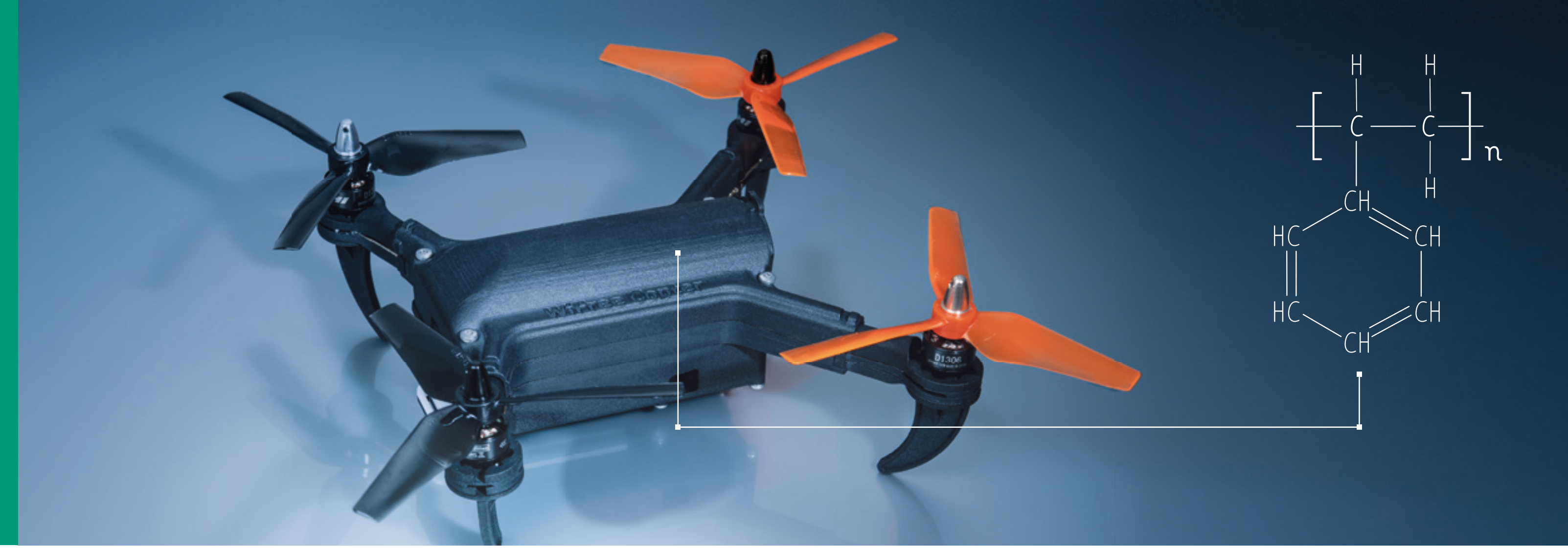
Besides demonstration models and individual prosthetics, tools produced by means of additive manufacturing are increasingly being used in operations. Drilling and sawing templates are used here, because dysfunctional parts must be precisely replaced with the help of the body’s own bones.

These special templates are designed on the basis of the existing bone structure and then produced by means of additive manufacturing in accordance with predefined parameters. This results in a significantly optimized – and thus safer – operative procedure, which is attributable to the improved precision when removing bone sections.

The advantages of additive manufacturing in medical technology are clear:

- ➜ **Patient-specific demonstration models**
- ➜ **Improved communication between doctor and patient**
- ➜ **Precise planning of individual stages of an operation**
- ➜ **Shorter operation times due to new surgical techniques using parts made by means of additive manufacturing**

POLYMERS



DIFFERENT METHODS WITH THE SAME GOAL

Additive manufacturing with plastics permits the production of virtually any type of part. Plastics are much lighter and cheaper than metals, although they are not as strong. Materials from almost any plastic group – ranging from thermoplastics and thermoset plastics to thermoplastic elastomers – can be used for additive manufacturing. The FDM and SLS processes, in particular, make it possible to produce prototypes and small series parts that can be transferred to industrial applications in large-scale production runs.

While the FDM process features the widest selection of materials, a robust process, and very large build envelopes, the SLS process provides parts with isotropic mechanical properties, having no need for support structures. It is also a cost-efficient process for producing parts in large numbers as well as small production runs.

Additive manufacturing with plastics can produce specific items such as flexible TPU damping elements or motorbike covers made from high-strength, fiber-reinforced polyamide. The CLIP process represents a good solution when high surface quality and maximum strength is required. Here the parts are made from a thermoset plastic. This is done by drawing parts out of a resin in a process with a high build-up rate. The PolyJet process allows parts to be made in full color and from transparent materials. Groundbreaking systems for multi-material processing have also been developed. They will create huge potential for functional integration and econimization.

What we can do for you

We help you to find the right technology for your business and the right systems for your applications, guiding you through the entire process from the development of the desired material to the design and production stage. We are on hand with our expertise and our solutions, while also empowering you to realize your own ideas. For instance, we can train your employees and also help you to build up additive manufacturing expertise within your company.

- Printing services: SLS (PA12, PA6, PP, TPU) and FDM (ULTEM, ABS, PC, PETG, PA6, etc.)
- Consulting services: system comparisons, profitability analyses, feasibility studies
- Material development
- Employee training courses at the Additive Academy
- On-demand production of spare parts: scanning, redesigning, printing

Functional integration

Our new approach of manufacturing threedimensional electronic components gives the opportunity to employ additional functions, such as electrical conductivity on the part surface. Therefore plastic parts are build in the SLS process which can be selectively metalized afterwards.

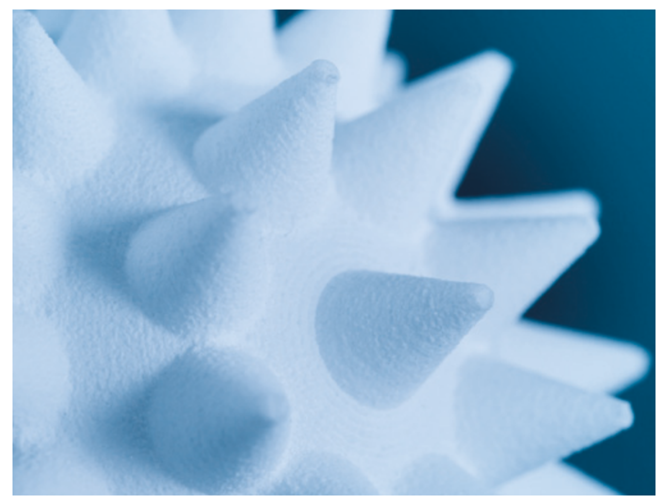
Examples of component integration:

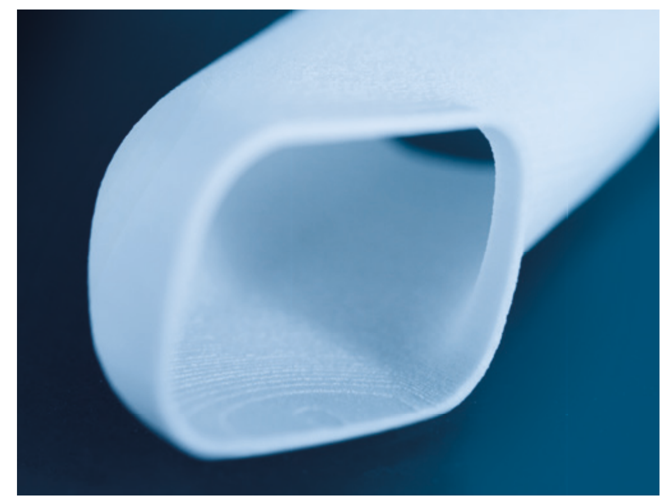
- PCB traces
- Sensor technology
- Heating systems
- Antennae
- Electromagnetic compatibility (EMC)

Design suited to the process

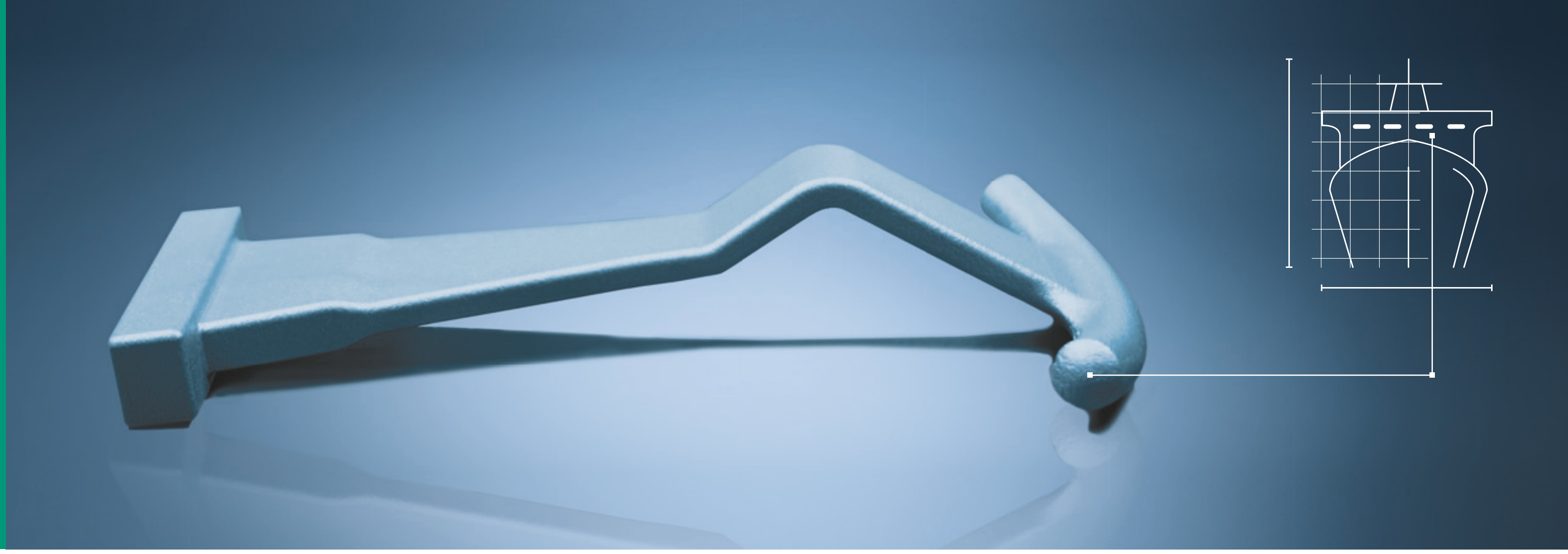
Structures that are too big to fit within the build envelope of one single additive manufacturing system can be produced by first printing the individual plastic parts separately and then joining them together as an assembly group. This is how we were able to help Airbus to manufacture the first airworthy THOR (Testing High-tech Objectives in Reality) prototypes by designing the fuselage and manufacturing all printed parts.

- Dimensionally stable design for large structures
- Optimized production with efficient use of the build envelope and little distortion
- Joining by bonding and welding





SHIP AND RAIL



SHIPS AND RAILROAD CARS

Ships and railroad cars may move around on different media, but there are nonetheless numerous parallels in terms of their structural elements, their uses, and thus also their requirements. Besides the relatively large dimensions, the characteristics they share include the high number of different components and interfaces as well as the complexity of the tasks, the processing stages, and the production process.

3D-printed spare parts

The long service life of railroad vehicles, ships, and other offshore facilities frequently presents a problem in terms of the supply of spare parts. Spare parts must either be kept in stock for a long period of time at great expense or there is the risk of a defective yet critical component not being available at short notice.

In such cases, spare parts produced using 3D printers can be a fast solution for restoring a ship or railroad vehicle to working order once again. Even the provisional, temporary use of a printed spare part as a so-called "homecomer" is a useful way of exploiting additive manufacturing technologies if it can minimize costly downtime.

We identify the components from your portfolio of parts that are suited to additive manufacturing, giving you the following benefits:

- No stockpiling of spare parts, especially those that are rarely needed
- No stockpiling of expensive molds, deep-drawing tools, or forging tools
- A part's weak points can be improved (redesign)

Redesign and reverse engineering

We offer you constructive support to optimize your parts. We make sure that a design is suitable for 3D printing and eliminate weak points by modifying the design. If a component fails because a wall is not thick enough, for example, the area can be reinforced locally so that the printed replacement can withstand the usual load. If no digital design data sets are available for the spare parts you need, we use the latest scanning technology and a high-precision coordinate measuring machine to generate CAD models using the defective original parts, which then serve as a basis for the 3D print. You can produce spare parts anywhere in the world you wish to use them with the help of this data.

Additive manufacturing of large structures

In shipbuilding and railroad car construction, there is also an urgent need to produce large structures using additive manufacturing. The challenge is to achieve the highest possible build-up rate to satisfy economic demands without losing the precision that near-net-shape additive manufacturing allows. Downstream milling operations should be avoided. Additive manufacturing also makes it possible to build complex component geometries with free-form surfaces without having to spend a long time programming. Potential examples include ship propellers, the flow-improving Mewis Duct, and aerodynamically formed panels such as the nose of a high-speed ICE train. In order to adhere to the lightweight construction principle, the printing process makes it possible to distribute the material in a targeted manner along the load path within the component, to ensure that your large structure weighs as little as possible. There is also the option to integrate functions by imprinting various channels and openings directly in the component, for example.

A more cost-effective alternative to complete printing is offered by hybrid structures of 3D-printed components such as connecting nodes and conventional sheet metal, or profiles that are then welded together. The hybrid structure utilizes the benefits of additive manufacturing in the places where it adds value and draws on simple, standardized elements to bridge larger distances within an assembly.

We develop your processes

Our expertise will help you to use innovative and cost-efficient processes that are also optimized in terms of quality in order to ensure that your manufacturing operation is fit for the future. Whether using powder, wire, or filament, we process almost any desired material in the form demanded by the process. We select the process from our portfolio that best suits your specific task in terms of structure and material.

At the same time, besides the core additive processes, we always look at the entire process chain, which includes any subsequent work such as heat treatment of parts and methods for treating surfaces.

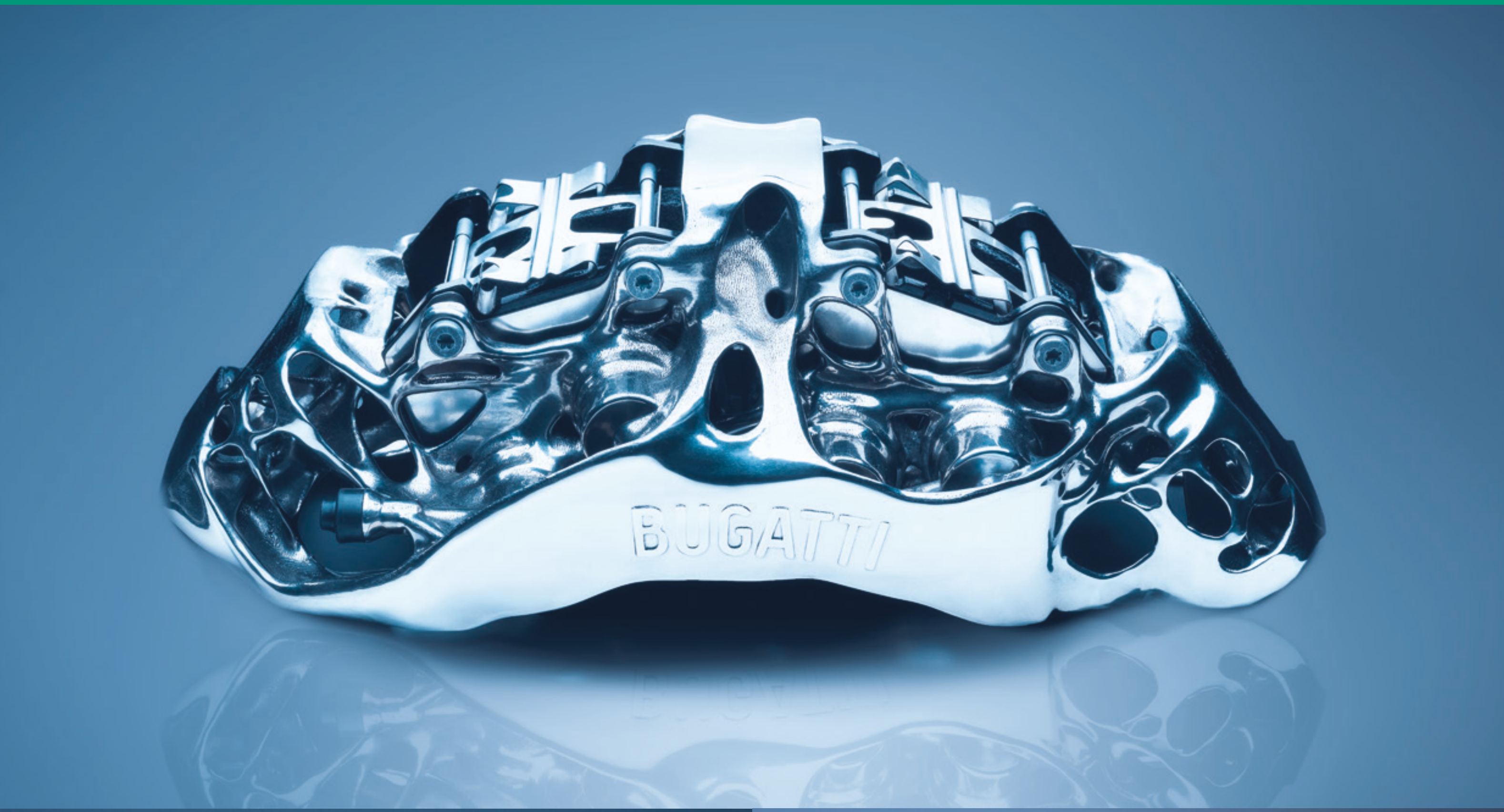
Our welding expertise is one particular strength from which you can benefit. Laser-based joining processes serve to increase the welding speed and reduce the heat input within the welded sections, keeping any deformations caused by heat to a minimum. For large structures in shipbuilding and railroad vehicle construction, these high-performance welding processes are essential for manufacturing parts with precision. They also reduce the need for extensive straightening work and facilitate the use of fully automated process chains.

We possess extensive expertise in the following processes:

- Powder bed fusion of metals and plastics (selective laser melting and selective laser sintering)
- Laser metal deposition
- Wire arc additive manufacturing
- Hybrid laser-arc and laser welding
- Fused deposition modeling of plastics
- Contour crafting

System technology and development

Fraunhofer IAPT has developed new mobile laser systems and 3D printing technology. One such example is the prototype of a handheld hybrid laser-arc welding device designed with a motor for use in shipyard environments. It goes without saying that we can adapt the system to your circumstances and take into account your special requirements.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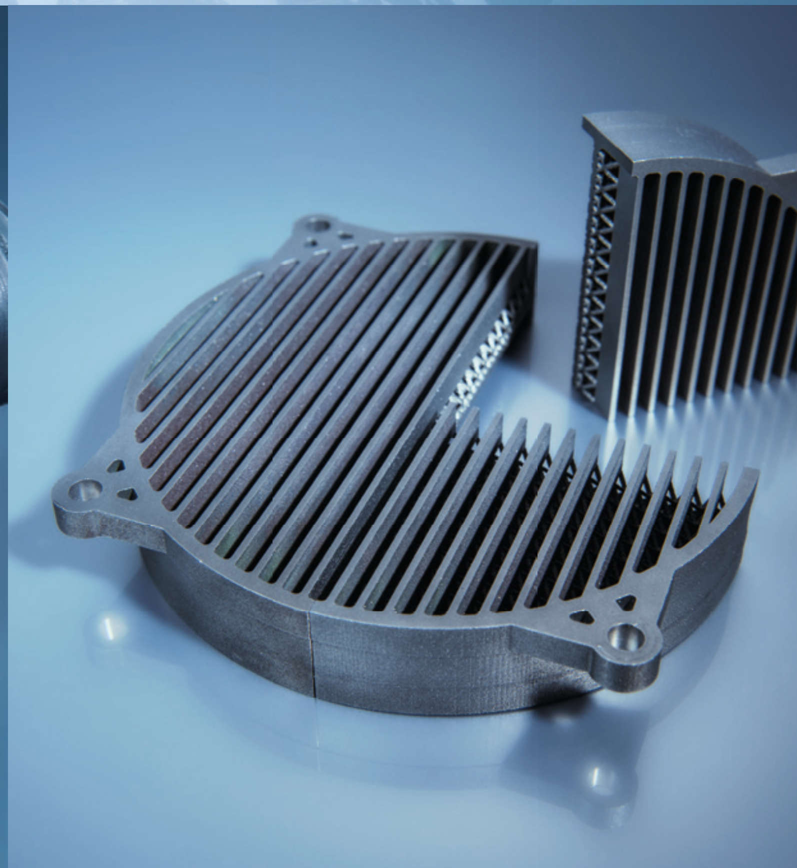


Imprint

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