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MESSER
Gases for Life

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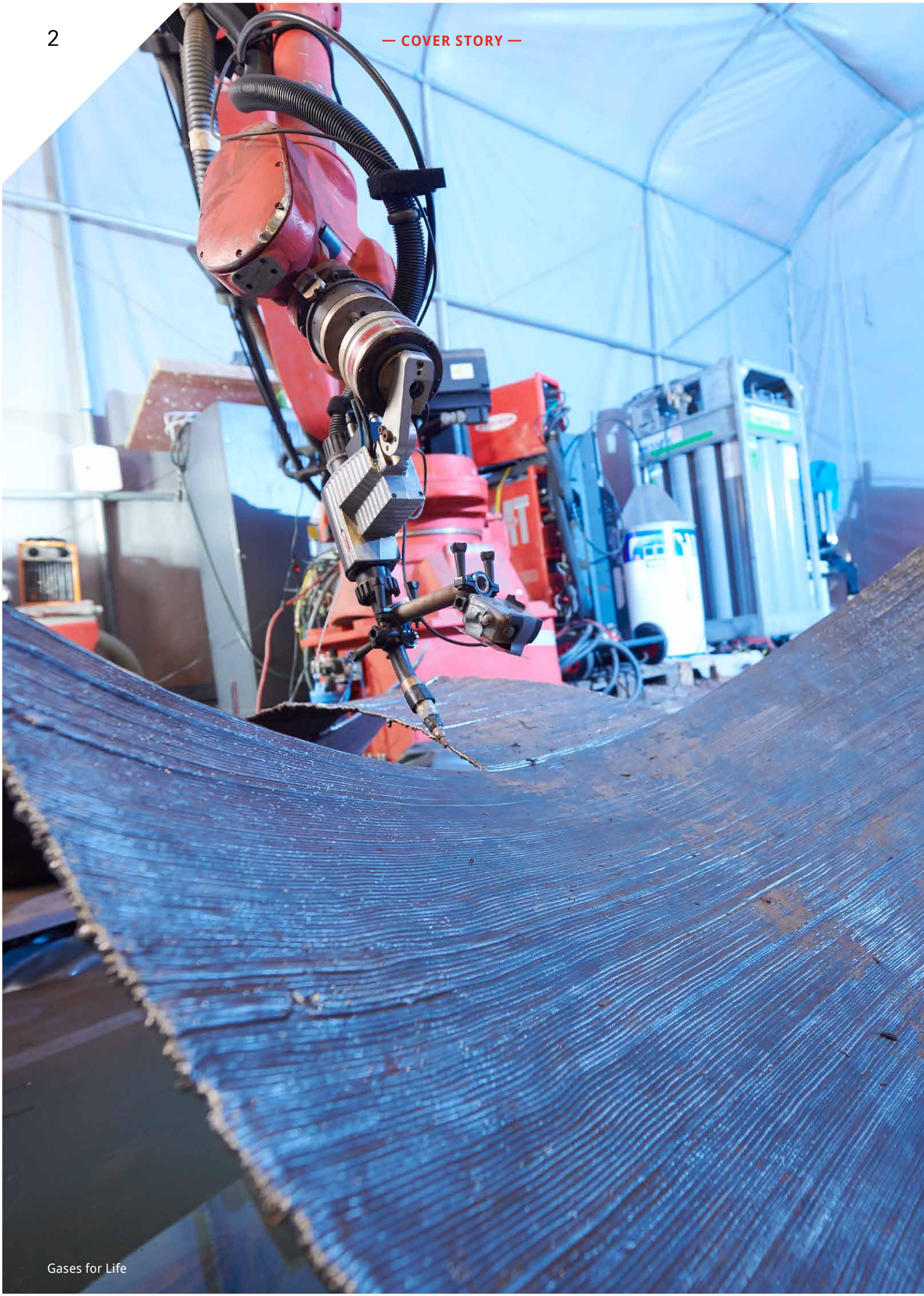
The industrial gases magazine

3D printing with metal



Bridge to the future of production

Not that long ago, 3D printing still had a definite futuristic air about it. Today, it has already become standard in some areas and is even possible with metallic materials. As is so often the case, (almost) nothing is possible without gases.

A world premiere took place in Darmstadt last autumn. For the first time ever, a steel bridge was constructed in the open air using 3D printing. Admittedly, the watercourse that had to be bridged wasn't exactly the Amazon – just an artificial stream in the grounds of the University of Technology. And the three-metre span meant that the bridge was of a fairly manageable scale.

But in addition to the first ever such construction anywhere, the bridge also demonstrated the success of a new process. While virtually all 3D processes involve a vertical operation from bottom to top, here the material was also added horizontally, i.e. from the side. "Only thanks to this fact were we able to complete the entire construction on site," project manager Thilo Feucht, a research assistant in the field of steel construction, explains: "The new method gives us additional construction options, including for considerably larger structures."

Metal drops as basic material

The beginnings of 3D printing – also known as additive manufacturing in the technical jargon – go back to the 1980s. Initially the process was limited to plastics and used primarily to make prototypes and moulds. However, since the beginning of this century, it has increasingly been used in mass production. In recent years, its use has also been extended to metallic materials. It has since become a standard production process in more and more sectors and fields of application.

Metals are processed in the form of powder or wire in 3D printing. While the wire is usually the equivalent of conventional welding rods, producing the powders is more involved and requires the use of special methods. In most cases, this involves molten metal being injected through a nozzle and transformed into fine droplets. "The spherical form of the particles ensures a free-flowing powder," Dr Dirk Kampffmeyer, a welding and additive manufacturing expert at Messer, explains. "In many processes, this is a crucial prerequisite for effective processing of the powder." To prevent oxidation of the hot metal, it is pushed through the nozzle by an inert gas – usually argon – at high pressure.

Powder bed, spraying and wire feed

The finished powder enters the powder bed, a container with a bottom able to be lowered. The powder is introduced in layers. A computer-controlled laser or electron beam heats the powder at specific points. This triggers a kind of sintering process, whereby the powder is turned into a solid form. When a layer is finished, the bottom is lowered by the thickness of a layer. New powder is then applied, and the next layer is sintered onto the one below it. Workpieces are thus produced layer by layer. Powder bed processes can achieve high levels of accuracy, often making rework unnecessary. The main limitation concerns the dimensions of powder beds, with the largest ones measuring 80 by 40 centimetres.

Powder spraying is not affected by this limitation. With this technique, the metal powder is sprayed through a nozzle into a laser beam – again argon is the main gas used. Melted by the laser, the powder is deposited on a base as a "bead". This technique is generally used in conjunction with a tilt & turn table. The component is given its specific form by tilting and turning the base underneath the fixed nozzle. Instead of using a powder, another possibility is to feed a wire into the laser beam. Wire is much more straightforward and less expensive to produce than metal powder. The latest developments feature a coaxial wire feed mechanism that facilitates directional independence, just like with powder spraying. This involves a split laser beam being merged again in the melting zone. The use of wire can make additive manufacturing cost-effective even for components well below the high-end price segments.

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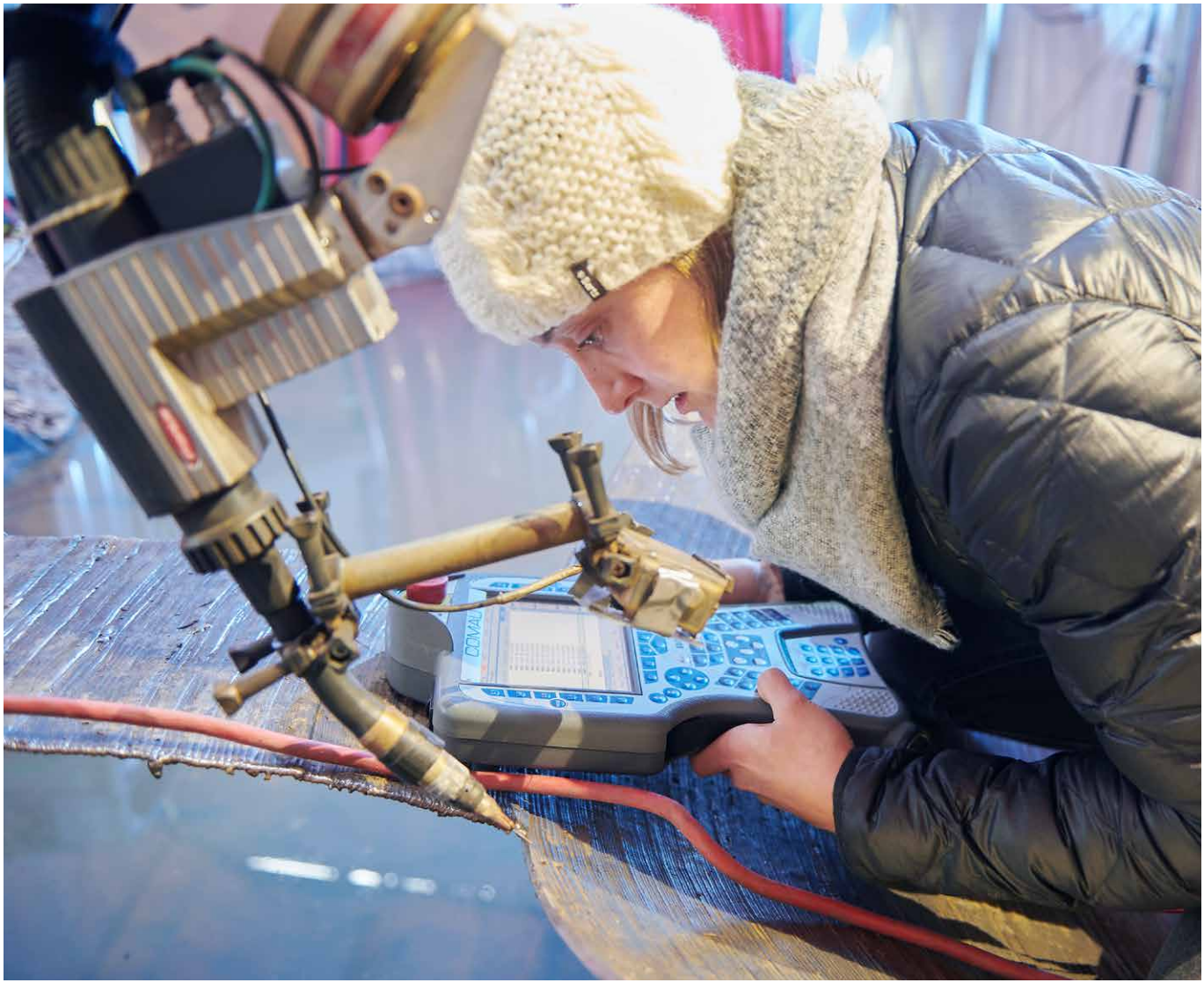
Quality and welding know-how

The latter applies all the more to Wire Arc Additive Manufacturing (WAAM). In principle this process corresponds to the tried and tested MIG/MAG welding method. Instead of putting down a single weld, the welding robot proceeds on a bead-by-bead, layer-by-layer basis to produce a three-dimensional object. This process was also used by the bridge-builders in Darmstadt. According to Thilo Feucht, their raw material was a "common-or-garden welding wire" no different from common structural steel. Incidentally, the trick of adding liquid metal from the side without it dripping down is to time the phases correctly: "The material has to cool down before new metal is added. We therefore assembled the entire bridge from individual weld spots at one-second intervals."

Almost all welding and sintering processes have one thing in common: they can only achieve the required quality in an inert gas atmosphere. "This is where our specific know-how comes into play," Dr Hildebrandt, head of the welding and cutting application area, emphasizes. "We have a good understanding of the interaction of the various metals and alloys on the one hand and the gases and gas mixtures on the other. The desired result can only be achieved if both are combined in the optimal way. Here we can provide comprehensive advice to our customers."

To ensure that we always do this on the basis of state-of-the-art technology, Messer is also a network member of the Aachen Center for Additive Manufacturing, along with some of the biggest car manufacturers and automotive component suppliers as well as other technology leaders in metal 3D printing. Furthermore, Messer takes part in the Formnext trade fair every year, where additive manufacturing experts from all over the world meet. Dr Kampffmeyer: "Additive manufacturing complements conventional metalworking processes and will replace some of them. As gas experts, we are at the forefront of this development."

Editorial Team



Juliane Keppler, working student at TU Darmstadt, controls the 3D printers work by a panel.

Shielding gas for overhanging structures

Interview with Maren Erven, Christopher Borg Costanzi and Thilo Feucht, Steel Construction Department, Technische Universität Darmstadt

What was the biggest challenge you faced when building the bridge?
M.E.: The most important thing was to control deformation of the material after it cooled down. The degree of deformation was considerably greater than first assumed.

How did you resolve it?
C.B.C.: Initially, we had got the robot to weld along the entire cross section of the bridge. In order to minimize the distortion, we had a narrow section made in the middle, with a further two strips then being attached to the left and right of it.

Why did you choose Wire Arc Additive Manufacturing (WAAM)?
T.F.: Because, compared to other additive processes, it's quick, economical and location-independent.

How do you see the future of WAAM?
M.E.: We believe it opens up a wealth of new possibilities in the building and construction industry. You can attach virtually any shape to existing parts. There is no need to cut parts to size and hold them in place during the attachment process. This can save a lot of time and expense, particularly with smaller or special applications as well as complex shapes.

What role did the welding gas play?
C.B.C.: The gas influences the width and height of the weld. Messer's mixture ensures a very flat and wide weld, which is attached from the side, making it very good for overhanging structures.
T.F.: We needed large quantities of the gas in the course of building the bridge, and Messer provided us with it free of charge. We are very grateful for that.

AM Bridge Project
The Steel Construction Department at Technische Universität Darmstadt completed its AM Bridge Project in November 2019. AM stands for Additive Manufacturing. The 3D printing of a cantilever bridge on site was a world first.

l. to r.: Thilo Feucht, Maren Erven and Christopher Borg Costanzi

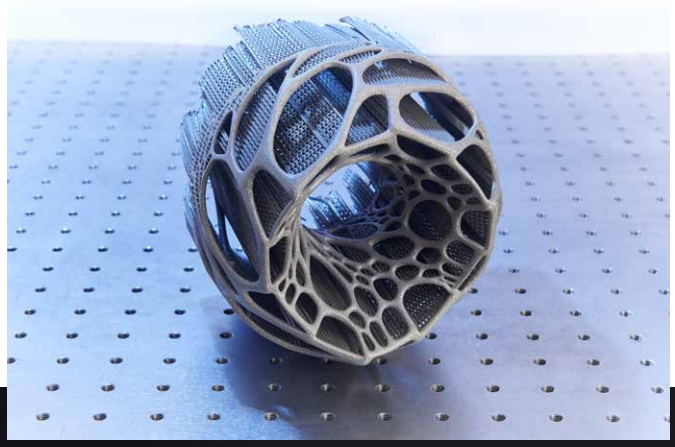
3D printing with metal – the most important processes

Powder bed (L-PBF / EBM)
Metal powder is sintered in layers with a laser or electron beam. Any geometry possible, very accurate, little or no rework, limited size (max. approx. 50x50 cm), relatively slow, cost-intensive.

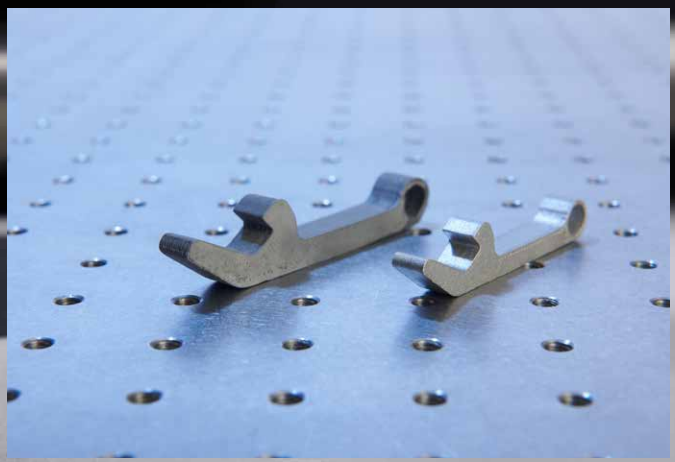
LMD with wire feed (LMD-Wire)
Wire is fed into a split laser beam and melted by it. Process is similar to powder spray, economical material.

Powder spray (LMD-Powder)
Metal powder is sprayed into a laser beam and melted in it. Quicker and more economical, but less precise than powder bed. Larger objects possible, limitations in terms of geometry.

Wire Arc Additive Manufacturing (WAAM)
In principle, Wire Arc Additive Manufacturing corresponds to the MIG/MAG welding process. Large objects possible, with lower precision and possible rework required. Economical and quick.



3D component out of the powder bed



Binder jetting (left: green body, right: finished component)

Addline – Gases for 3D printing

3D printing involves the use of a variety of gases at different stages of the production chain.

The latter essentially begins with the production of the powders used in 3D printing. Metallic powders are atomized with a gas jet to give them their spherical shape. Plastic powders, by contrast, undergo a cryogenic grinding process. This involves the use of liquid nitrogen.

To guarantee their quality, some powders have to be permanently stored in a shielding gas atmosphere. Special containers filled with shielding gas are used for this purpose.

Depending on the specific process, printing a component involves the use of shielding gases, carrier gases and/or cooling gases. In the majority of printing processes, the type of gas required – and its purity – depends on the material.

Gases are also needed for subsequent treatment of components. This is done either through subsequent heat treatment designed to achieve homogeneous component properties or by carrying out a subsequent sintering process. Stress relieving annealing, a process that requires the use of a shielding gas, is the typical heat treatment. But other types of heat treatment may also be required. Contact us and we will gladly provide advice about these gases.

You want to learn more about our gas know-how for 3D printing with metal? Our application specialists will be pleased to support you:

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Technical centres – sources for innovation
For the development of new technologies in the field of welding and cutting, Messer operates technical centres in Germany, Hungary and China. These facilities provide ideal conditions for innovative projects as well as customer presentations and training courses.

Portfolio of gases – comprehensive and clear
Messer offers a spectrum of gases that extends well beyond the standard fare: it ranges from just the right gas for each application, and clear, application-oriented product designations to the continuous introduction of new gas mixtures designed to address current trends.

Specialised on-site consulting – right where you need it
Specifically in the context of your particular application, we can show you how to optimise the efficiency and quality of your processes. Along with process development, we support you with troubleshooting and process development.

Cost analyses – fast and efficient
We will be glad to analyze your existing processes, develop optimisation proposals, support process modifications and compare our results with the previous situation – because your success is also our success.

Training courses – always up to date
For the optimal handling of our gases, we can train you on processes and how to use them. Our training courses illustrate the use of various shielding gases for welding and explain how to handle them safely. This also includes the storage of the gases and the safe transport of small quantities. Information and training materials for your plant are also part of the service, of course.

Read more online ...
This and other topics you will find in our new „Gases for Life“ online magazine. Available as of 20. December 2019 at **gases-magazine.messergroup.com**

www.messergroup.com