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Additive-capable zero point clamping system

NEWSLETTER

Postprocessing in series production

with AM-LOCK

When manufacturing a bracket from 1.4404 stainless steel, the support structures are removed through Hirtisation® and the surface smoothed. Only the structures that prevent distortion are retained. (Image: SLM Solutions and M&H CNC Technik)

Automated postprocessing as a prerequisite for industrial series production using metallic 3-D printing

The potential of additive manufacturing of metal components has been demonstrated impressively in recent years. From production of prototypes to 3-D printing of replacement parts, a variety of applications can be found in all branches of industry. The next logical step in development is now at hand: the transition from single piece part manufacturing to series production. However, additional fine tuning and automation of essential production steps will be necessary before large quantities of parts can be manufactured reproducibly and meet the standards of modern quality assurance. Postprocessing represents a decisive factor in this regard.

It is precisely through use of the possibilities and design freedom, now no longer bound by the limitations of traditional manufacturing, that 3-D printing of metal parts has a justifiable right to be recognized as a separate manufacturing method. However, with mass production and the associated need to automate, the manual machining steps typical of single piece part production must be replaced. The printed metal parts do not exit the printer in ready-to-use condition. The parts are usually fixed to the substrate plate by supporting structures and first need to be separated from this plate. Attaching to the plate is also intended to counteract internal stresses in the parts that arise during printing, above all due to temperature differences during the printing process. Only a subsequent heat treatment relieves the stresses in the part so that there is no longer any risk of distortion. The supporting structures also allow certain geometries such as overhangs, undercuts and larger cavities when printing

The H3000 finishing module is a stand-alone «Plug-and-play» machine for fully automatic postprocessing of 3-D printed parts using the patented Hirtisation® process.

with the powder bed method. While attempts are made to reduce the supporting structures to a minimum through suitable design, this usually limits one of the major benefits of 3-D printing - design freedom. In addition, powder residue adheres to the parts, some of which may be melted to the surface. Powder can also collect in the cavities. If the outlets are blocked, e.g. by supporting structures, the cavities cannot be emptied easily.

The above-mentioned thermal postprocessing can be supplemented further through simultaneous application of pressure, so-called hipping (hot isostatic pressing). The benefit of hipping is that micropores remaining in the material are reduced, usually allowing the packing density of the printed parts to be increased to more than 99 %. Once the part is depowdered, heat-treated and separated from the substrate plate, the supporting structures at the various locations are removed mechanically. This involves manual milling, cutting off with clippers and filing. Next, the industrially unacceptable surface roughness of the parts is reduced via blasting and some form of vibratory grinding. This includes new methods based on chemically assisted vibratory grinding. Common to all of these methods is that neither interior regions nor geometric undercuts can be processed. In addition, may manual steps are involved in the postprocessing described above. The process sequence is discontinuous and as a result cannot be automated. This means that high-volume production is not possible. Moreover, some of the interesting geometries and thus the design freedom of 3-D printing are excluded. Production of large quantities of parts, on the other hand, requires as much automation as possible, perfectly coordinated process steps and maximum traceability and reproducibility.

Electrochemical alternative

At this point, electrochemical (galvanic in the broadest sense) methods come into play. The best known example here is classical electropolishing, but in many areas it also has similar limitations regarding part geometry and interior regions, which cannot be electropolished at all or only with enormous effort. As a dynamic process, only the patented Hirtisation® is suitable for these tasks. This process has its roots in electrochemistry as well, but was developed specifically for the different postprocessing tasks associated with 3-D printed metal parts. As a chemical-electrochemical process, it represents an alternative to the commonly used mechanical machining steps.

Using systems based on liquid media, even areas and interior regions of parts that are difficult to access geometrically can be reached. In its unique three-step process, Hirtisation® removes the supporting structures and the caked-on powder residue in the first step, smoothes the surface to a technically usable point in the second step (Ra < 2µm) and, if necessary, polished the part in the third step. In this regard, the chemical-electrochemical process acts as an enabler for new part geometries and in this way promotes design freedom, one of the greatest strength of 3-D printing. Furthermore, the unlimited scalability of electrochemical processes contributes to the transformation of 3-D printing into a capable, reliable method for series production. Hirtisation® is provided either as a service at a finishing center of Hirtenberger Engineered Surfaces or employed on-site using compact, fully automated finishing modules at the 3-D printer. The process can also be set up for incoming large quantities in finishing lines using an H12000 with a capacity of 500 parts per hour.

at left: The process can also be set up for incoming large quantities in finishing lines using an H12000 with a capacity of 500 parts per hour. **at right:** The stainless steel vacuum gripper is freed from the supports and ready for use after finishing by means of Hirtisation®. (Images: Materialise)

Digital twin extending to postprocessing

When transitioning to high-volume production, all interfaces along the entire processing sequence must be defined, self-contained and monitored in terms of quality assurance. Creation of so-called digital twins is a very important aspect in this respect. The digital twin is the virtual replica of a specific product that accompanies its physical counterpart over its entire life. This simulation model is assigned to an individual product and fed with the real load data obtained from sensor data in an initial (transition) step. Precisely in terms of efficiency, the virtual representation of machines or equipment as a replica on a digital platform offers the company many benefits over the entire lifecycle – from product design through production planning and engineering to startup, operation, service and modernization of systems and equipment. The twins – digital and real – are permanently connected to one another and in this way develop a common object memory. Ideally, this already forms during the initial study. In this way, the simulation model reflects the current physical condition of the entity. However, the digital twin should not only describe the part as such, but also the entire genesis of the part along the whole production chain. From the starting material through all processing steps to the finished part, not only are all geometric changes recorded completely step by step, but also all property changes. Using the digital twin, it is thus possible to know the real part in every stage of its existence and in turn perform the entire manufacturing process for the part on the digital level. The virtual replica in the form of this intelligent 3-D model furthermore allows early identification of development errors and potential problems that would otherwise not arise until production had started.

With dimensions of 500 x 500 x 300 mm, the H6000 offers a considerably larger working compartment than the H3000. It can simultaneously postprocess multiple parts in different materials.

The properties are predictable on the basis of the selected processing steps and their manufacturing parameters. Moreover, it is exactly here that a major development step occurs almost unnoticed! The genesis of a part over the course of the entire manufacturing sequence is now taking place in a virtual space. Production and the part itself exist first in the cloud before there is a physical counterpart. A radical change in thinking is needed here. The part already exists digitally (actually!) in the digital sphere and only materializes in the physical world from this virtual world. Postprocessing in particular needs to be incorporated into these thoughts. The following processing steps already need to be considered when designing the part, e. g. the change in part size as the result of postprocessing. In this way, the entire process, including final finishing, can be traced and monitored.

Incorporating industrial coating technology

In conclusion, I would like briefly to address one further essential point that to date has hardly drawn attention in the 3-D printing sector. Classically manufactured parts are coated in a final step almost as a matter of course. This is intended to provide protection against corrosion, enhance the visual, decorative appearance, increase the chemical stability during use or protect against wear. The appropriate coating is selected on the basis of the requirement. This may be a galvanic coating, painting, a cathodic immersion coating, anodizing or a ceramic coating (usually by means of a physical process such as PVD). Since such surface protection is essentially an industry standard today, it can be assumed that sooner or later this subject will become a matter of discussion for 3-D printed parts as well. I am thinking above all about use of this technology for high-volume automotive part production. This aspect is also part of postprocessing and must be integrated into the entire process sequence via the above-mentioned interfaces.

Hirtisation® has its roots in electrochemistry, but was developed specifically for the different postprocessing tasks associated with 3-D printed metal parts.

Consideration of postprocessing already during design

In summary, postprocessing is a major aspect of the transition from single piece part manufacturing to high-volume production. If 3-D printing expects to become an established, independent production method, it must make this jump to large-scale production. In the area of postprocessing, it needs defined and self-contained interfaces, automation to the greatest possible extent and scaling of the individual processing steps. This integration is best achieved through use of digital twins and consideration of postprocessing already in the design files.

If new paths are taken regarding part design and there is not simply an attempt to replace existing production methods, which have been optimized over decades, with 3-D printing, then 3-D printing of metal parts will find its way into industrial-scale series production. Intelligent solutions using the almost endless freedoms in design can also lower cost pressures here. Coordinated and automated production sequences, from design through printing and postprocessing, further reduce costs to a point that is economically attractive and allow essential, traceable quality management. Postprocessing should not be considered a hindrance, especially here!

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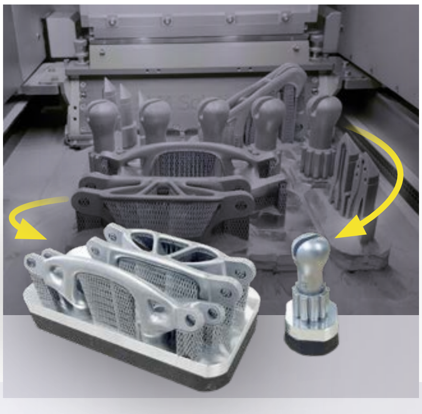
Segmented substrate platforms and zero point clamping for maximum flexibility and process stability

Postprocessing depends greatly on the printed workpiece. One of the above-mentioned «defined and self-contained interfaces» is the workpiece carrier system. This is where the AM-LOCK from pL LEHMANN come into play. For automated postprocessing such as fit bores, threads, precision surfaces or even just measuring after 3-D printing, it must be possible to separate the individual parts without removal from the substrate platform. Only in this way is the workpiece zero point retained. It must be possible to channel the printed workpieces on the basis of their individual need for postprocessing. Separation from the carrier pallet should furthermore take place at the latest possible moment in order to achieve maximum efficiency and accuracy.



Maximum flexibility with maximum precision and process stability. (Image: pL LEHMANN)

Since a zero point clamping system is subjected to special conditions in the powder bed, the usual moving mechanism should be avoided. AM-LOCK uses the process heat and meets this requirement with Thermo-Lock. Many users, however, are already using known systems in postprocessing. Accordingly, an additive-capable zero point clamping and workpiece carrier system must be prepared for this. For this reason, AM-LOCK is easily adaptable to various systems without having to release the printed 3-D parts from the substrate plate.

Looking at 3-D printing of metal workpieces as a whole, the entire added-value chain needs to be considered to reach the level of an industrial-scale manufacturing technology: from design through data preparation, printing and post processes, data consistency within software, workpiece transfer in terms of hardware to traceable quality management, there are still many unanswered questions – but also very good system solutions already. One of these is Hirtisation on AM-LOCK.

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