Tech Article

Selecting Finishing Fluids for 3D Printed Parts

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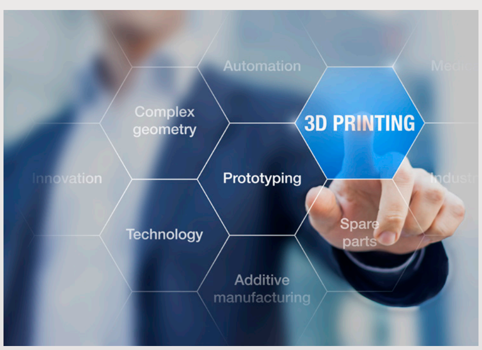

3D printing is ideal for prototyping and short runs of complex parts.

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3D printing, a subset of additive manufacturing (AM) has been in use for decades. Many have traditionally viewed it as something only used by hobbyists to make figurines or other decorative objects. However, 3D printing has quickly gained widespread acceptance within the medical device manufacturing industry for functional applications.

With the advancement of technologies and materials, 3D printing is now a viable alternative to the more conventional production methods like cutting or injecting. In some instances, it is eliminating the need for machining completely. It is allowing medical device designers to create ever more complex parts with intricate geometries that would otherwise be incredibly time-consuming or even impossible to make using more traditional methods.

In the past, design compromises were made for parts that were too intricate or too small. But now, 3D printing has opened up design possibilities that are almost limitless. It is providing a way make detailed, precise and patient-specific parts matched to their unique anatomy. Dental aligners, hearing aids, dental crowns, contact lenses, prosthetic devices and dentures are 3D printed and custom made for each individual patient.

This article examines how one AM process, binder jetting, produces these 3D printed products. It also explores how choosing the correct binder jetting finishing fluids plays a key role in the success of that process.

Binder Jetting – A Quick Overview

There are a number of additive manufacturing methods used to make parts. Some, like selective laser melting (SLM) and electron beam melting (EBM), are quite sophisticated processes that require specialized equipment, complex safety procedures and very skilled operators. Binder Jetting (BDJ) is a faster, more affordable alternative to those other AM processes. It does not employ lasers or electron beams to build parts, therefore making it easier to use with minimal training.

Binder jetting makes three-dimensional parts from a CAD (computer aided design) file. It uses a powdered material, typically plastic or metal, and a binding agent. Nozzles on the printer deposit an ultra-fine layer of powder on a build platform. Then a liquid wax bonding agent binds the particles together. The print head continues to drop alternating layers of the powdered material and the binding material, layer by layer to form a solid part. The quality and precision of parts made with this 3D printing process often result in parts requiring minimal post-processing to create a finished part with excellent dimensional repeatability.

The 3D printing process using binder jetting may seem straightforward. However, it is important to get the details right for the best possible end product. This includes choosing the best finishing methods and fluids for the printing material being used.

Fluid Finishing for Plastic Parts

Historically, 3D printing was mostly restricted to making plastic parts. Even today, over 80% of 3D printed parts are made using polymers. 3D printed plastic parts are made by depositing multiple layers of special polymers and binders built up

Binder jetting builds a part out of fine metal powders and binders.

3D printing allows patient-specific, customized prosthetic limbs.

layer-by-layer. Since the plastic parts are built progressively, it sometimes leaves the printed parts with a stepped or terraced surface. The surface then requires smoothing to get a finished part.

Traditional methods of smoothing out the terraces, like grinding, buffing or sandblasting, are extremely manual, time-consuming and often leave particles behind. Today, smoothing fluids are available for use in a vapor degreaser. Immersing the unfinished parts in a fast-evaporating solvent vapor slightly melts the surface of the plastic parts, leveling out any irregularities and removing the terraces. It leaves a smooth finish without any leftover particles or damage to the finished part.

In order for the smoothing to work, it is necessary to understand the chemical composition of the polymer used and to find the correct chemical solution for the application. Trained vapor degreasing experts have experience selecting smoothing fluids for specific types of 3D printed polymers and can guide part designers through this process.

Debinding Fluids for Metal Parts

While many people still associate 3D printing with plastics, the commercialization of metal 3D printing is quickly evolving. Until recently metal 3D printing was reserved for prototyping or low volume runs. It was too expensive and too slow for mass production and overly complex for wide scale use. However, as technologies advance, metal 3D printing is quickly making its way to the manufacturing floor. It is now a viable option for higher production runs of end-use parts.

Metal 3D printing employs the same layered-build process as plastic 3D printing, but uses fine metal powders instead of polymers. Typical metal powders include stainless steel, tool steel, and many other ferrous and nonferrous alloys. The binder jetting process uses alternating layers of the fine metal powder and a binding agent to create the green-state parts. The binding agent is typically paraffin wax, carnauba wax, or specialty polyethylene waxes. After printing, the green parts are cleaned and sintered in an oven to make it a fully dense metal part.

The binding agents serve a critical purpose in the forming process, but in many instances must be at least partially removed before the part can be exposed to the high heat required for sintering. In many cases, the binders are removed using a specialty solvent that is engineered to selectively remove some, but not all of the binders. The binder is removed to avoid contamination of the metal during sintering. But, it is essential that some of the binder remains so that the part maintains dimensional accuracy during the sintering process.

Selectively Removing the Right Amount of Binder

Selection of a debinding method is a balance of removing the binder in the shortest amount of time and with the least amount of damage to the structure. Because, as the binder exits, the structure becomes fragile. Solvent extraction of the binder is done in either the solvent vapor or the liquid phase in a vapor degreaser. Both rely on the solvent flowing through the pores, internal channels and passageways of the structure to dissolve the wax. This allows the parts to be exposed to higher temperatures in the sintering furnace. This significantly reduces the time to achieve a finished part.

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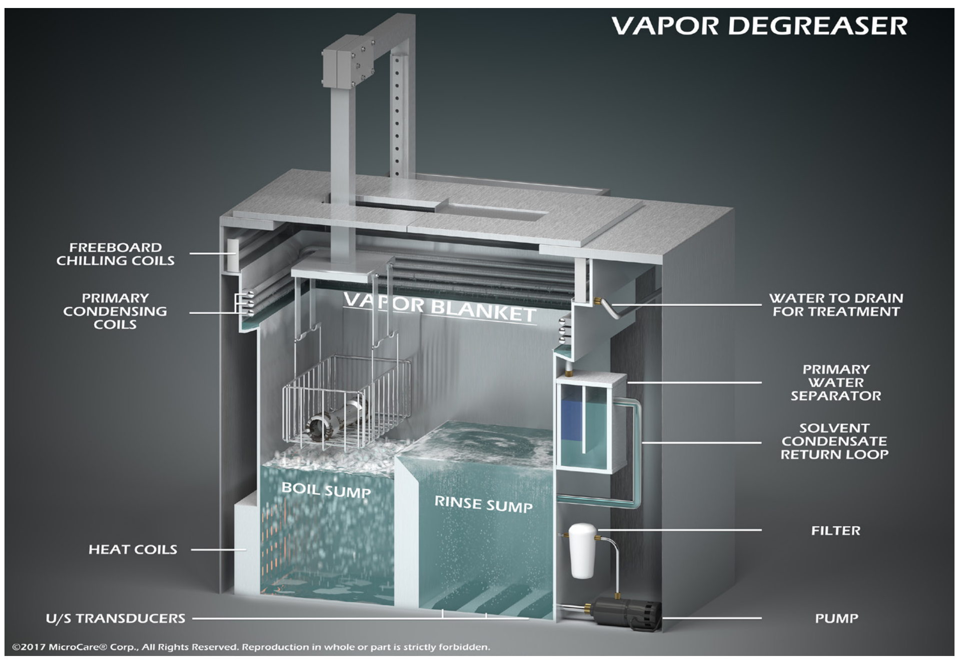
New Debinding Options

New solvent blends speed the solvent debinding process without the use of n-propyl bromide, methyl pyrrolidone, polyethylene glycol, heptane, or trichloroethane, which all carry health and or environmental baggage. The new debinding fluids boast low viscosity and surface tension ratings, are nonflammable, and are engineered for selectivity so the right amount of binder is removed without damage to the part structure. These new debinding fluids, when used in a vapor degreaser, are also distilled and reused in the debinding process.

Once the debinding fluid is fully removed from the part structure, the parts are then thermally sintered under high heat to bond the metal powder into its finished solid mass state. The remaining binder in the part burns off at sintering temperatures. After that the parts can be post-processed using standard metal finishing techniques like grinding, cutting or coating.

Companies looking for help in determining the correct debinding fluid or method should consult with a critical cleaning partner. Especially one that specializes in vapor degreaser debinding. Some fluid manufacturers have field engineers that conduct on-site audits to evaluate debinding methods. They can also perform comprehensive in-lab tests with sample parts to ensure cleaning and debinding success.



In some shops, part debinding typically happens inside a vapor degreaser using a specialty debinding fluid.

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One Thing Always Remains the Same

Today, the medical device manufacturing industry is in a constant state of flux. New, unique and state-of-the-art designs are developing daily. However, one thing will always stay the same. Even state-of-the-art designs and manufacturing processes can benefit from unique chemistries that make some of these advancements possible. Post-processing using specialty fluids and solvent-based treatments make plastic and metal 3D printing viable options within the medical device industry. However, it is essential to work with a partner that has specialized experience. They should also have expertise in solvent technology to recommend the fluids and methods that will work best.

About the Author:
Venesia Hurtubise is a Technical Chemist at MicroCare which offers precision cleaning solutions. She has been in the industry more than 6 years and holds a MS in Green Chemistry from Imperial College. Hurtubise researches, develops and tests cleaning-related products that are used on a daily basis in precision cleaning and medical applications. For more information, visit www.microcare.com.

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