Tech Article

Finishing Fluids for 3D Printed Parts

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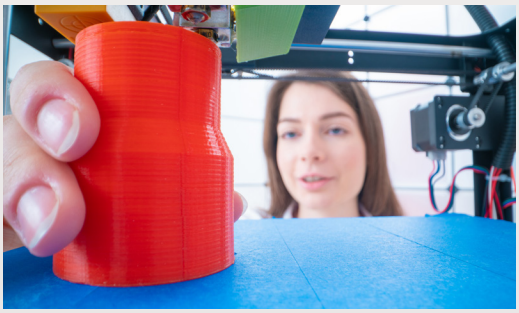

Today over 80% of 3D printed parts are made using thermoplastic or thermoset polymers.

Choosing the correct post-processing 3D finishing fluids plays a key role in the successful construction of plastic and metal 3D printed parts.

3D printing (3DP), a subset of additive manufacturing is gaining widespread acceptance for functional applications within the aerospace manufacturing industry. With the advancement of technologies and materials, 3DP is now a viable alternative to more conventional large-scale production methods. These include subtractive manufacturing or injection molding. In some instances it is eliminating the need for machining altogether.

Ideal for producing parts with complex geometries, 3D printing helps maximize production. 3D printing replaces methods that are too expensive or time-consuming to make using traditional machining methods like lathing or turning. Parts are now produced in hours instead of the days needed when using more conventional methods. 3DP is no longer restricted to prototyping samples and low production runs. It is now used to make high-volume, fully-finished, machine-grade parts.

Building the Parts is Just the Beginning

Today over 80% of 3D printed parts are thermoplastic or thermoset polymers. Metals, ceramics and other composite materials comprise the other 20%. 3DP parts use a variety of 3D printing methods including FFF, DLP, SLM, EBM or material jetting processes.

Common to all these methods is that the parts are created from a computer aided design (CAD) file. All are fabricated using a polymer or metallic construction material. The construction material is either powder-deposited or extruded through a nozzle in progressive layers. The layers are built, level-by-level, until the parts reach their final shape. The quality and the precision of the items made using 3DP processes result in parts requiring minimal post-processing and with excellent dimensional repeatability. However, building the parts is just the beginning of the 3DP process. Choosing the correct post-processing fluids also plays a key role in the successful construction of the 3DP components.

Fluid Finishing for Plastic Parts

The layered 3DP process leaves some plastic printed parts with a tiered or stepped surface. This requires smoothing to get a finished part. Traditional methods of smoothing the tiers, such as sandblasting, buffing or grinding, are manual, time-consuming, and often leave particles behind. A more efficient method for smoothing parts to their finished state is to use a specialty smoothing fluid inside a vapor degreaser to chemically even them out. Immersing the unfinished parts in a fast-evaporating fluid vapor inside the degreaser slightly melts the surface of the plastic parts. This levels out any irregularities and removing the tiers. It leaves a smooth finish without any leftover particles or damage to the finished parts. The quality of the finished parts is comparable in quality to parts using more traditional injection molding processes.

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Complex metal parts are made using fine metal powders and binding agents.

For smoothing to be effective, it is necessary to understand the chemical composition of the polymer parts. For instance, approach ABS, acrylic, polycarbonate and highly basic materials with a pH of 10 very carefully. Some fluids soften and swell the materials. Finding the best smoothing fluid can often be a delicate balance between selecting one with a high enough solvency to effectively level out the parts, but not so strong that it damages them or compromises their structural integrity. Trained vapor degreasing experts have experience selecting smoothing fluids for specific types of 3DP polymers and can guide part designers through this process.

Removing Particulate

In addition to smoothing the parts, the fluid must also be effective at removing soils or particulate left behind from any other manufacturing processes. The fluid, when used in a modern vapor degreaser dissolves and cleans a variety of oils, greases and waxes. Any stray particulate like dust or shavings are typically non-soluble and will not dissolve in the cleaning fluid. Therefore, the particulate must be removed using displacement cleaning where the cleaning fluid gets under the particulate, dissipates any static charge and lifts it off the surface. The key to effective displacement cleaning is to use a dense, heavy fluid that floats the particles of dust and dirt off the substrate surfaces. Today's modern fluids are typically 20% heavier than water and 50% heavier than alcohol, making them an ideal choice for displacement cleaning of 3DP polymer parts.

An added advantage of fluid smoothing and cleaning of 3D printed aerospace parts is that they dry very quickly and completely. The fluid leaves no residue on parts and are cool after they exit the vapor degreaser. This allows parts packaging or post-processing immediately, speeding production and overall throughput.

In addition, modern-day 3DP post-processing fluids are nonflammable and safe for use in cold operations, heated machines or in ambient temperatures. Their formulas do not use n-Propyl Bromide, Methyl Pyrrolidone, Polyethylene Glycol, Heptane, or Trichloroethane, all which can create groundwater and air quality issues.

Debinding Fluids for Metal Parts

Until recently metal 3DP was only for parts prototyping or for low-volume runs. It was considered too expensive and too slow for mass production, and overly complex for wide-scale use. However, as the technology advances, metal 3DP is quickly making its way to the manufacturing floor. Especially for higher production runs of end-use parts.

Metal 3DP uses the same layered-build process as plastic 3DP but employs a combination of fine metal powders and a binding agent, typically paraffin wax, carnauba wax, or specialty polyethylene waxes, to create green-state parts. The binders serve a critical purpose in forming the metal powder into a specific shape. However, they are ultimately sacrificial. They are selectively removed before the green parts are exposed to the high heat required for the next step of sintering.

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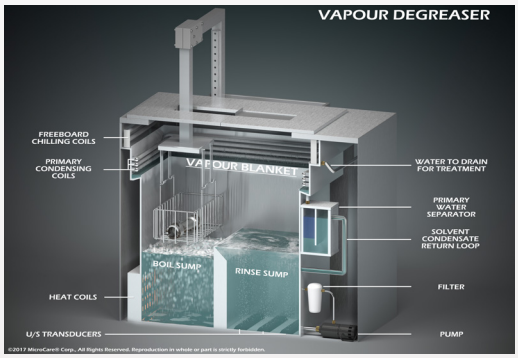
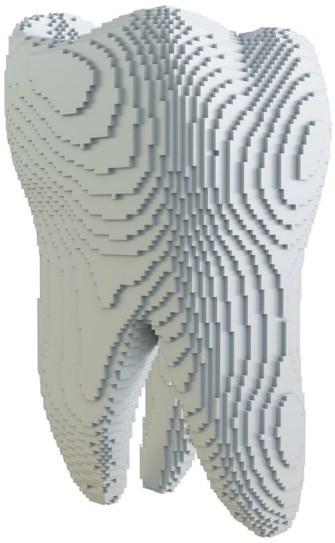


3DP finishing is reliably and consistently achieved using a vapor degreaser.



Plastic 3DP leaves parts with a stepped surface that is chemically smoothed.

Vapor Degreasing for Debinding

Fluid extraction of the binders is easy with a vapor degreaser. The debinding may be performed in either the vapor or liquid phase in the vapor degreaser depending on the metals used and the binders to be removed. Both vapor degreasing phases rely on the debinder fluid penetrating the parts. This efficiently dissolves the wax from the parts interior.

The wax binders are progressively removed to avoid deformation and cracking during sintering. This allows the parts to maintain their dimensional accuracy, compress uniformly and sinter evenly. Debinding is a balance of selectively eliminating some, but not all, of the binders. Plus removing the binders in the shortest amount of time limits damage to the parts structure. Because as the binders are removed, the parts become fragile. This is where the physical properties of the debinding fluid are important and the fluid should be chosen carefully.

Compatibility and Strength

The debinding fluid should have good materials compatibility with both the metal powders and the binders to safeguard the integrity of the formed parts. It should also feature low viscosity, low surface tension and high liquid density to allow the debinding fluid to flow over, around and into the internal pores of the parts to remove and wash away the binders more easily. The debinding fluid should be aggressive enough to selectively remove the soluble binders yet still maintain the integrity of the part. Too much binder left behind could result in cracking, deformation or part expansion during the sintering process.

Energy and Time Savings

A low-boiling debinding fluid melts the wax binders and additives. But it also allows the vapor degreaser to run more efficiently, saving energy costs. The low boiling point also prevents damage to the non-soluble components. Debinding fluids with a low boiling point and low latent heat of evaporation also dry more quickly. This translates into faster production times.

People and Planet Safety

Nonflammable debinding fluids are safer for workers and do not require specialty fire or explosion-proof equipment. They are distilled and reused inside the vapor degreaser, minimizing waste. In addition, some debinding fluids are shipped as “not hazardous, not regulated” anywhere in the world, even by air.

Finding a Partner

Post-processing using specialty fluids and solvent-based treatments help to make plastic and metal 3DP viable manufacturing options within the aerospace industry. Companies looking for help in determining the correct smoothing or debinding fluids and methods should consult with a critical cleaning partner. One that specializes in vapor degreaser smoothing and debinding. They can recommend the fluids and methods that will work best and ensure your 3DP post-finishing success.

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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.
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