FINISHING FLUIDS
FOR 3D-PRINTED PARTS

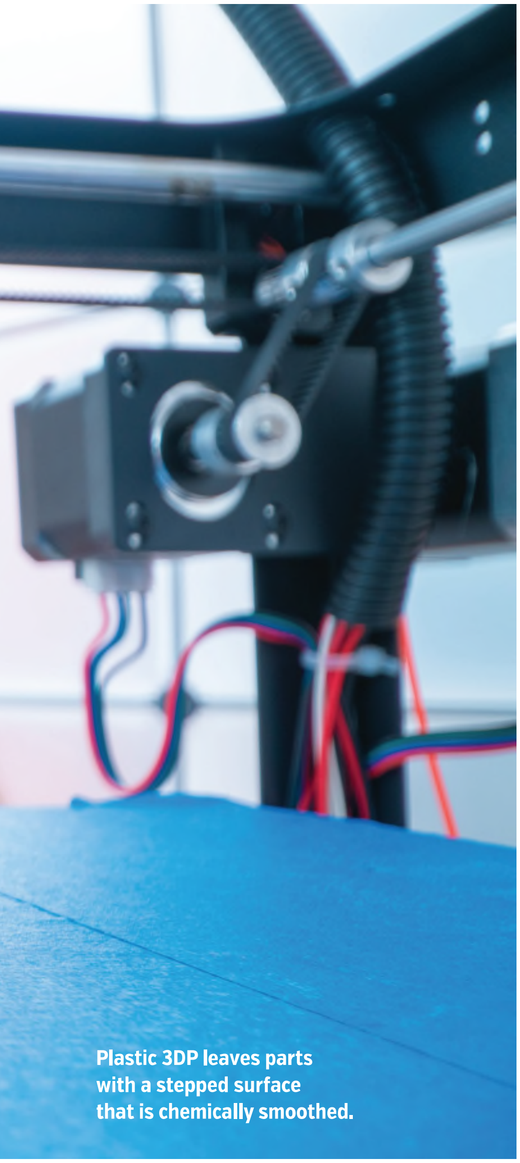
Choosing the proper post-processing fluid can save time, energy, and improve plastic and metal parts. **By Venesia Hurtubise**

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

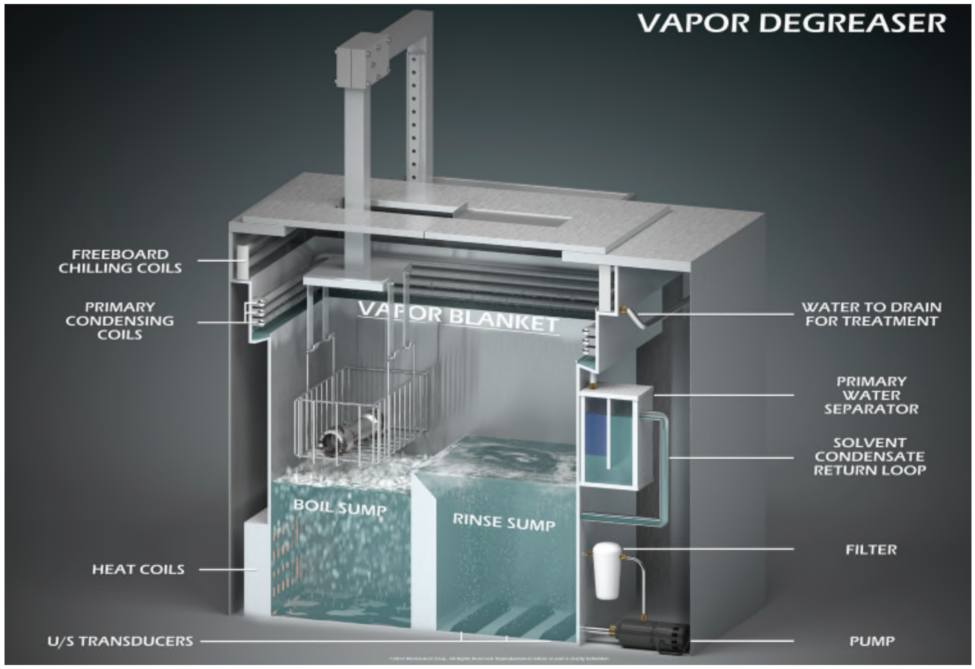
Ideal for producing parts with complex geometries, 3D printing can maximize production by creating parts in hours rather than days, which otherwise would be too expensive or time-consuming to make using lathing or turning. Instead of being restricted to prototyping samples and low production runs, 3DP is used to make high-volume, fully finished, machine-grade parts.

More than 80% of 3D-printed parts are made using thermoplastic or thermoset polymers, with metals, ceramics, and other composite materials comprising the other 20%. 3DP parts are manufactured using 3D printing methods including fused-filament fabrication (FFF), digital light processing (DLP), selective laser melting (SLM), electron-beam melting (EBM), or material jetting processes. Parts are created from a computer aided design (CAD) file and are fabricated using a polymer or metallic construction material that is powder-deposited or extruded through a nozzle in progressive layers until parts reach their final shape.

Items made using 3DP require mini-



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



3DP finishing is reliably and consistently achieved using a vapor degreaser. (Photo courtesy of MicroCare)

mal post-processing and have excellent dimensional repeatability. Building 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, requiring smoothing to get a finished part. Traditional smoothing methods – such as sandblasting, buffing, or grinding – are manual, time-consuming, and often leave particles behind. A more efficient method is fluid finishing. In this method, unfinished parts are immersed in a fast-evaporating fluid inside a vapor degreaser that slightly melts the parts' plastic surface – levelling out irregularities, removing the tiers, and leaving a smooth finish without any leftover particles or damage to the finished parts. The quality is comparable to parts made by injection molding.

For effective smoothing, it is necessary to understand the chemical composition of polymer parts. ABS, acrylic, polycarbonate, and highly basic materials with a pH of 10 or more have the potential for softening and swelling. Thus, the selected smoothing fluid should have enough solvency to effectively level parts but not be so strong that it damages them or compromises structural integrity.

In addition to smoothing parts, the fluid must be able to remove soils or particles left behind from other manufacturing processes. The fluid, when used in a modern vapor degreaser, can be used to dissolve and clean various oils, greases, and waxes. Dust or shavings typically will not dissolve in the cleaning fluid. Therefore, particles must be removed using displacement cleaning, where cleaning fluid gets under the particulate matter, 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 particles off the substrate surfaces. Today's fluids are typically 20% heavier than water and 50% heavier than alcohol, making them suitable for displacement cleaning of 3DP polymer parts.

An added advantage of fluid smoothing and cleaning is that they dry quickly and completely, leave no residue on parts, and are cool after they exit the vapor degreaser. This allows parts to be packaged or post-processed immediately, speeding production and overall throughput.

In addition, 3DP post-processing fluids are nonflammable and safe for use in cold operations, heated machines, or in ambient temperatures. They also are formulated without n-propyl bromide, methyl pyrrolidone, polyethylene glycol, heptane, or trichloethylene, all of which can create groundwater and air quality issues.

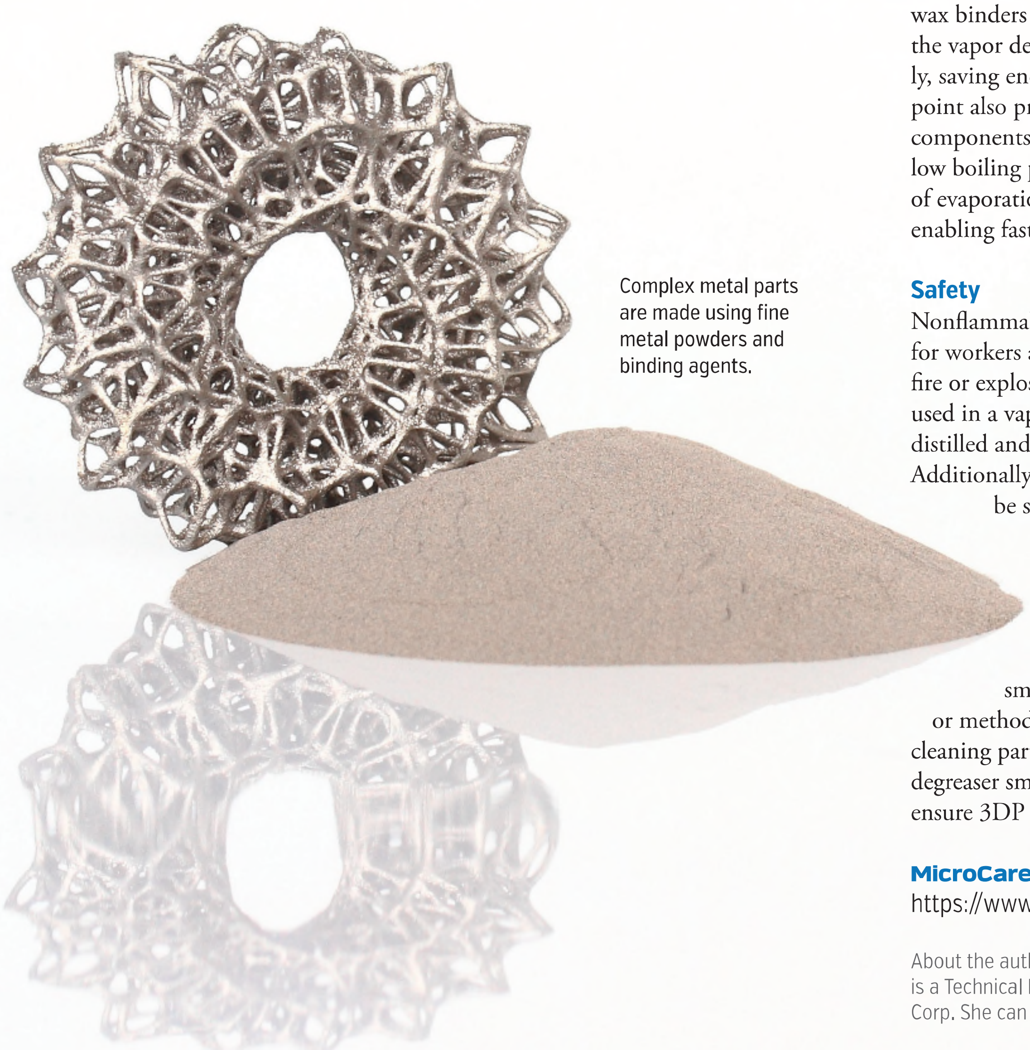
Metal debinding fluids

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

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

Fluid extraction of the binders is accomplished with a vapor degreaser. The debinding may be performed in either the vapor or liquid phase, depending on the metals used and the binders being removed. Both phases rely on the debinder fluid penetrating the parts efficiently to dissolve the wax from the part's interior.

The wax binders are progressively removed to avoid deformation and cracking during sintering while also allowing 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 in the shortest time and with the least amount of damage to the parts' structure, because as the binders are removed, the parts become fragile. This is why the debinding fluid's physical properties are important and the fluid should be chosen carefully.



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

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Compatibility, strength

The debinding fluid should have good materials compatibility with metal powders and 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 but still maintain part integrity. Too much binder left behind could result in cracking, deformation, or part expansion during sintering.

Energy, time savings

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

Safety

Nonflammable debinding fluids are safer for workers and do not require specialty fire or explosion-proof equipment. When used in a vapor degreaser, they can be distilled and reused to minimize waste. Additionally, some debinding fluids can be shipped as not hazardous, not regulated, even by air.

Finding a partner

Companies seeking help in determining the correct smoothing or debinding fluids or method should consult with a cleaning partner who specializes in vapor degreaser smoothing and debinding to ensure 3DP post-finishing success.

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