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2020 OUTLOOK: PREPARING FOR CHANGES AHEAD

Machine Tool & Cutting Tool Purchasing Trends

Sizing Up Deburring Operations

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Cover: Manufacturing has had an exciting 2019. As the year draws to a close, questions about how 2020 will look are the top of everyone's mind. While crystal balls may not really exist, this month's *Manufacturing Engineering* is full of insights from some of the greatest manufacturing fortune tellers there are.

SHOP SOLUTIONS

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Using Software to Find and Eliminate Machining Errors

The MIC Group LLC, Brenham, Texas, is a large job shop that machines a wide range of materials into a wide range of parts. Since each of the CNC programmers at MIC Group is personally responsible for the parts produced with their NC programs, they rely on VERICUT simulation software from CGTech to prove out their programs before they go on a machine tool. Frequently, programmers not only use VERICUT to simulate the complete toolpath, but also to do a dimensional inspection of the cut model.

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Team of Partners Helps MTU Aero Automate Production

As it developed a new, highly automated production system for the turbine blades used in its jet engines, MTU Aero Engines, Munich, Germany, knew it needed a multifaceted solution. It turned to a team of innovative suppliers, including Liebherr, Blohm, AMT and SOFLEX. Together, the partners developed a system of four parallel-operating, fully-automatic grinding cells that can be operated by just one technician.

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3D Printing Delivers Washout Tooling for Composites

RICK LUCAS
Chief Technology Officer
The ExOne Company

WITH TODAY'S FOCUS ON LIGHTWEIGHTING, hollow parts made from composite materials—such as ducting, fuel tanks, mandrels, and rocket shrouds—are in higher demand than ever before. The composite ducting market in the aerospace and defense sector alone is expected to reach $864.7 million by 2024, according to a recent report from Stratview Research.

Manufacturing composite parts with hollow features, however, has historically been a time-consuming and expensive endeavor. For decades, sacrificial tooling has been needed to create the core forms for composite layups (positioned on the tool by hand), standard prepreg methods, or filament winding. The tool covered in the layup is then autoclaved at high pressures and temperatures to create a final rigid part.

Filament winding on 3D-printed washout tooling from ExOne. (All images provided by ExOne)

Creating the core tooling for layups has always been a multi-step process that involves molds and other labor-intensive methods. What's more, it hasn't always been easy to remove the sacrificial tool after the final composite part has been completed. Today, that process often involves hot solvents, detergents, tools that deflate, and sometimes an old-fashioned chisel for removing tools out of the final part.

Several years ago, the R&D team at ExOne—which focuses on binder jet 3D printing of sand, metal and other powders—discovered and developed an easy-to-use new method: 3D printed tooling that washes out with tap water.

This approach is now being used successfully to create carbon- and glass-fiber reinforced composites for Sikorsky Aircraft Corp., a Lockheed Martin company, and other aerospace and automotive companies, including those in competitive racing. For example, ExOne supplied a washout mandrel for an engine air intake manifold for the University of Texas at Austin's racing team. The ExOne logo is displayed on the side of the rear wing of the car.

University of Texas at Austin Racing used an ExOne washout mandrel for an engine air intake manifold in its 2019 race car.

In another example, Royal Engineered Composites creates air ducting for Sikorsky to use in its heavy-lift helicopters. These CH-35K helicopters are required to perform consistently and support the weight of heavy equipment. ExOne washout tooling provided the cores/mandrels for the air ducts developed by Royal Engineered Composites for these aircrafts. Two of the CH-35K helicopters have already been delivered to the Marines for logistics demonstration.

Final composite mandrel created from 3D-printed sacrificial or washout tooling from ExOne.

Selective Binding

Binder jet 3D printing is a method of building objects in a powder bed by selectively binding thin layers of particles with a bonding agent applied through an array of inkjet print heads. In 2013, our team first discovered it could bind silica sand or ceramic sand particles with a proprietary solvent that remains water soluble to 180°C (356°F).

Our team is always at work developing new binders for a host of materials, including metallics, minerals, and more. We knew that we could develop water-soluble binders, but what application could benefit from 3D printing a solid part that could eventually be washed away? Our engineers with aerospace experience were quick to see the potential value to the composites industry.

After 3D printing the sand tool, we coat it in a proprietary spray that provides a smooth, impenetrable surface for the composite layup and dissolves during the final washout. Or, the part can be wrapped in Teflon tape for easy wind-out after the core is washed away.

We discovered other important benefits as well. Dealing with thermal expansion has always been a challenge during the autoclave process. This expansion must be considered when creating a final part that is dimensionally accurate. Thermal expansion can particularly challenge some geometries and forms.

However, what is unique with the printed tooling is that the expansion is driven by the media, or powder, that you are printing. That means it can be changed and controlled by simply changing the powder. For example, when printing with silica sand, the coefficient of thermal expansion (CTE) is 20 ppm/°C (11 ppm/°F) which could make sense for certain materials. In other cases, you might need a lower CTE in which case you would print with a ceramic sand where thermal expansion is closer to 3 ppm/°C (2 ppm/°F). This minimizes distortion and other challenges during autoclaving. Unlike other additive tooling materials, the thermal expansion is also isotropic—expanding in all three directions equally—resulting in high-quality, predictable results.

3D-printed sacrificial tool for composite layup from ExOne.

Hollow composite fiber parts created with 3D-printed sacrificial tooling that washes out with tap water.

Low Distortion, Easy Washout

Taken together, ExOne's low-distortion and easy washout process allows for the creation of innovative new designs and geometries that weren't previously manufacturable. For example, we have customers creating new and longer mandrel parts, or even tools that have unique integrated hardware features.

Overall, the process of using binder jet 3D printing to manufacture washout tooling is fast and affordable, with little to no concern for part distortion. Our customers compliment the washout for being fast and complete.

What's more, our 3D printed washout tooling process is sustainable with little to no waste: All of the washed-out sand can be recovered and reused for future print cycles.