FDM Deep-Draw Metal Forming Tool

Challenge

Sheet metal forming operations for automotive, aerospace and general industrial applications are typically accomplished with steel forms and dies machined from tool steel. This is an effective approach for high unit volumes since the tool material is able to withstand high-cycle operations. However, for low volume production such as automotive vehicle development, machined tools are a costly and time consuming approach. These scenarios typically require tooling changes as designs evolve, which drive additional time and cost into the project or limit the design scope.

Application Solution

3D printed sheet metal forming tools made with FDM® thermoplastics offer a durable yet cost- and time-efficient alternative to machined metal tools. FDM technology offers several polymer materials suitable for limited-run sheet metal prototype production, tool validation, and similar scenarios, where the intended yield of sheet metal parts is relatively low. The application is also advantageous when there is a higher likelihood of tool design changes, making an iteration process with machined tool steels cost-prohibitive.

The primary benefit of this application is the time and cost savings compared to machining metal forming tools. In some cases, the process of machining the tools has to be outsourced, resulting in long lead times and the risk of delays from supply chain disruption. Tools made in-house typically use machining resources that could otherwise be used for value-added production. In contrast, a 3D printed tool can be produced in hours and quickly changed by revising the CAD model and printing another iteration. In addition, 3D printing avoids the labor associated with machining. As a result, the cost is typically lower since the 3D printing process requires no labor. Material cost equates to only what is needed to make the tool.

3D printing typically results in a faster workflow than machining. A CAD model of the tool is required for both 3D printing and machining but once completed, 3D printing involves only uploading the model to the printer. In contrast, machining requires CNC programming and machine setup.

Several FDM thermoplastics are suitable for metal forming operations and include polycarbonate, carbon-fiber nylon, and PEIs (ULTEM™ 9085 resin and ULTEM™ 1010 resin). Selection is based on the type of metal being formed and the desired yield, as different materials will have varied lifecycles.

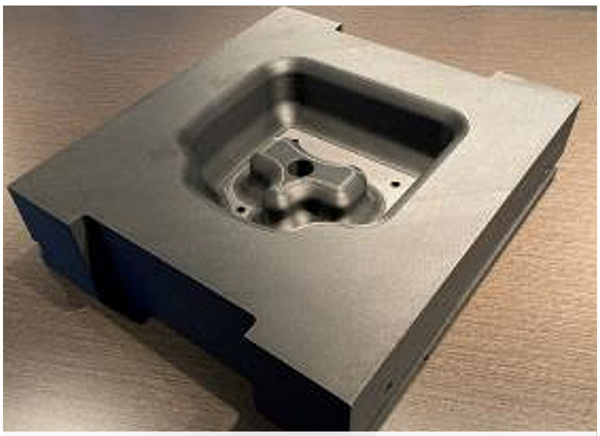
FDM is a best fit for

- Low production volumes (10s to low 100s)
- When tool design changes are needed/probable
- Short development timelines

Benefits of FDM over traditional methods

- Faster tool production
- Lower cost
- Easily implemented design changes

FDM Nylon 12CF punch.



FDM Nylon 12CF die.

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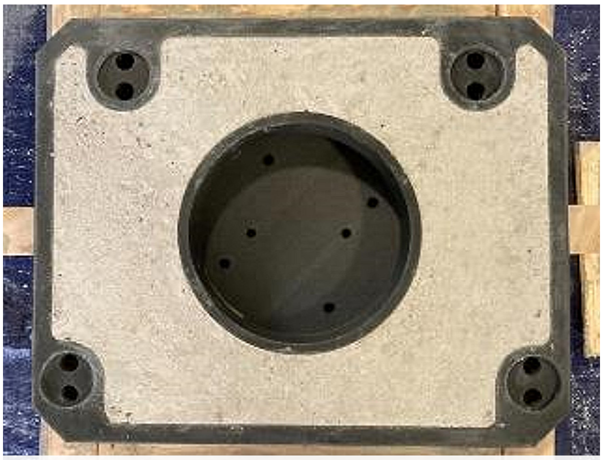
Customer Experience

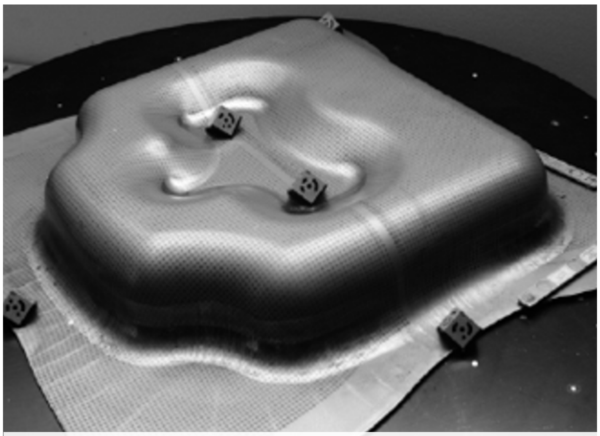
99P Labs, a digital proving ground for mobility and energy innovations, backed by Honda and The Ohio State University, used 3D printing to make a universal formability testing (UFT) tool, which is used to quantify the formability of new sheet metal materials. This geometry was chosen because it imparts several different stress and strain states on the sheet metal being formed as well as the FDM tool. These strain levels are representative of what is required to produce production sheet metal parts and the results can be directly compared to the parts made on a traditional steel UFT tool. The tool was printed with FDM® Nylon 12CF, a composite polymer filled 35% by weight with chopped carbon fiber. UFT tools and similar sheet metal stamping forms are used during vehicle development, when design changes are likely and part production quantities are low.

Engineers printed a solid form initially but changed the design to a shell-type tool to reduce cost. The 3D printed shell was then filled with concrete to provide increased tool stiffness and solidity for the forming operations. 99P Labs engineers also developed a process of using a standard bismuth-tin alloy solder as an alternative to the concrete fill.

The tool was used to form 1.6 mm thick dual-phase 590 advanced high-strength steel. Engineers from 99P Labs performed stress and strain analysis to validate the 3D printed tool's capability to meet the forming loads and found it acceptable with the concrete fill. Ultimately, the FDM Nylon 12CF forming tool provided successful results, yielding 40 parts, easily within the desired production target. The 3D printed solution also achieved a 65% cost reduction over the traditional machined-metal form tool option.



3D printed die with concrete fill backing.



Sheet metal formed by the 3D printed tool.

Results for 99P Labs

- 65% reduction in tool production cost vs. traditional methods
- 40-pc production yield

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