Printed Tools for High-Volume Production

Ford Uses Additive Manufacturing with FDM Technology for Producing Assembly Tools in its Automotive Production

Ford has selected desktop 3D printers to create various assembly tools, and can now produce jigs and fixtures, and even in highly complex designs, in-house at low cost. Ultimaker's open filament system enables the automaker to create parts with various filaments from a range of material manufacturers and meet specific material properties exactly.

For the precise placement of logos, branding marks and vehicle lettering Ford also uses additive templates and jigs in series production (© Ultimaker)

The automotive industry was one of the first sectors to recognize the potential and benefits of 3D printing. Its advanced technology has significantly transformed the development, design, manufacturing and distribution processes of car manufacturers over the last decade. The results are lighter-weight parts, novel designs and, in many cases, reduced costs and faster development and production processes. A study undertaken by Allied Market Research [1] in November 2017 has shown that 3D printing increases the value of existing parts and functionality in all aspects, making it indispensable in the automotive industry. The development of assembly tools for more efficient production is today one of the most successful new applications of 3D printing in the automotive industry.

3D Printing at Ford

During the car design and manufacturing process, engineers and production line operators use many custom tools, often designed for one specific task and model (**Title figure**). Just for the production of the high volume Ford Focus model, more than 50 jigs and fixtures are needed.

The production and procurement of traditionally-manufactured tools provided by contract manufacturers is time consuming, costly and slows down the construction process. In order to optimize the workflow, the additive manufacturing team at Ford-Werke GmbH in Cologne, Germany, decided to integrate fused deposition modelling (FDM) desktop printers supplied by the Dutch manufacturer Ultimaker B.V., Geldermalsen, Netherlands, into its production. The result is that the tools, some of which entail complex designs, can be produced cost-effectively, quickly and onsite (**Fig. 1**).

Thanks to Ultimaker's open filament system, filaments marketed by various providers can be used to manufacture components. As a result, printed assembly tools can be individually adapted to applications with filaments exhibiting differing material properties, without creating a dependency on any one individual filament provider. "The open filament system allows us to apply industrial materials in order to produce even more robust tools and fixtures for our series production," said Lars Bognar, Research Engineer Additive Manufacturing, Ford-Werke GmbH, located in Cologne.

The manufacturing and assembly tools are developed centrally in the pilot plant at Ford in Cologne. The tools are then produced or printed decentrally in all of Ford's European factories. The plant in Cologne has a complete small batch production area for additive assembly tools, in which the gauges and templates for new vehicle designs can be devel- »

oped to production maturity. Compared to conventionally-produced metal tools, the additively-produced plastic tools are not only significantly lighter, but also more durable (**Fig. 2**).

Assembly Tools Require Various Filaments

The use of FDM printers in the production of equipment, tools and assembly aids has disruptive potential and could lead to a paradigm shift. Especially in regard to assembly tools, the range of applications is not only very diverse, but also particularly extensive. The variety of available filaments and the array of material properties facilitate a tailor-made solution for each application. Any requirement profile includes factors such as strength, elasticity, temperature and material resistance, robustness and durability. So too, a specific requirement profile may require that certain areas of an assembly tool be constructed according to other characteristics. It is important, however, that a filament can be printed in sufficient quality without loss of its material properties.

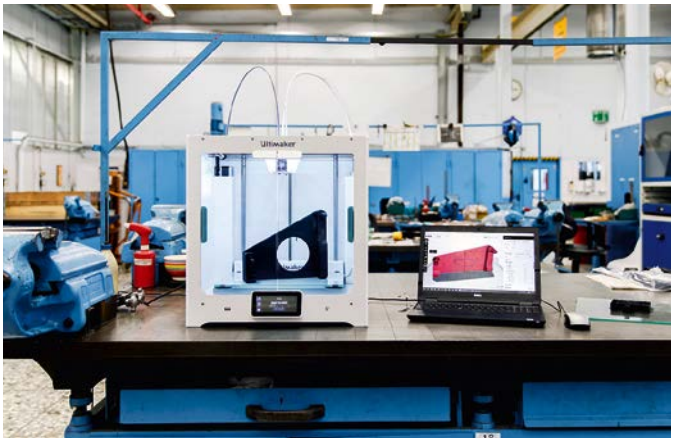

Fig. 1. Ultimaker's FDM desktop printers enable rapid in-house production of assembly support tools (© Ultimaker)

At Ford, various filaments and other materials are used in making production tools, including gauges, mounts and templates. The polymers used have specific properties that offer advantages at certain points or areas in the tool, or meet the requirements for more difficult purposes:

- Thermoplastic polyurethane (TPU) is used for assembly tools that are applied to the surface of a vehicle. This elastic and flexible material avoids damage to already painted bodies; it is also used to additively manufacturer protective covers. In addition, TPU is very durable and suitable for components that are exposed to extreme loads or wear quickly. The material is easy to work with. A heated workspace is not necessary, and the shrinkage and distortion behavior is minimal.
- PLA (polylactic acid) is a standard filament because it is versatile and uncomplicated to process. However, PLA is brittle and loses strength from about 60 °C, making its use limited primarily to models or prototypes. Ford uses the PLA technical filament (grade: Tough PLA, manufacturer: Ultivmaker B.V.) that is comparable in robustness to ABS, but easier to handle, and thus very well suited to printing large-scale technical models.
- ABS (acrylonitrile-butadiene-styrene copolymer) can be used universally as a filament for FDM processing. It is more flexible than PLA, and is characterized by better durability and temperature stability. The pressure temperature for ABS is between 210 °C and 250 °C. Hence, there is a risk that a component could warp on cooling. But ABS is excellent for tool handles or applications that require load-bearing capacity and durability.
- Polyamide (PA) filaments exhibit high resistance, strength, flexibility, low friction and high corrosion resistance. Due to its very good mechanical properties, nylon is ideal for 3D printed tools, functional prototypes and technical components. Ford's European factories use various PA filaments from well-known automotive material suppliers such DSM N.V., Heerlen, Netherlands, Clariant AG, Muttenz, Switzerland, or BASF SE, Ludwigshafen, Germany.

Function Follows Color

In addition to their material properties, variously-colored filaments can be used in order to mark entire tools or certain areas of the gauges and templates. The specifically-colored tools offer an additional visual signal, useful when several vehicle variants are assembled on the same production line. By identifying colors, the tools can be assigned to model types, special editions or a vehicle side or a certain vehicle area. When, for example, five and three door vehicles are simultaneously produced on the same assembly line, the assembly tools for one vehicle variant can be produced in red, and the gauges for another vehicle can be produced in blue. These small measures contribute significantly to a flawless process and to increased production efficiency.

The Author

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Practical Benefits

Due to the small production quantities, the production of gauges and templates for the series production of automobiles is complex, lengthy and expensive. Due to the use of FDM printers assembly tools can be produced quickly and in line with requirements. In comparison to the conventionally manufactured auxiliaries, each gauge printed by a 3D printer is around EUR 1000 cheaper, considerably lighter and available within 24 hours.

Service

References & Digital Version

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High Print Quality thanks to Optimum Materials

For material suppliers, 3D printing filaments for the FDM process are a new lucrative market. They are very interested in further expanding their long-standing relationships with the automotive industry in the field of injection molding. To meet the growing demand of their customers, about 80 material producers are currently cooperating with Ultimaker, including DSM, BASF, DuPont, Owens Corning, Mitsubishi, Henkel, Kuraray, Solvay or Clariant, to bring industrial-grade filaments to the market. To assure both uninterrupted printing and high-quality components, optimal coordination between hardware, software and material is crucial. The plastic filaments can exhibit various behaviors during processing. Criteria such as geometry, layer thickness or applied material mass affect the printing process significantly and must be precisely controlled by the software and the mechanical printer components.

Like Ford, all other customers can benefit from the collaboration between Ultimaker and the material manufacturers. If a customer chooses an application for a material whose processing profile is not yet captured by Ultimaker and available for download from the Ultimaker Cura Marketplace, he or she contacts the material supplier. Together with Ultimaker, the filament supplier creates the necessary material profiles for processing with the Ultimaker printers. The profiles are preconfigured for the Ultimaker Cura slicing software and are then available for download from the Ultimaker Cura Marketplace. This eliminates the need for other users to manually enter printing parameters, and the open filament system creates an ever expanding portfolio of engineered plastics and composites for use with Ultimaker 3D printers. In the Ford example, both Ford's original material profiles and those of Ultimaker were used; in addition, the developers had to create many Ford profiles themselves or request them in order to achieve the desired result.

Further Conceivable Fields of Application

The advantages of desktop 3D printing are many. They include comparatively-low production costs considering small batches, faster availability in the event of an unplanned need, and weigh about 70 % less than conventionally-manufactured, partially-metallic tools. Compared with external partner tool costs, the 3D printed assembly aids save about 1000 EUR per template or gauge. Instead of an average partner-related ten week delivery time, even complex fixtures are now available after ten days at the latest.

Ford uses desktop 3D printers in all its European plants. The development team in Cologne provides the design of manufacturing and assembly tools for all production sites, where they can be printed within 24 hours. In addition to assembly tools, Ford also prints protective devices, covers and placeholders for missing small parts in prototype construction. New applications for low-volume equipment or consumables are emerging almost daily, with the result that Ford is currently investigating in which other application fields the use of FDM desktop printers is economically and technically feasible. ■

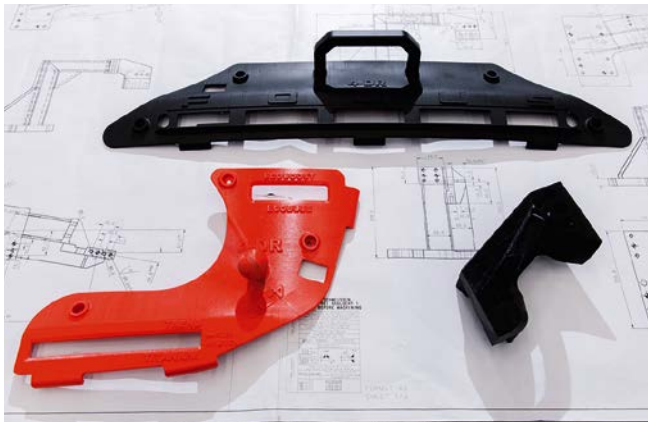

Fig. 2. Additively-produced gauges and templates are much lighter and less expensive than conventionally-manufactured tools
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