FORWARD AM
Innovating Additive Manufacturing

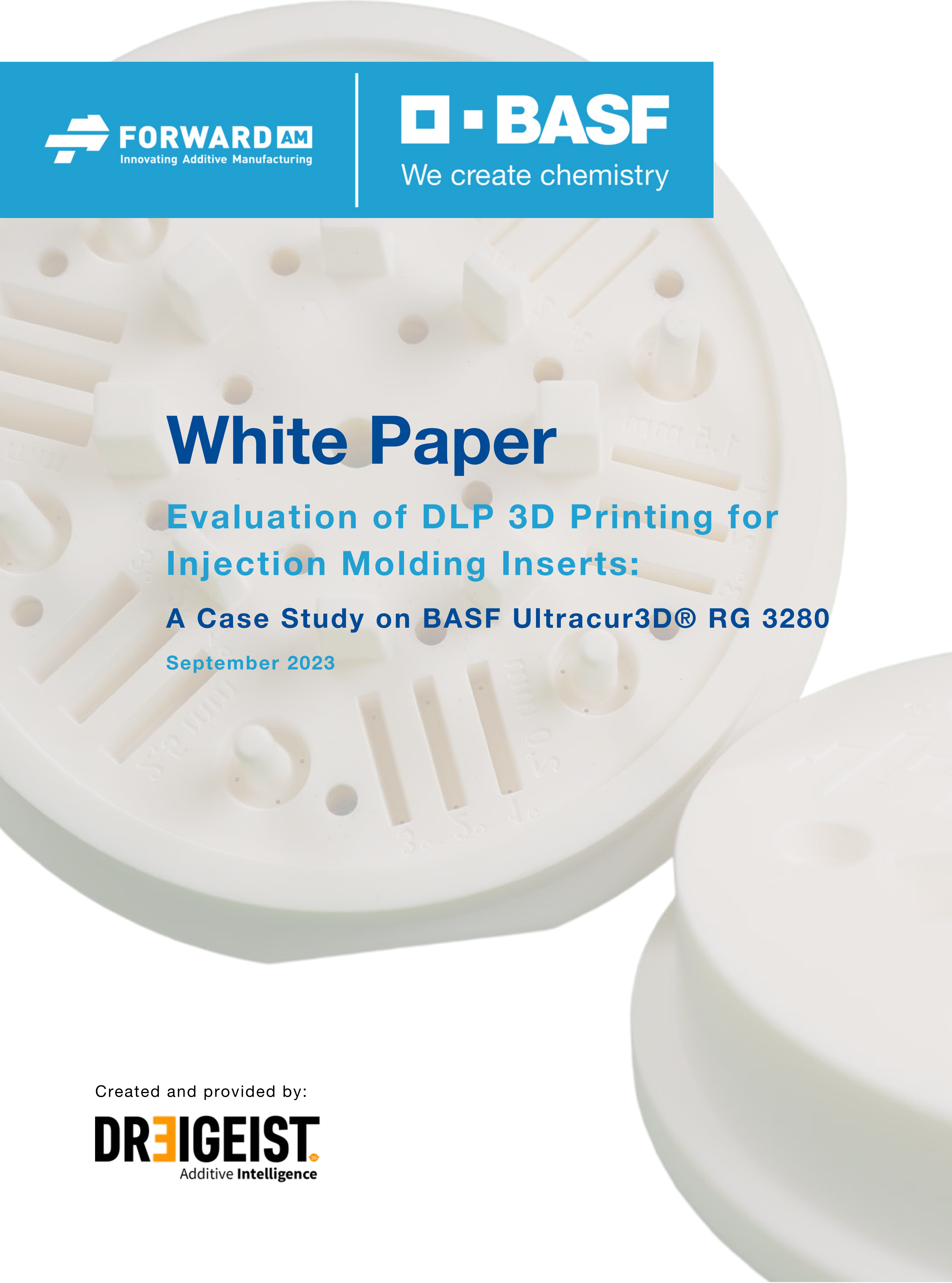
BASF
We create chemistry

White Paper

Evaluation of DLP 3D Printing for Injection Molding Inserts:

A Case Study on BASF Ultracur3D® RG 3280

September 2023



Created and provided by:

DREIGEIST
Additive Intelligence

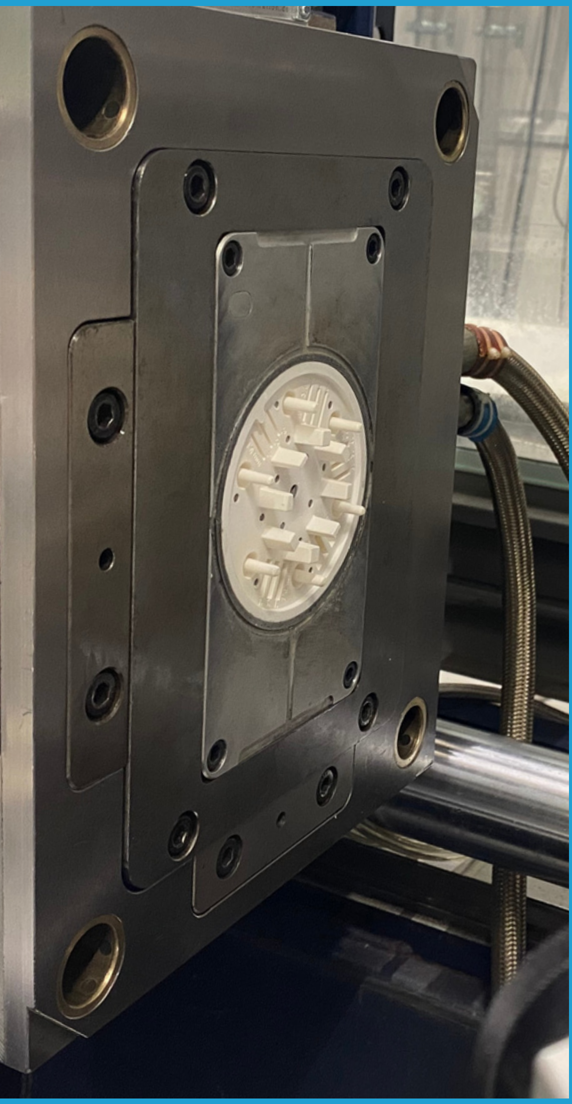
Executive summary

By merging additive manufacturing with traditional toolmaking, rapid tooling introduces groundbreaking methods to tackle today's challenges in product development and production.
Instead of acting as a replacement, it stands as a valuable extension to conventional toolmaking. Its strengths shine especially in areas like prototype creation, the validation of geometries for injection molding, and efficiently producing small batches.
By seamlessly blending the rigidity of traditional toolmaking with the adaptability of additive manufacturing, it's becoming clear just how transformative this synergy could be for the future of product innovation and manufacturing.

This extensive study delves into the **BASF Ultracur3D® RG 3280** ceramic-filled resin system, tailored for the DLP process. We particularly address the following areas:

- **DLP printing process:** What procedures must the resin undergo to meet the targeted properties and outcomes?
- **Part design:** Which design principles are pivotal to harness the full potential of the resin?
- **Compatibility with thermoplastics:** We undertook a thorough analysis of how the resin interacts with different injection molding thermoplastics to ensure seamless integration into existing production workflows. Our findings highlighted the resin's notable compatibility with technically significant granules like ABS, POM, PC, and glass-fiber-filled PP, PBT, and PA6.6 varieties. These thermoplastics each bring their unique requirements to tool design and injection molding process control. For highly polar plastics such as PBT, we're deeply examining various release agents. Among them, silicone oil has emerged as the most promising candidate.

Table of contents



3D printed tool insert
Image © DREIGEIST

Foreword

Leveraging 3D printing in injection molding: unlocking new possibilities

Introduction to the industry's challenges

The injection molding sector faces a myriad of intricate challenges. These encompass cost and time constraints, a scarcity of adept professionals, escalating utilities costs, a dip in raw material production within the EU, mounting procurement risks, and a burgeoning demand for digitalization.[1]

3D printing is steadily gaining traction as a potential supplement to conventional manufacturing processes. With its inherent promise in flexibility, efficiency, and appeal to the younger skilled workforce, it holds the potential to alleviate some of these pressing challenges.

3D printing as an augmentation to injection molding technology

Given these considerations, the pertinent question arises: How can 3D printing be specifically employed to complement conventional injection molding techniques?

Notably, when it comes to producing injection molding inserts, this technology demonstrates substantial potential.

The advantages are multifaceted, encompassing rapid prototyping, the diminution of tooling expenses, and the feasibility of executing limited production runs where the time factor is pivotal.

Additionally, 3D printing champions sustainability due to its prowess in material and energy efficiency, alongside a reduction in transportation efforts and manufacturing waste.[2]

Technological adoption and advancement

Integrating 3D printing unveils fresh avenues, catering to enterprises eager to amalgamate innovation with tradition. This technology not only fosters enhanced production agility, hastened innovation trajectories, and tailored solution efficiencies but also presents a strategic response to contemporary industrial quandaries, such as expertise deficits and sustainability imperatives.

Objective of the White Paper

Within this White Paper, we delve into the capabilities of 3D printing using the material BASF Ultracur3D® RG 3280 within the realm of injection molding technology.

Our exploration is centered on structured test sequences, examining the performance boundaries of injection molding inserts.

This technical examination illuminates not just the material's functionality but also provides pragmatic perspectives on its application's potential and constraints.

Partners & roles

DREIGEIST Additive Intelligence

Dreigeist, headquartered in Nuremberg, Germany, stands at the forefront of **application development for additive manufacturing using photopolymers**. The firm is adept at harnessing the benefits of 3D printing to foster sustainable and streamlined industrial production processes. In this case study, Dreigeist took the helm not only in the creation of the 3D-printed injection molding inserts but also in project management. Their profound expertise facilitated a consistent manufacturing procedure, ensuring the material was utilized to its utmost potential.

SKZ – German Plastics Center

Established in 1961, the **SKZ - German Plastics Center** has consistently been a prominent provider for research, education, product testing, and process evaluation within the plastics industry. Renowned for their expertise in injection molding, SKZ conducted the injection molding experiments at their Model Factory's technical center. Utilizing the "Stonehenge" geometry, a design innovation of SKZ, they thoroughly assessed the practical potential and constraints of BASF Ultracur3D® RG 3280 in injection molding applications. SKZ's decades of industry experience rendered them an invaluable collaborator for this case study.

BASF Forward AM

BASF Forward AM has addressed a notable market void with the launch of BASF Ultracur3D® RG 3280, a material tailor-made for the DLP process, establishing its position in the domain of 3D-printed injection molding inserts.
BASF Ultracur3D® RG 3280 presents an economically viable and readily available alternative for injection mold tooling, exemplifying the capabilities of the DLP process for such applications.

1

3D printed injection molding inserts

Insights into materials, technology and process control

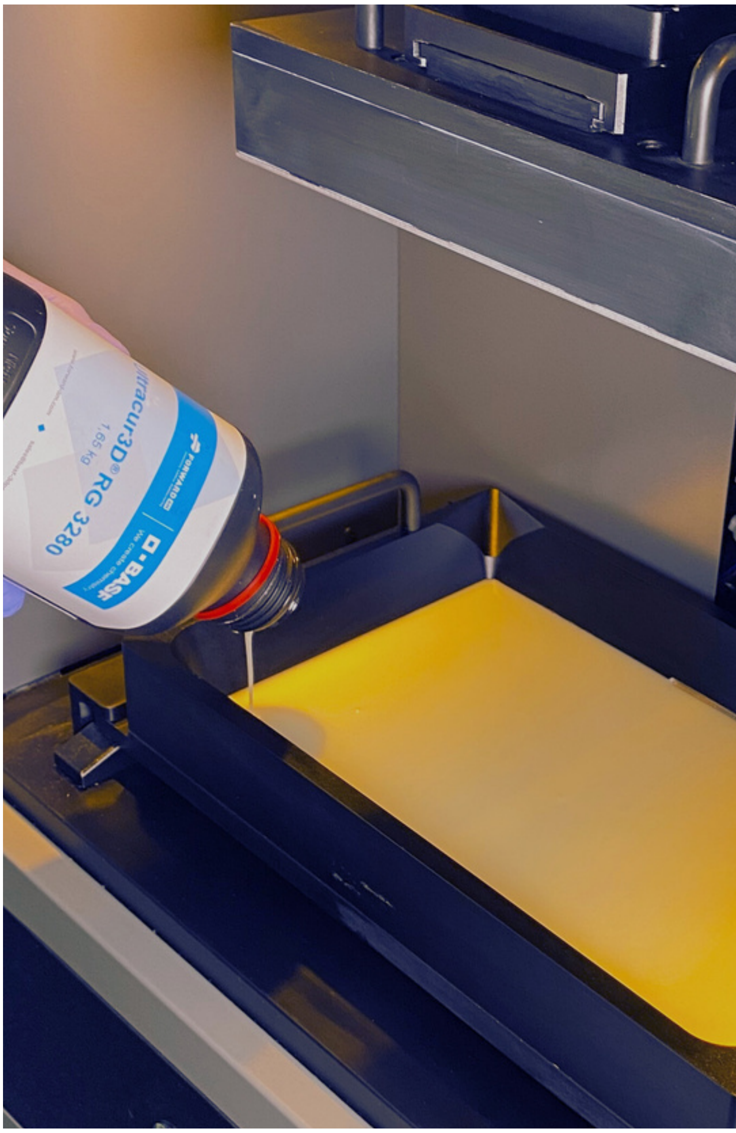
What distinguishes 3D printing with photopolymers from other methods? Which criteria are essential when selecting 3D printing materials for tool inserts? How does one meticulously follow the steps throughout the process chain from design to post-curing?
Explore this chapter for a comprehensive understanding.

DLP Technology: Precision, Efficiency and Sustainability

The DLP (Digital Light Processing) process has secured a prominent position within the diverse array of additive manufacturing technologies. Utilizing the curing of UV-sensitive resin in sequential layers via precise light irradiation, DLP facilitates the fabrication of components with exceptional detail and accuracy.

One salient feature of DLP is its ability to cure entire layers simultaneously, optimizing production efficiency. The deliberate application of resin ensures minimal material usage, augmenting the sustainability of the procedure. The adaptability of DLP is further exemplified by its compatibility with various materials, notably the specialized **BASF Ultracur3D® RG 3280**.

From a manufacturing perspective, the DLP process stands out as a nimble, economical, and resource-efficient approach, bringing to the forefront innovative prospects in terms of design, agility, cost-effectiveness, and ecological responsibility.



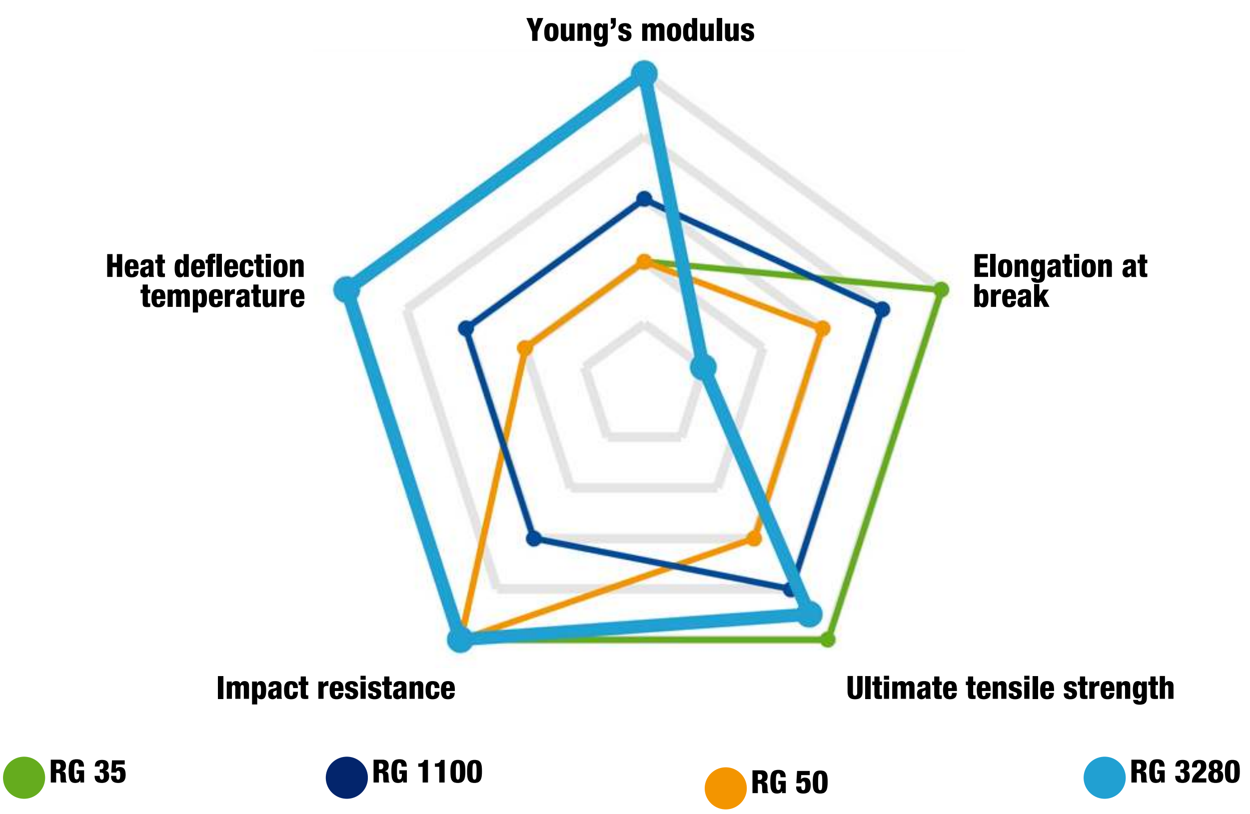
UV resin is filled into the material vat of a DLP 3D printer.
Image © DREIGEIST

Material selection: BASF Ultracur3D® RG 3280

BASF Ultracur3D® RG 3280 is a ceramic-filled resin with a Young's modulus of around 10 GPa and a heat deflection temperature of over 280 °C.
These technical properties allow the material to withstand the rigorous conditions encountered in injection molding.
Therefore, BASF Ultracur3D® RG 3280 is well-suited for the production of 3D-printed injection molding inserts.

In addition, the low viscosity and high suspension stability facilitate the 3D printing process.

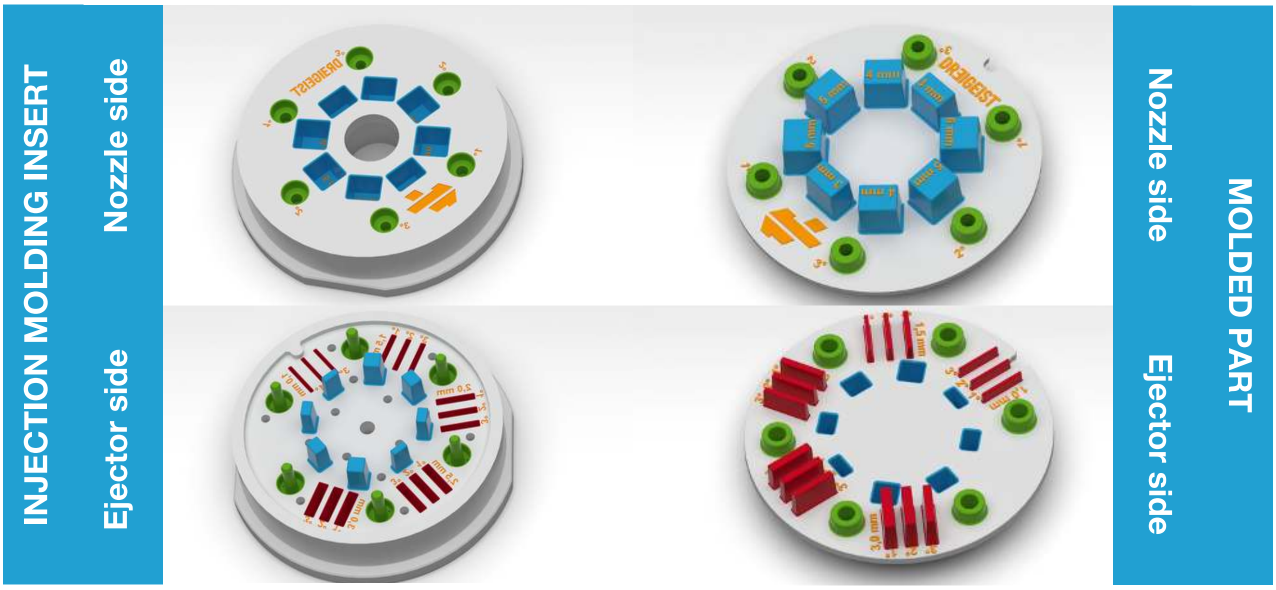
Overall, BASF Ultracur3D® RG 3280 offers an optimal combination of mechanical properties that make it an excellent choice for the production of injection molding inserts.
It meets the specific requirements of injection molding technology regarding precision, efficiency and costs.



The characteristic values of the BASF Ultracur3D® RG family in direct comparison. Image © DREIGEIST

The tool geometry for sampling: "Stonehenge"

Sampling in injection molding is fundamental to ensuring economical production. During this phase, weaknesses are identified and rectified early when a mold is commissioned. Additionally, the **injection molding process parameters** are determined, and the desired component properties are verified. This process holds equal importance for 3D-printed injection molding inserts. Given their design flexibility, it's advantageous to evaluate their printability and material pairings beforehand, especially with complex geometric elements. To aid this purpose, starting in 2017, SKZ introduced the "**Stonehenge**" geometry. This design has been continuously refined in collaboration with DREIGEIST, and its quality characteristics are outlined below.



CAD images of the Stonehenge tool (left) and the associated molded component (right) with geometric features highlighted in color. Image © DREIGEIST

Cores → Cubes

In the process, the thermoplastic melt flows around rectangular cores. These cores serve to assess demoldability and to produce hollow cubes with varying wall thicknesses. Should the resin's strength be insufficient or the melt's flow behavior be unsuitable, the cores can break during cavity filling.

Pins → Domes

The pins, designed with draft angles of 1° to 3°, serve as touchpoints for producing domes and for investigating part design variations based on different resins and thermoplastics. Owing to their small cross-section, the pins are the most delicate elements of the tools. They are flowed around by the melt on one side. A quality feature to look for in the molded part is a burr-free upper edge on the domes.

Grooves → Thin walls

The grooves in the tool create a thin-walled structure in the molded component, varying in heights, widths, and draft angles, including venting considerations. A breakout of the walls between the indentations indicates material failure in the tool.

Labels

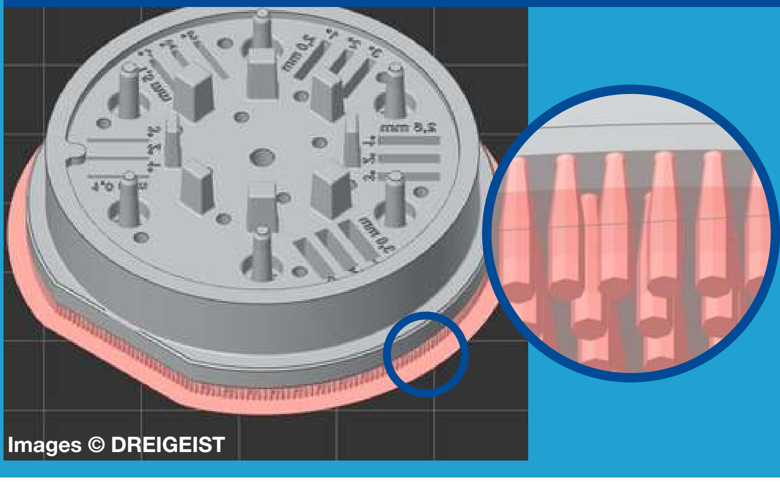
The recessed fonts in the tools offer insights into the basic resolution of the 3D printing material and machine. If there's heat-induced material fatigue on the tool surface or excessive adhesion between the resin and thermoplastic, it can lead to breakage of the detailed recessed fonts.

Best practices in the DLP process chain

Pre-processing

A proper orientation of the 3d printing build will minimize the **3d printing staircase effect**. However, depending on the geometry of the injection-molded part, **rotating** along the x-or y-axis might be beneficial **to prevent suction and subsequent warping** between the cavity and the resin. In this study, support structures are employed to ensure adequate ventilation of the drill holes.

The most relevant support parameters in this study:


Images © DREIGEIST

- 4 mm support height
- 1,0 mm support width
- 1,2 mm support distance along the contours
- 1,6 mm support distance within the part

Material preparation

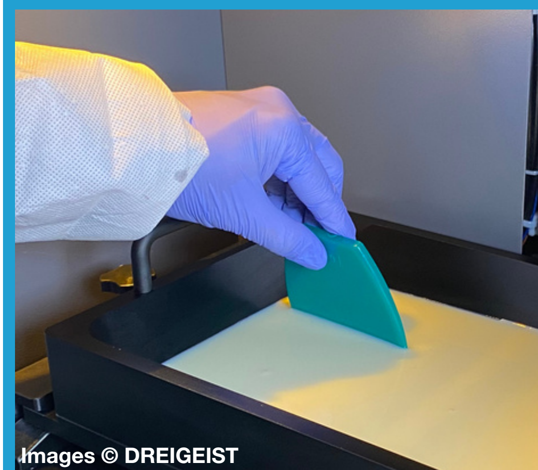
To achieve the most uniform mixing of the suspension, roll the unopened bottle on a **bottle roller for at least 2 hours.**

Immediately before printing, slowly pour the resin into the vat. If there are any air bubbles, they can be removed using a silicone scraper. However, take care not to scratch the film lining the inside of the vat.

Slow filling of new material:

Image © DREIGEIST

Carefully removing air bubbles:

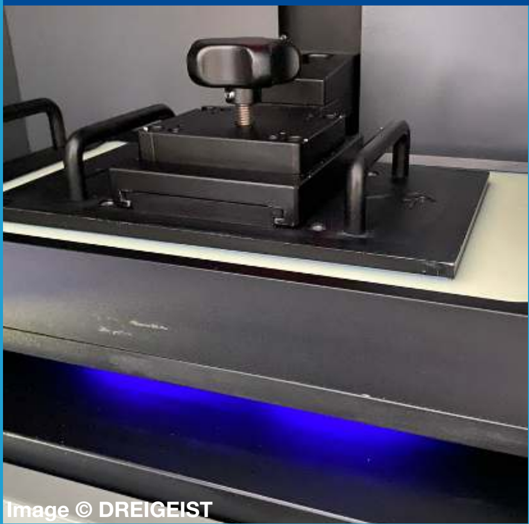

Images © DREIGEIST

DLP process parameters

In this study, a **light intensity of 1.25 mW/cm²** achieves the mechanical properties necessary for injection molding applications.

Different exposure strategies can be beneficial for the support, infill, and contour. During printing, it's essential for the support to be especially stable, while the contours should exhibit a high level of detail.

The most relevant DLP process parameters in this study:



- **Energy setting:** 1.25 mW/cm²
- **Exposure times:**
  - Support: 3.3 s
  - Infill: 2.6 s
  - Contour: 2.3 s
- **"Burn-in" in the first 3 layers:**
  - Layer 1: Exposure time x 3.5
  - Layer 2: Exposure time x 2.5
  - Layer 3: Exposure time x 1.5

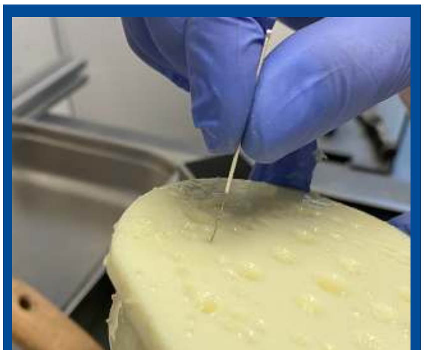
Post-processing: Support removal and pre-cleaning

Use a spatula to separate the tool halves from the support while they remain attached to the platform. **Caution:** Handle the inserts with care, as the unfired (green) parts are fragile and can be easily damaged. Afterward, use compressed air and tools like pipe cleaners to remove as much residual resin as possible.

During cleaning, it's crucial to act swiftly, as the material remains reactive and will continue to cure upon exposure to daylight.

Detaching the part


Using compressed air


Pre-cleaning holes

Post-processing: Washing

The remaining resin residues are washed off in an **isopropyl alcohol (IPA) bath (duration: < 1.5 minutes!).**
This is followed by drying with compressed air.

Speed is important when washing, as media such as IPA are believed to damage the material. IPA penetrating the component can cause micro-cracks that affect the mechanical properties of the part.

The impact of washing time using isopropyl alcohol is evident when comparing molded components A and B. Their respective tools were cleaned for **1.5 minutes for A and 5 minutes for B.** Both A and B represent the first cycle of their corresponding tools. Despite having identical process parameters, in component B, the stable cores broke off and remained embedded in the part.

Molded part A, the intact tool had 1.5 minutes of IPA contact

Molded part B, the broken tool had 5 minutes of IPA contact

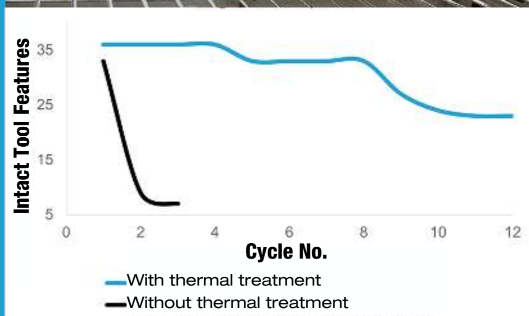
Images © DREIGEIST

Post-processing: Post-curing with UV light and temperature

For optimal mechanical and thermal properties of the resin, post-crosslinking is performed using **UV light and heat.** The subsequent diagram underscores the significance of this thermal treatment: tools that forgo this additional step fail in injection molding after only a few cycles.

UV:
125 mW/cm², 2 x 22 Minutes

Thermal: 150 °C; ramp-up 2 h, hold 3 h, ramp-down 2 h



Images © DREIGEIST

Quality assurance and final scaling

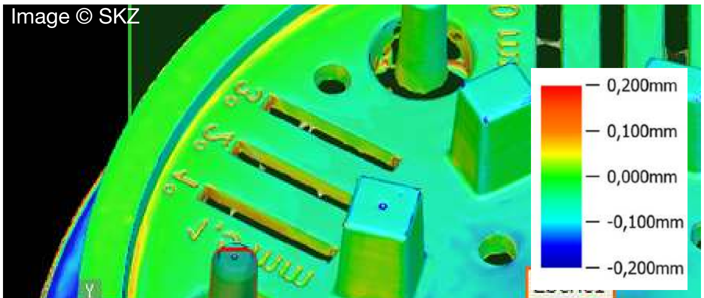
The best practices mentioned earlier ensure not only the stability of the tools but also their precise fit.
Without this dimensional accuracy, tools might be damaged upon assembly in the injection molding setup at worst.
One method to determine accuracy is through **optical scanning** with a 3D coordinate measuring machine, comparing the measured data with the CAD file.

The procedure outlined here achieves minimal deviations starting at:

- 0.02 millimeters (x/y plane)
- 0.05 millimeter (z plane)

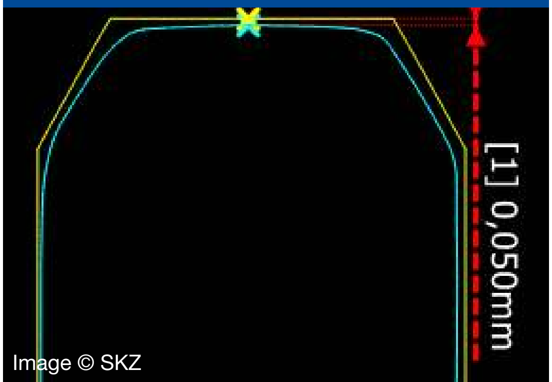
Don't! A worst practice example.

Due to significant deviations, the tool halves do not fit.



Comparison of tool and CAD file via surface topography

Do! Minimal deviations do not disturb the process.



Profile comparison (2D) of a pin in a tool (turquoise) and its .stl (yellow)

Beyond final quality assurance, a 3D scan can also assist in scaling the 3D printer based on system and component specifications.

"The performance of 3D printed tools depends on several factors: First, high intensities and temperatures in post-curing to enhance mechanical properties.
Second, customized exposure strategies within the layers to ensure detail accuracy, combined with adherence to a strict process routine to ensure tool quality and integrity."

Christopher König, CTO, DREIGEIST

2

Injection molding

Prerequisites, implementation and evaluation

Navigating additive manufacturing for injection molding: tool preparation and thermoplastic considerations. Delve into this chapter to understand the nuances of tool preparation and how to adaptively process diverse thermoplastics.

The injection molding checklist

Drying

As per material supplier recommended conditions

Machine

There are two basic requirements regarding the injection molding system for simple geometries :

- The desired mold size must fit.
- The shot weight must be suitable.

Mold Base

The 3D printed tool is inserted into a mold base.

Mold Cooling

With compressed air

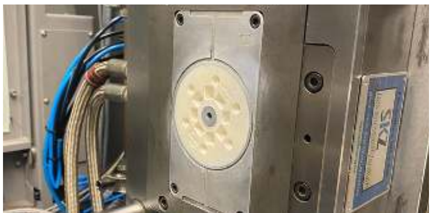
Thermography (infra-red)

When dealing with molds made from plastics, temperature management is paramount. Connecting a thermal camera is advisable in order to continuously monitor demolding temperatures, cooling times etc. Mold insert temperature measured when mold is open.

Machining of the mold insert build surface

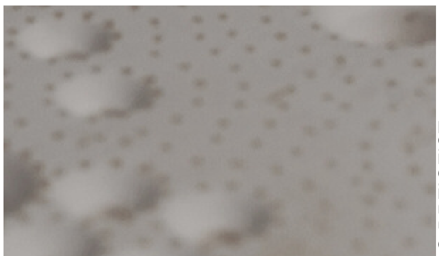
Utilizing 3d printing supports can result in unevenness, disrupting the flat contact of the tools within the master mold. To address this, an allowance is incorporated into the design, which can be precisely eliminated through processes like turning. Even a slight protrusion of just a tenth of a millimeter risks breakage upon closing the tool due to the material's limited flexibility.

Installing the tools



Insert in master mold

Process monitoring



Support artifacts

Preparation of the tools

The influence of release agents

Release agents facilitate the demolding of thermoplastics by preventing adhesion to the mold, especially under prolonged temperature and pressure loads.
Four specific release agent types are considered in this study:

Silicone oil	Silicone-free (general)	Silicone-free (PC, PMMA, ABS)	Teflon

The analysis shows that release agents contribute to smoother component surfaces and also significantly increase the service life of the tools.

Surface of part from cycle 1 (dry tool)

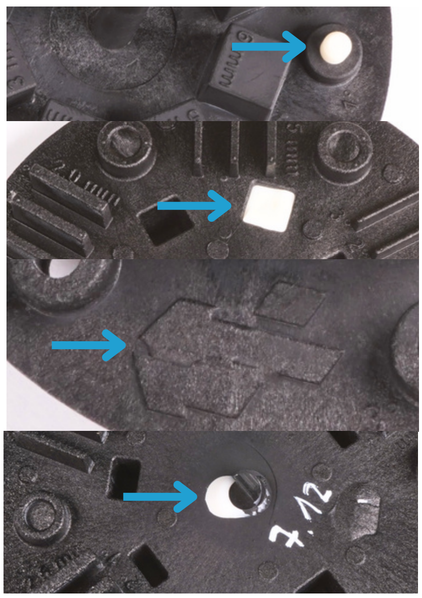
Surface of part from cycle 1 (tool with silicone oil)

Images © DREIGEIST

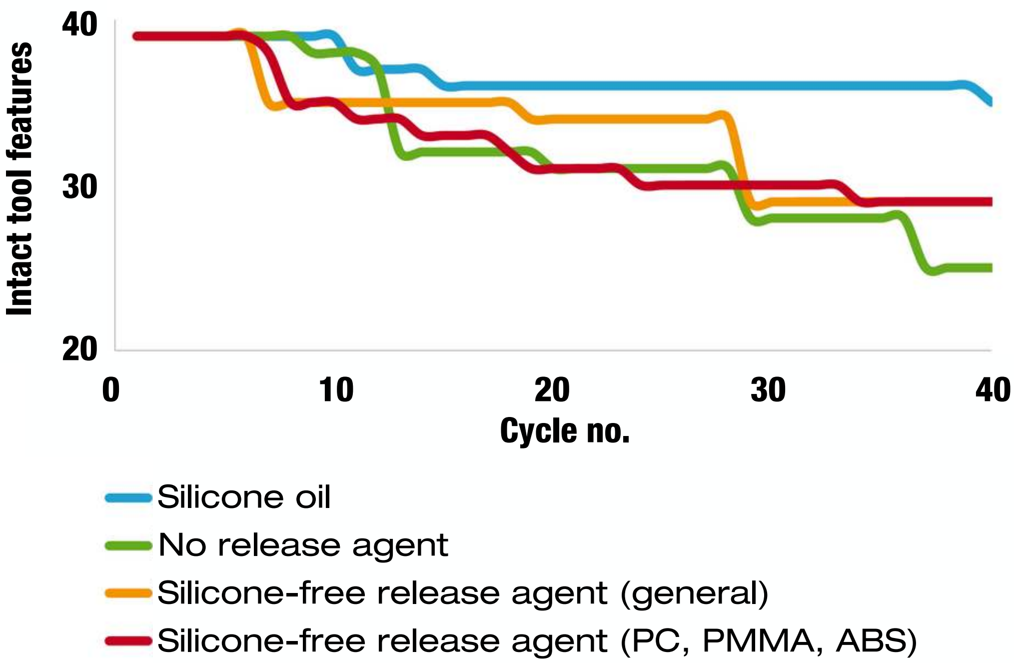
As illustrated above, omitting release agents in the injection molding process can result in rough surfaces on parts due to mild adhesion between the mold and the component. If this adhesion is more pronounced, critical features like pins or cores may extensively break off.

The evaluation of the effectiveness of the investigated release agents for the injection molding of glass-filled polybutylene terephthalate (PBT) was performed by analyzing the resistance of tool features over continuous cycles. The **feature count (maximum value: 39)** changes due to the breaking of individual components, which are weighted differently:

- **6 Pins** (top right): very sensitive, weighting factor 1
- **8 Cores** (second from top): less sensitive, factor 3
- **Labels and walls between grooves** (second from bottom): counted only once each, factor 2
- **Surrounding surface** (bottom): Chipping indicates failure of the tool, factor 2



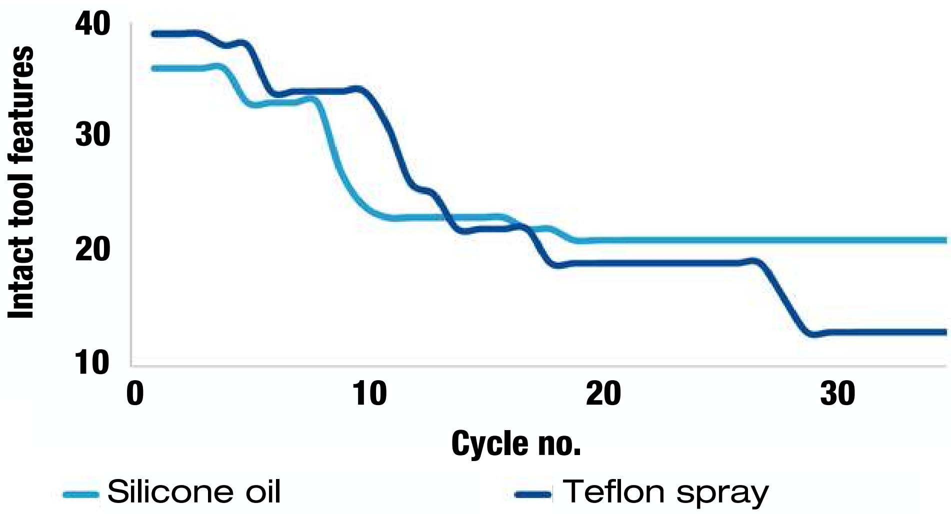
Images © DREIGEIST



Direct comparison of the release agents for processing PBT GF30. Image © DREIGEIST

The combination of silicone oil with BASF Ultracur3D® RG 3280 and PBT GF30 proves especially efficient for demolding.

In comparison, the glass fiber-filled PA6.6 is more challenging to process and tends to damage delicate insert elements more rapidly. When examining PA6.6 GF25, both silicone oil and Teflon spray are compared for their demolding effectiveness. Even in this context, silicone oil tends to be the preferred choice, particularly for increasing cycle numbers.



Direct comparison of the release agents silicone oil and Teflon spray for processing PA6.6 GF25. Image © DREIGEIST

In the tests conducted, the demolding behavior of BASF Ultracur3D® RG 3280, when combined with six different thermoplastics (detailed on the next page), reveals the following trends for various release agents (RA):

Silicone oil	Silicone-free general RA	Silicone-free RA for PC, PMMA, ABS	Teflon
Very suitable	Suitable	Less suitable	Less suitable
Provides the best demolding, shows the most stable process	Effect wears off earlier compared to silicone	Remains as a dusty film on the component surface	Is intended for metal pairings

Silicone oil achieves the best demolding results.

However, if downstream processing of the components like pad printing, is planned, residual silicone can hinder these processes. In such scenarios, silicone-free alternatives are recommended. When processing PBT GF30, the silicone-free general release agent shows promising outcomes.

For this specific case it was helpful to regularly apply the release agent during the injection molding process. Depending on the thermoplastic and release agent used, reapplication is recommended approximately after every 5th to 15th cycle. Chemical resistance of the polymer being injection molded should also be considered.

The classification of release agents presented here should be viewed as a general trend. For a conclusive determination of the interactions between tool material, release agent, and thermoplastic more in-depth investigations are required.

"Typically, release agents are seldom use in injection molding. However, when it comes to 3D printed tools, they could become the norm. Additively manufactured mold inserts made of photopolymers don't replace conventional molds but rather complement them: they offer unparalleled potential for swiftly bringing component variants and their iterations to life. Yet, they have their unique set of rules and necessitate a different approach than what we're accustomed to."*

Christian Deubel, Senior Engineer & Industry Coordinator Injection Molding, SKZ

*and often not allowed

The injection molding process

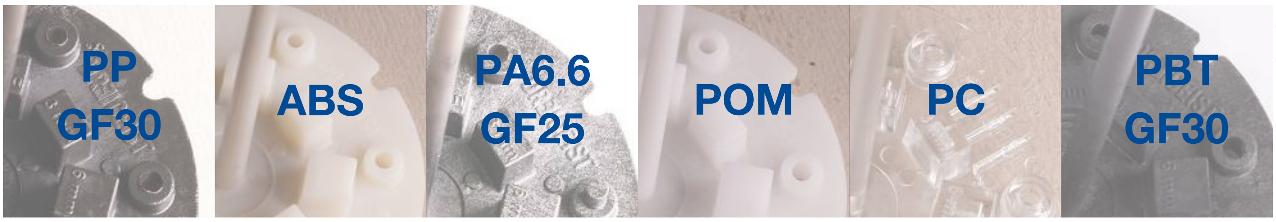
Finding the parameters

The key to successful injection molding with additively manufactured tools lies in a careful and step-by-step approach.

- **Pre-Drying temperature and time**: as per recommendations for the thermoplastic being molded.
- **Plastic melt temperature:** Start with the lower limit of the temperature range specified for the nozzle in the thermoplastic's technical data sheet.
- **Clamping force:** When using printed tools for closing, introduce them slowly to the force. Initially, close without applying any pressure, then gradually increase in increments of 50 kN.
- **Pressure/filling:** Before reaching the dosage volume, ensure the initial shots are significantly underfilled and without holding pressure. Later on, the low thermal conductivity of the tools and extended cycle times will allow the use of a decreasing holding pressure profile.
- **Cooling:** Due to their reduced thermal conductivity, these tools need extra cooling. This can be achieved by directing compressed air onto the opened tool between cycles.
- **Residence time:** The extended cycle times mean the melt will stay in place longer. Sensitive materials should be flushed out regularly, approximately every 10 to 20 cycles.

The thermoplastics

In this study, tools made from BASF Ultracur3D® RG 3280 were utilized in the injection molding of the following thermoplastics:



Images © DREIGEIST

	Plastic melt temperature in °C	Tool temperature in °C	Clamping force* in kN	Injection pressure in Bar	Holding pressure** in Bar	Cycle time in s
PP GF30	220	30	300	530	120 / 190	138
ABS	230	30	300	600	130 / 200	160
PA6.6 GF25	290	90	300	670	70 / 130	90
POM	190	60	300	920	120 / 200	110
PC	290	60	300	830	130 / 200	169
PBT GF30	250	80	250	840	90 / 190	100

*The magnitude of the clamping force is influenced by the chosen closing method. In this case, the clamping is done directly via the printed insert, demanding careful consideration. Depending on the specific design, clamping might also be conducted through the mold base, which can enable the application of greater forces.
**Holding pressure in a decreasing profile, starting with the higher value.

Evaluation of the investigations

The relevance of the number of shots for 3D printed mold inserts

The number of shots and the associated service life, i.e. the duration for which an injection mold remains effectively in use, are central factors in the injection molding industry. Together, they determine the lifespan and cost-effectiveness of a mold.

3D printing as a technology offers particular opportunities in this context. Despite some industries being sceptical, 3D printing allows for rapid iterations, complex geometries, and personalized production without requiring extremely high numbers of shots.

Our testing focuses on investigating the compatibility of 3D printed injection molding inserts with various materials, rather than maximizing cycle numbers. Nevertheless, the observed conditions of the molds provide an estimate of the possible shot numbers. For exact data, additional endurance tests are necessary.

The study is primarily intended to highlight the technical possibilities and limitations of 3D printing in the production of injection molding inserts and not to serve as a substitute for traditional methods with high shot counts.

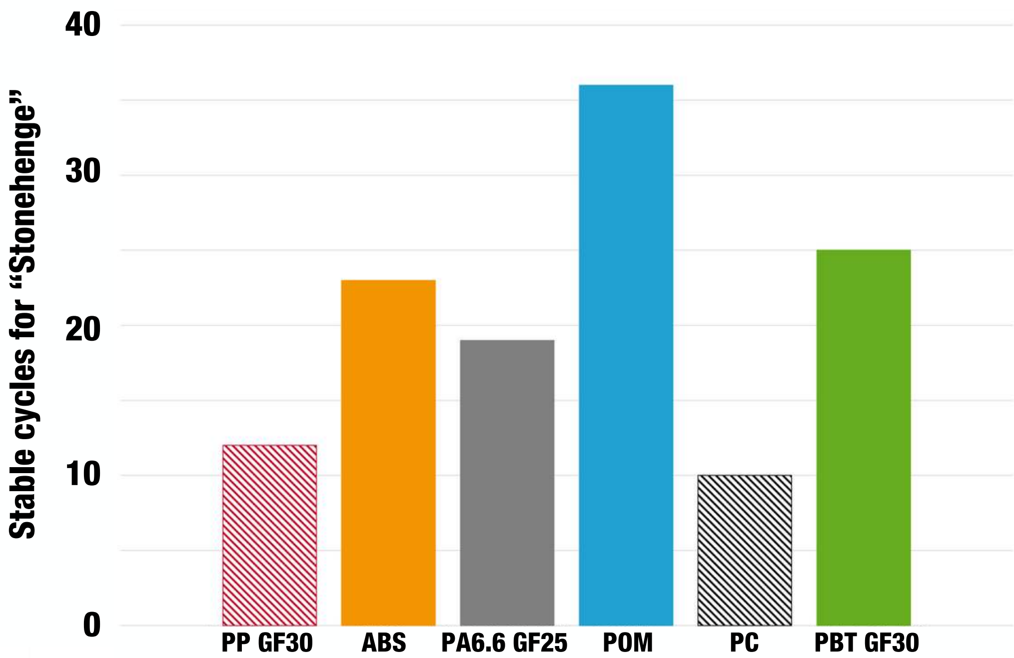
Shot 1 (top, start up, incomplete fill), and shot 37 (POM). Images © DREIGEIST

The shot count is indeed a factor in assessing 3D printed injection molding inserts, but it isn't the only criterion. 3D printing's agility and swiftness enable efficient mold development and adaptation, making the shot count just one of several factors to consider based on the application's context and specific needs.

Notably, the tool material's resilience to damage stands out.

The processability of different thermoplastics

Different thermoplastics are differently demanding in processing and damage the inserts or their geometry-related weak points to different degrees. In the following, with selected injection molding materials, the number of shots is determined over which the process is stable, i.e. the number of the Stonehenge features does not change for values ≥ 25.



The number of stable cycles for various technically relevant thermoplastics. Image © DREIGEIST

The total number of cycles performed was between 35 and 60 for all thermoplastics, except for PC and PP GF30. These were only investigated to some extent and are therefore not representative. It can be seen from the figure above that the POM is molded easily with the RG 3280 insert. In contrast, PBT GF30, ABS and finally PA6.6 GF25 are more challenging to process.

In summary, the selected plastics can be classified as follows with regard to their mold ability when using RG 3280:

	PP GF30	ABS	PA6.6 GF25	POM	PC	PBT GF30
Difficulty level (1 = rather easy; 5 = rather difficult)	Tends to be lower	3	4	2	Tends to be higher	3

CONCLUSION: All the thermoplastics analyzed can be injection molded with BASF Ultracur3D® RG 3280, with varying demands on design and process management!

Time & costs: 3D printing

Suppose an injection molding service provider is considering venturing into 3D printing to offer in-house manufactured tools. How much would it cost to produce such a tool?

Considerations:

- An injection molding machine equipped with an appropriate mold base.
- 3D printer, UV curing station, and oven. The associated machine costs consider a service life of 3 years with a single-shift operation. This includes maintenance, calculated interest, footprint, and electricity expenses.

"Stonehenge" production	3D printer	UV station	Oven
Machine run time / h	1.5	0.75	6
Material consumption RG 3280 / g	500		

For this case production costs for making the core and cavity insert were approx. 120 euros*

*plus personnel and operating material costs

Use case: Bumper for RC cars

Bumpers made from PA (black) and PP GF30 (orange) on the left; the associated two-cavity mold (right). Images © DREIGEIST

Sampling guides the design of a mold insert tailored to a specific resin-thermoplastic combination. From the results, one can determine aspects such as:

- Appropriate draft angles.
- Required wall thicknesses.
- The delicacy permissible for elements within the cavity.

An exemplary demonstration of the durability of components crafted with 3D printed molds is the bumper for remote-controlled (RC) cars. This use case vividly showcases the potential and opportunities that arise from merging injection molding and 3D printing technologies.

On the left are bumpers crafted from PA (black) and PP GF30 (orange); on the right is the corresponding two-cavity mold.[3]

Future prospects and conclusions

Rapid tooling: advantages and challenges

Implementing 3D printing within an injection molding setting allows for rapid iteration, facilitates customized production, and can lead to potential cost savings. Such benefits are particularly pronounced in prototyping and small-scale production.

- **Process chain in 3D printing:** The DLP process stands out for its exceptional precision and keen attention to detail. Ensuring the quality of a 3D printed tool requires steadfast commitment to the complete process chain from initial design through post-processing. Though there might be an initial training phase and learning curve, meticulous application and adherence to best practices can yield outstanding results.

- **Production cycles:** Using 3D-printed injection molds is especially beneficial for prototype development, small runs, and unique applications where high shot counts aren't necessary.

- **Flexibility and iteration:** Rapid tool changes and iterative design not only boost the efficiency of the production process but also help reduce overproduction and resource wastage.

- **Transport and logistics:** Being able to 3D print necessary parts and tools on-site or near the point of use can curtail transportation costs and related emissions.

- **Lower production costs:** Typically, 3D-printed tools are more cost-effective than their traditional counterparts, making them a financially savvy choice in the right situations.

- **Specific customer requirements:** For businesses that grapple with unique client demands or intricate designs, 3D-printed injection molding inserts provide an added avenue to meet market demands.

For whom is rapid tooling beneficial, and what challenges need to be addressed?

For companies with in-house injection molding capabilities, as well as forward-thinking injection molding firms, rapid tooling presents significant potential. Adopting this technology demands a strategic mindset, necessitating investments in both hardware and training—particularly when transitioning from steel molds to photopolymer molds.
However, such challenges shouldn't be viewed as mere impediments. Instead, they should be seen as essential stepping stones towards the adoption of a groundbreaking technology that can future-proof a business.

By embracing these challenges and planning deliberately, businesses can not only surmount initial barriers but also seize key competitive advantages. Rapid tooling epitomizes efficiency, adaptability, and sustainable production. It's a strategic investment that promises enduring rewards, equipping companies to dynamically respond to evolving market demands.

3D printing of injection molds is poised to revolutionize contemporary manufacturing, particularly when the demands of flexibility, speed, and technical nimbleness come into play. By weaving strategic integration with purposeful investment in rapid tooling, businesses stand not just to bolster their sustainability credentials but to truly drive the industry's forward momentum. It's an exhilarating vista, beckoning those with the foresight to seize the latent opportunities and embrace challenges as stepping stones towards innovation.

Contributors

Christopher König
CTO @ DREIGEIST

Mareike König
CEO @ DREIGEIST

Anne Richter
Technical Marketing Communications Manager @ DREIGEIST

Endnotes

Citation - Please cite this White Paper as: König, M., König, Ch., Richter, A. (2023). *Evaluation of DLP 3D Printing for Injection Molding Inserts: A Case Study on BASF Ultracur3D® RG 3280. BASF Forward AM.*

1 Brinkdöpke, Sascha. (2019). *Herausforderungen der Kunststoffindustrie*

2 Fastermann, Petra. (2016). *Nachhaltigkeit – 3D-Druck als umweltfreundliche Technologie?.* 10.1007/978-3-662-49866-8_15.

3 Wevolver. Miley, Jessica. (2023). *Additive Manufacturing Delivers Durable Mold Parts for Quick Tool Production*. https://www.wevolver.com/article/additive-manufacturing-delivers-durable-mold-parts-for-quick-tool-production

Contact

BASF 3D Printing Solutions GmbH

Speyerer Straße 4, 69115 Heidelberg
Germany
Website: www.forward-am.com
Email: sales@basf-3dps.com

DREIGEIST Additive Intelligence oHG

Nordostpark 89, 90411 Nürnberg
Germany
Website: www.dreigeist.com
Email: info@dreigeist.com

SKZ - KFE gGmbH

Friedrich-Bergius-Ring 22, 97076 Würzburg
Germany
Website: www.skz.de
Email: info@skz.de