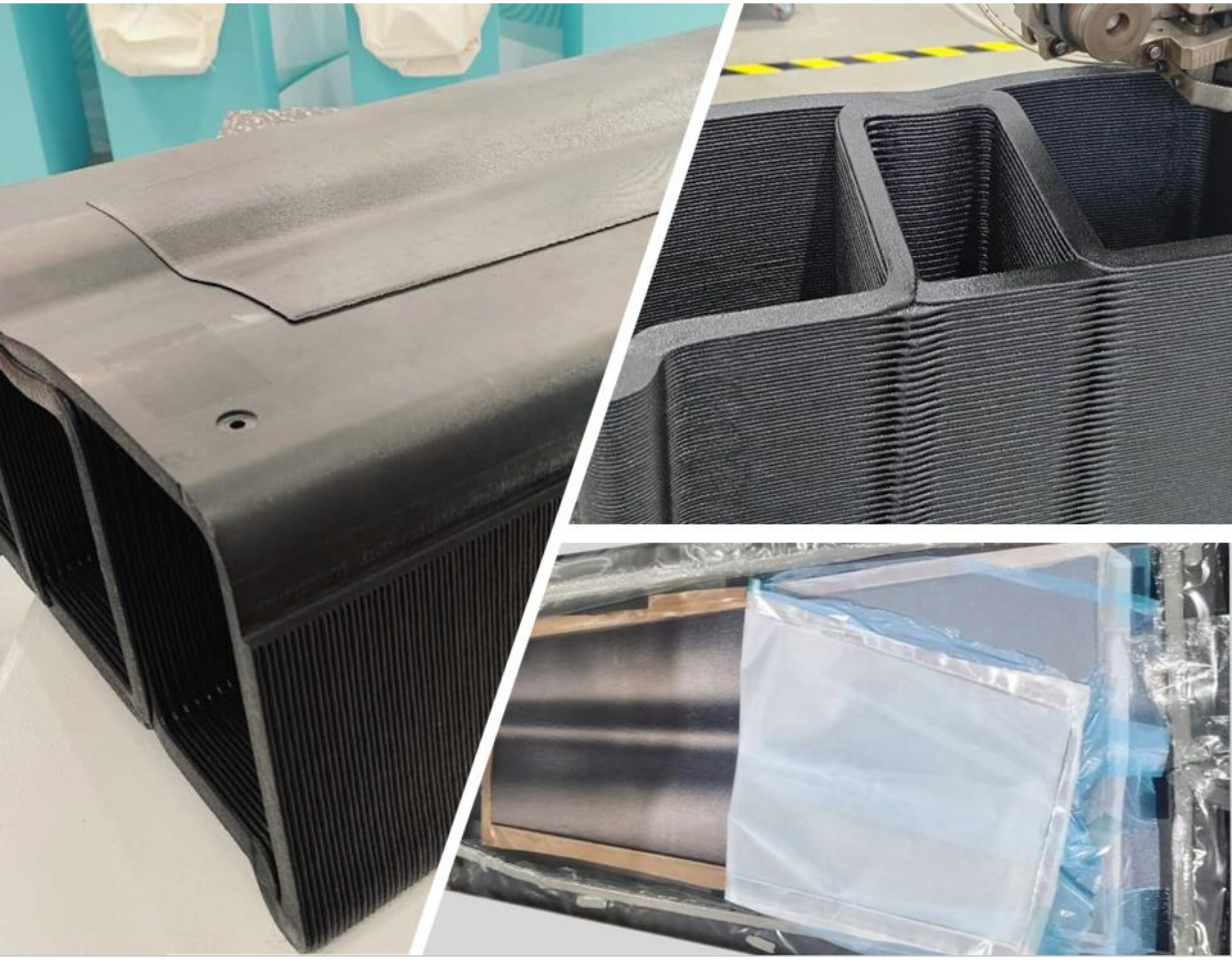
Utilizing PolyCore™ PC-7413 for Medium-Temperature Composite Mold Manufacturing



Application Overview

Medium-temperature composite molds are vital for producing high-quality composite parts, particularly in the aerospace and automotive industries. It's important to note that composite molds can be used with various curing methods, including hot press molding, resin transfer molding, and autoclave molding. In this case, the curing method used was autoclave molding, which is most employed in aerospace. These molds typically operate within a temperature range of 80 °C to 120 °C, enduring intense pressure and heat during the curing process. However, traditional mold manufacturing methods still face challenges such as high costs, long lead times, and difficulty accommodating frequent design modifications.

By using Fused Granule Fabrication (FGF), also known as Large-Format Additive Manufacturing (LFAM), 3D printing has revolutionized this field by providing:

- **Rapid Production**: Acceleration of iterations and reduction of development cycles.
- **Cost Efficiency**: Minimization of material waste and manual labor.

Polymaker's PolyCore™ PC-7413, a 30% glass fiber-reinforced polycarbonate (PC), is specifically engineered for these demanding applications, delivering exceptional performance while addressing traditional manufacturing challenges.

Key Features of PolyCore™ PC-7413

- **Excellent Heat Resistance**: With a heat deflection temperature (HDT) of 136 °C at 1.82 MPa, PolyCore™ PC-7413 is ideal for autoclave curing processes up to 120 °C .
- **Exceptional Printability**: Glass fiber reinforcement minimizes warping during printing, while finely tuned rheological behavior ensures smooth extrusion and excellent layer adhesion.
- **Cost Effectiveness**: PolyCore™ PC-7413 provides a cost-effective alternative to traditional carbon fiber reinforced materials, enabling companies to scale production without compromising performance.

This case study illustrates how PolyCore™ PC-7413 effectively addresses the challenges of traditional manufacturing, demonstrating its exceptional performance in real-world applications.

Real-World Application: Aerospace Composite Mold

A mold specifically designed for manufacturing aircraft skin components was developed in collaboration with a reputable Chinese manufacturer specializing in 3D printed composite molds and tools for the aerospace industry. During the initial design phase, special attention was given to optimizing the tool path for FGF/LFAM technology while ensuring the mold's rigidity by incorporating internal reinforcing ribs. The printing process was further optimized using Helio Additive's 'Dragon' software, which improved thermal distribution across the mold to reduce internal stress and enhance layer adhesion. As a result, the mold was successfully printed on the first attempt, achieving a 38% reduction in print time. Notably, all PolyCore™ product profiles are integrated into 'Dragon' for enhanced user convenience.

After printing, the mold underwent precision CNC machining to refine its surface, followed by a series of validation tests to assess surface quality, dimensional accuracy, and airtightness. Finally, the mold was subjected to an autoclave curing process at 120 °C and 0.6 MPa pressure, successfully producing a carbon fiber part. Dimensional inspections of the carbon fiber part and the used mold confirmed the mold's suitability for medium-temperature composite applications.

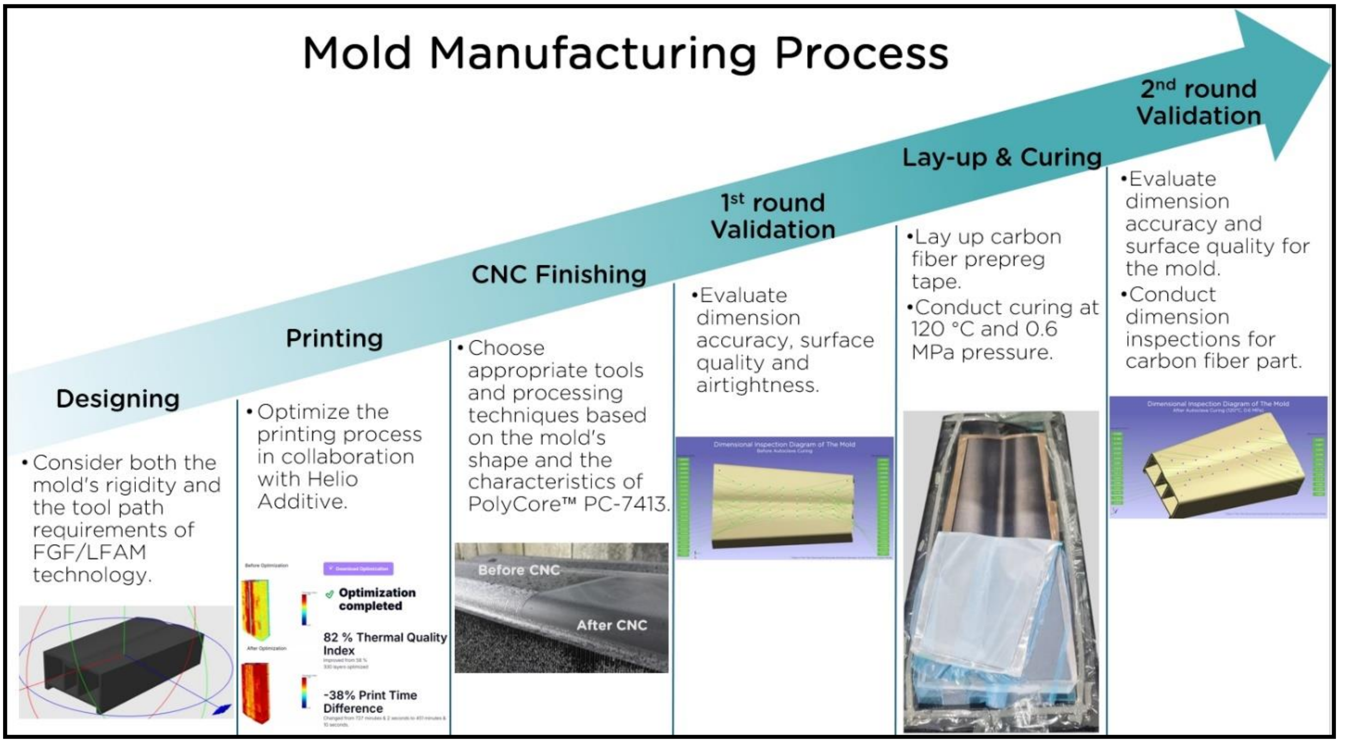


Figure 1 | Complete process of mold manufacturing

Polymaker's experts defined two critical application requirements:

- **Retention of Dimensional Accuracy**: Consistent achievement of dimensional accuracy of ±0.2 mm across the mold surface before, during, and after autoclaving.
- **Airtightness**: Ability of the mold to maintain a vacuum before, during, and after autoclaving.

The mold underwent high-precision laser scanning at 27 points across its surface after CNC finishing and autoclave curing, confirming it met the required dimensional accuracy of ±0.2 mm. This demonstrates that PolyCore™ PC-7413 provides the necessary heat resistance and stiffness to maintain dimensional stability.

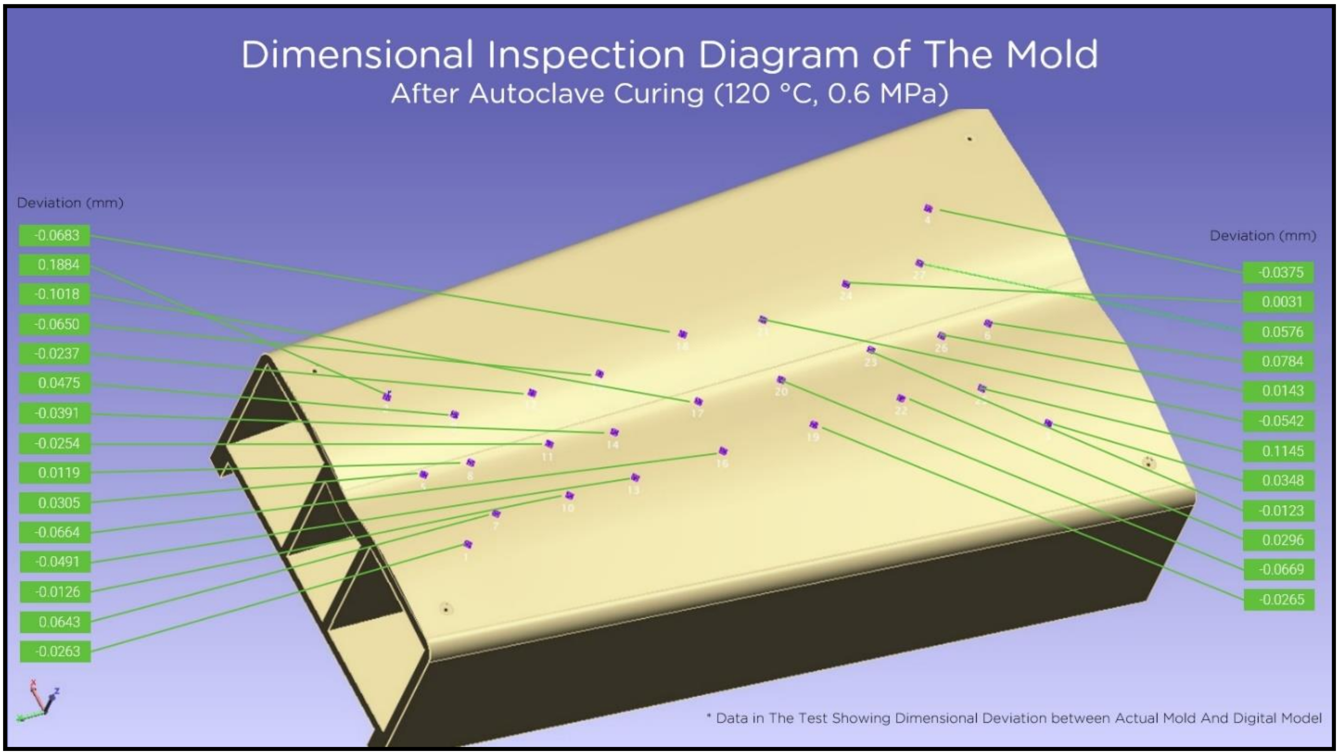


Figure 2 | Dimensional inspection result of the mold after autoclave curing

Prior to autoclave curing, the mold surface was vacuum-sealed at -0.85 bar for an airtightness test. After 30 minutes, the vacuum remained below -0.82 bar, confirming an effective seal. This performance is primarily attributed to reduced interlayer defects, resulting from the smooth bead surface and strong layer adhesion achieved through the finely tuned rheological behavior of PolyCore™ PC-7413.

Finally, we conducted dimensional inspections on the carbon fiber part produced using this mold, confirming it exhibits excellent dimensional accuracy with no surface or internal defects, thereby ensuring compliance with application requirements.

Advantages of FGF/LFAM in Mold Manufacturing

Leveraging FGF/LFAM technology, this mold delivers significant advantages:

- **Faster Lead Time**: A quick turnaround of 7 days, significantly shorter than the 20-30 days typically required for fiberglass molds and 25-40 days for steel molds.
- **Cost Savings**: Up to 60% savings compared to the cost of steel molds. The 3D printed mold is priced at $2,100, while a steel mold typically ranges from $3,500 to $5,500. The cost of 3D printed mold is also competitive with fiberglass molds.

Lead Time and Cost Comparison

Mold Type	Lead Time (Days)	Cost (USD)
Fiberglass Mold	20 - 30	1,800 - 2,700
Steel Mold	25 - 40	3,500 - 5,500
3D Printed Mold	7	2,100

Note:

- *The cost and lead time data of the 3D printed mold is derived directly from the production of this specific mold.*
- *The cost and lead time data of fiberglass and steel molds are based on an analysis of multiple Chinese manufacturers using the design of this mold.*
- *The steel type is Q235.*

Figure 3 | Lead time and cost comparison

This innovative approach also minimizes material waste and labor costs, further enhancing its sustainability and contributing to the automation of manufacturing.

Conclusion

This case study showcases how Polymaker's PolyCore™ PC-7413, combined with FGF/LFAM technology, offers an innovative solution for medium-temperature composite mold manufacturing. This approach enables manufacturers to significantly reduce mold production lead times, save cost, minimize material waste, and leverage advanced automation, ultimately accelerating the development of carbon fiber or fiberglass parts in industries such as aerospace, automotive, and beyond.

For more information, please contact Polymaker at
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About Polymaker

Polymaker is a developer and manufacturer of 3D printing materials committed to innovation, quality and sustainability. Its award-winning product portfolio has enabled numerous of individuals and companies to "better create and innovate". Headquartered in Changshu, China, Polymaker has multiple office locations in Shanghai, Utrecht and Houston ready to serve customers across the globe.

About PolyCore™

PolyCore" is a family of pellet-based 3D printing materials for Fused Granular Fabrication (FGF). Built on Polymaker's 10+ years of experience and expertise in material-extrusion based 3D printing, PolyCore™ features excellent printability and is widely compatible with most pellet-extrusion 3D printers. It is worth emphasizing that all PolyCore™ series products have been developed based on specific applications, particularly in the fields of architecture and mold applications.