SmartMold - Competitive and sustainable molds for tomorrow's composite production through function-integrating additive

Abstract:

The SmartMold project develops a new technology for rapid, cost-effective, and sustainable production of molds for composite components (e.g. in aviation or automotive sectors). It enables faster, cheaper, and 100% recyclable molds with integrated heating and sensing. The approach combines additive manufacturing of plastic molds with automated integration of resistive heating elements made from carbon fiber rovings, topology-optimized on the mold surface. Both the mold and heating elements are made from the same carbon fiber reinforced thermoplastic, allowing easy recycling at end of life.

Countries involved

Application sectors
Aerospace, Automotive, Railway

Research and innovation domains
Advanced manufacturing processes, Smart & adaptative manufacturing systems, Sustainable manufacturing

Total cost in M€ (millions)
0.93 M€

Starting date
01/01/2025

Duration (in months)
24 months

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RATIONALE OF THE PROJECT

"Today, molds for fiber composite manufacturing are typically produced by milling solid blocks or creating positive foam models laminated with thermoset-impregnated glass or carbon fiber textile layers (FRP). These tooling molds are crucial in the FRP production value chain but can be difficult to manufacture due to complex geometries and specific material requirements. Additive manufacturing offers a way to overcome these challenges by enabling the creation of complex, functionally integrated molds that are difficult or impossible to make with traditional methods. The SmartMold project enhances the Fused Granulate Fabrication (FGF) process by integrating advanced heating structures. A key benefit of FGF is the use of standard injection molding granulates with short fiber reinforcement, which are fully recyclable. A unique innovation is the incorporation of carbon fiber heating elements into the mold. This allows precise control of composite matrix curing and ensures efficient heat transfer to all component surfaces. Consequently, there is no need for energy-intensive autoclaves when producing FRP components with low-temperature resins, significantly reducing energy use and manufacturing costs. To ensure high process reliability, a sensor system monitors the complete curing cycle. SmartMold follows a fully recyclable concept, enabling full reuse of processed materials. "

TECHNOLOGICAL INNOVATION, ACHIEVEMENTS AND RESULTS

“SmartMold is developing a process-oriented system for additive manufacturing of large-format, heatable, and sustainable molds, with the following main goals:

1. A material system tailored for SmartMold will be identified through process- and application-oriented testing, focusing on processability, durability, and recyclability.

2. Additive manufacturing will be carried out using robot-controlled extruder adapted to this material system. A newly developed dual-extrusion mold will embed heatable carbon fibers into the mold surface for integrated heating.

3. SmartMold targets the production of composite parts using prepreg and infusion processes outside autoclaves. By topologically designing the fiber heating layout to match part geometry and optimizing curing parameters, controlled and uniform curing is achieved. A prototype mold assembly with integrated heating is under development.

4. On the software side, the entire mold production workflow is adapted to the sustainable SmartMold system. This includes new CAD/CAM features, tailored build strategies, and an extended FGF CAM parameter set. The approach shifts from a monolithic to a hybrid FGF-CAM planning system (additive + subtractive), enabling seamless transitions between layer-by-layer manufacturing and post-processing. “

MARKET POTENTIAL

“The use of fiber composites and lightweight construction materials has grown rapidly in recent decades. These materials are widely applied in aerospace, automotive, and construction industries to reduce weight and enhance efficiency. For instance, global demand for carbon fiber reinforced plastics nearly tripled between 2010 and 2023. 3D printing of molds for composites brings significant advantages by enabling the production of complex molds faster and at lower cost. Especially in aerospace and medical sectors, there is a high demand for top-quality components and reliable process data—needs that can be met through intelligent sensor technology and integrated heating systems. For composite product manufacturers, this offers great added value: producing high-quality molds quickly and cost-effectively. Sensor integration and mold heating also contribute to improving the final product quality. “

IMPACT POTENTIAL

Smart molds using function-integrating additive technologies offer faster, more efficient production through 3D printing, reducing time, costs, and increasing competitiveness. It enables advanced mold designs with complex geometries and integrated features, enhancing performance and lowering expenses. Using sustainable materials and minimizing waste supports environmental goals. Integrated sensors and digital tools allow real-time monitoring and optimization, improving product quality and customer satisfaction.their advantages, they will undoubtedly capture an increasing share of the above market, which we estimate at 4% by 2028.