Additive Manufacturing of Fiber-Reinforced Polymers

The presented research work contains studies concerning fiber-reinforcement in additive manufacturing. The overall process chain was considered and investigated during the project, including materials, design, production, quality control, and simulation.

A series of experimental and numerical investigations were carried out to determine the influence of short fibers on the additive manufacturing process chain. These investigations were conducted on multiple additive manufacturing machines, injection molding machines, and scientific testing equipment. Methods were developed to optimize and enhance the required properties of the material and the final parts in terms of thermal properties, mechanical properties, lifetime, life cycle, and implementation in a digital production environment.

Descriptive research was performed on the manufacturing process of parts with fiber-reinforcement focusing on fiber-matrix interface, fiber orientation, and fiber distribution within the part. A specialization was considered for vat photopolymerization technologies. Conclusions were drawn from the investigations and included in the development of injection molding inserts as an industrial application.

The digital manufacturing process chains of injection molding machines with a special focus on injection molding inserts were investigated further and challenges were identified. Among them were a reduced lifetime, increased molding cycle time, and thermal management of the insert. Those challenges were tackled in further investigations resulting in a significantly enhanced lifetime and a cycle time reduction.

Further aspects of digital manufacturing were considered in conceptional investigations regarding advanced cooling of the inserts and opening the possibility for automated injection molding prototyping and design phases. The later will play a significant role in an industry 4.0 manufacturing environment. In comparison to the vat photopolymerization process, investigations were performed on extrusion-based methods elaborating on the differences and enhanced challenges as compared to resin-based manufacturing technologies.

General information
Publication status: Published
Organisations: Manufacturing Engineering, Department of Mechanical Engineering
Contributors: Hofstätter, T.
Number of pages: 259
Publication date: 2019

Publication information
Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
Keywords: Additive manufacturing technologies, Fiber-reinforced polymers, Injection molding, Numerical simulations
Electronic versions:
PhDThesis_Hofstaetter.pdf