Be on trial – fiber-reinforced components from 3D printer

Report: Florian Arbeiter, Herfried Lammer

Additive manufacturing or 3D printing is superior to other processes in terms of cost efficiency, customizability and sustainability and is therefore gaining ground in more and more areas. The possibilities are not yet optimized in all extents. The FFG project eFAM4Ind - endless fiber reinforced additive manufacturing for industrial applications, which was launched in April 2020, aims to explore these in the high-performance product segment and lightweight construction: Under the direction of the Chair of Materials Science and Testing at the University of Leoben and together with SinusPro, the Polymer Competence Center Leoben (PCCL), the Competence Center Wood and Head Sport as research partners, testing and simulation routines for predicting the durability and service life of fiber-reinforced components from the 3D printer are to be developed.

Highly stressed industrial applications are currently still a difficult patch for additive manufacturing methods: the used or usable materials often do not yet meet the requirements regarding reliability and service life cannot yet be estimated. However, the use of reinforcing fillers such as glass, carbon or natural fibers can significantly improve the properties. Such reinforcing materials can and have already been successfully processed with the FFF method ("Fused Filament Fabrication", strand laying process, known from commercially available desktop 3D printers). The FFF method allows the processing of a wide variety of fibers and lengths - from short to endless.

The aim of the FFG project: 3D printing should be ready for high-performance applications

In addition to the challenges in manufacturing such applications, there are also those of reliability and durability testing. The problem zone in additive manufacturing is usually the quality of the weld seams between the deposited strands. Although component testing under real conditions would be useful, it is also very complex and cost-intensive. Therefore, this type of life cycle analysis contradicts the basic idea of additive manufacturing, namely the fast, efficient and thus sustainable production of parts. A more efficient possibility is the testing of test pieces in combination with process data and computer simulation. Routines already exist for established production processes, but unfortunately not yet for 3D printing.

New routine should increase reliability
The project goal of eFAM4Ind is now to create inspection routines based on test specimen tests and finite element (FEM) simulations also in the 3D printing area. Since both process path and history of the FFF process are known, possible weak points in components can be calculated by means of FE models that include these known basic conditions and the lifetime can be predicted. The research focus at the University of Leoben is the testing of materials and the filaments produced from them, the testing of prototypes and the evaluation of the data.

Potential applications could lie in the sports industry, since elements of sports equipment often have to withstand high loads while remaining as light as possible. Often it is also necessary or desired that equipment is perfectly adapted to the athlete and his/her requirements. In this case fiber composites are the ideal material solution, 3D printing the perfect manufacturing process.

Grant: Österreichische Forschungsförderungsgesellschaft FFG, Produktion der Zukunft, Produktion der Zukunft, 32. AS PdZ - Nationale Projekte 2019, 2020-2023.

Partner: Montanuniversität Leoben – Lehrstuhl für Werkstoffkunde und Prüfung der Kunststoffe (Lead Dipl.-Ing. Dr.mont. Florian Arbeiter), SinusPro GmbH, Polymer Competence Center Leoben GmbH (PCCL),

Kompetenzzentrum Holz GmbH, Head Sport GmbH

Figure 9: fiber-reinforced plastics are frequently used for highly stressed components. In the future, such fiber-reinforced polymers will also to find their way increasingly into additive manufacturing.