

From train carriages to medical devices: solutions for quality-assured 3D printing with plastics

15 partners aim to establish Central Germany as a "3D printing region"

Establishing Central Germany as a "3D printing region", opening up new fields of application and making additive manufacturing with thermoplastics eco-nomically viable for small and medium-sized enterprises: With this goal in mind, 15 partners have joined forces in the "AddiQ" project. The Fraunhofer Institute for Microstructure of Materials and Systems IMWS in Halle (Saale) is involved in projects on heavy-duty components for transportation and light-weight, comfortable orthoses.

Global sales of additive manufacturing amounted to almost 10 billion euros in 2022, with annual growth rates of around 20 percent. Fast production times and great geometric design freedom make 3D printing ideal for the production of components in small quantities, among other things, and enable manufacturers to react quickly and flexibly to changing market and customer requirements. If thermoplastics are used as the starting material, the investment costs for printers and the materials used are also considerably lower than for 3D printing with metallic materials, for example.

However, quality assurance is a challenge when using additive manufacturing. There is often still insufficient experience, measurement methods and standards for both the manufacturing processes and the components produced using them. Filling this gap and thus creating a decisive competitive advantage for companies in Central Germany is the aim of the "Quality Assurance in Additive Manufacturing (AddiQ)" project, which is being funded as part of the "RUBIN - Regional Entrepreneurial Alliances for Innovation" funding program of the Federal Ministry of Education and Research. A total of 15 partners from industry and science have joined forces in this project.

"We want to provide local companies with software solutions that enable the documentation and automated evaluation of process data as well as predictions of component quality and the integration of various systems along the process chain. If this is successful, we will facilitate the introduction of additive technologies and improve their performance. This gives regional manufacturing companies the opportunity to use quality-assured additive processes to manufacture high-quality and advanced products economically and with a high degree of automation and to transfer them to production," says Dr. Patrick Hirsch, who coordinates the activities of the Fraunhofer IMWS in "AddiQ" together with Dr. Ralf Schlimper.

Highly resilient, additively manufactured components for the transportation industry

The institute is active in two sub-projects within the consortium. Together with SLV Halle GmbH, IKTR (Institut für Kunststofftechnologie & -recycling e.V.) from Weißandt-Görlau and studio.201 software GmbH from Magdeburg, the possibilities of 3D printing are to be used in "Quality-oriented production of obsolete components for the transportation industry using generative processes" in order to reduce downtimes of complex large-scale equipment such as machine tools, railcars, wagons, ships and aircraft.

Railroad wagons, for example, consist of a large number of assemblies and components. If one of these elements is defective and cannot be replaced immediately - for example because there are supply bottlenecks, manufacturers no longer exist or have changed their product range - the entire wagon will fail even though all the other components are still intact. This is where 3D printing with plastics modified to meet the requirements of the transportation sector (granulates made from polylactide PLA, polyamide PA or an acrylonitrile-butadiene-styrene copolymer ABS) comes in handy for quickly producing suitable spare parts, even as individual items. "In this sub-project, we want to consider the entire, very complex value chain, from the material to production to the component. To ensure that this is reproducible and quality-assured, we will create a digital twin to accompany the production process," says Schlimper.

The Fraunhofer IMWS will focus on the sensing of the printing process using fused granulate fabrication (FGF). The data obtained will enable a more detailed understanding of the extrusion-based component manufacturing process, while at the same time allowing the optimization and adaptation of parameters during production using machine learning approaches. Finally, a comprehensive material-mechanical and morphological evaluation of the demonstrators created in the project as well as their quality and a life cycle assessment of the component will be carried out. In addition, a standardization concept will be developed in the joint project, accompanied by the partner SLV.

Lightweight, comfortable orthoses using 3D printing

The second AddiQ sub-project of the Fraunhofer IMWS, in collaboration with SLV Halle GmbH and Automation, Sonder- und Werkzeugmaschinen ASW GmbH from Naumburg, focuses on components for orthotics manufactured using multi-axial 3D printing. Ideally, such medical aids are custom-made and adapted to the individual body shape. "This is where additive manufacturing can

fully exploit its potential. It makes it possible to produce custom-made products quickly with a high degree of design freedom at low prices and with lightweight materials that are easy to wear," says Hirsch. "Our aim is to leverage this potential even better by digitally mapping the entire value chain, from the measured body part to the necessary design adjustments to the production of an individual part. We focus on fiber-reinforced plastics and bionic construction methods."

The result of the sub-project should be a lower leg orthosis consisting of a material composite with a contact side to the body (polyethylene terephthalate), a stiffening structure (PA) and fiber-reinforced material (PA and fiber). In addition to 3D printing with different materials, the challenges are the quality requirements for dimensional accuracy, mechanical stability and wearing comfort. The project partners rely on fused deposition modeling (FDM) print heads and reinforcement using continuous fibres deposited in a load path in a printing system. The force-fit connection of the thermoplastic-coated continuous fibers to the basic structure of the orthosis, which was previously manufactured in the same construction space, is to be achieved by targeted local heating with a laser. The project objectives also include comprehensive sensorization of the multi-axial control systems of the printers - also in order to be able to derive specific standardization procedures for orthoses using 3D printing on the basis of the data obtained.

The Fraunhofer IMWS contributes its expertise primarily for the material-mechanical investigations of the printed samples and test structures as well as the suitability of the manufacturing parameters for the component properties to be achieved. Finally, the Fraunhofer team verifies the suitability of the fiber-reinforced and load-path-compatible demonstrator using suitable tests.

Central Germany as a "3D printing competence region"

The combination of the dimensions of data, material, process, component and standardization should result in a new level of application possibilities for additive manufacturing with thermoplastics. The aim is also to transfer the business idea to additive value chains, for example with metallic materials, as well as additive manufacturing in combination with conventional manufacturing technologies. This will make it easier for small companies in particular to get started with an innovative manufacturing technology. In the medium term, a 3D printing competence region with national and international appeal is to be created around Halle and Merseburg.

Source: [Fraunhofer Institute for Microstructure of Materials and Systems IMWS](#)

Additional assets available online: [Photos \(1\)](#)

<https://press.invest-in-saxony-anhalt.com/2024-01-31-From-train-carriages-to-medical-devices-solutions-for-quality-assured-3D-printing-with-plastics>