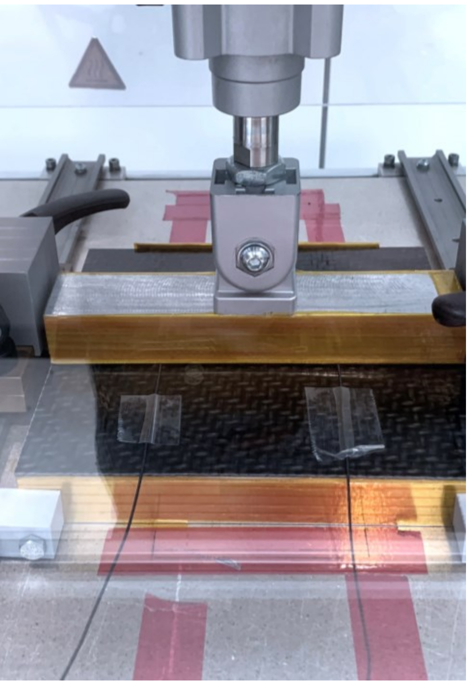
Welding Technologies

FASERINSTITUT BREMEN

Summary

Welding technologies for thermoplastic composite are enabling their efficient use. Depending on the materials and geometries of the parts which are to be welded, different technologies may be employed. Therefore, the electrical resistance welding, static and continuous ultrasonic welding are mainly investigated, while research on induction welding is conducted additionally. The FIBRE focusses on the small scale, coupon and small demonstrator levels. We mostly explore the process-material interaction via measurement, simulation and data-driven analysis of the thermal distribution, healing & crystallization, high-speed interaction, consolidation and downstream research questions such as regarding weld characterization such as NDT, thermal cycling, fatigue, crash, creep, residual stresses, hydrogen permeability and crystallinity.



Selected projects

- ThermoTwin – A construction method for thermoplastic fiber composite components consisting of a structure-bearing insert that is functionalized by overmolding. The process chain will be modeled in a digital twin and parts are welded by ultrasonic, resistance and induction welding
- Dom4Composites – Disassembly optimized design for composites in large structural applications. Welding and Intermoulding of GF/Elium and GF/PA6 substrates made from thermoplastic pultrusion
- HyFrame – Functionalization of a load-bearing window frame structure for the aviation sector based on CF/PAEK hybrid yarns using Overmoulding and induction welding
- HIOS – Technology development for the quasi-continuous production of highly integrated organosheets for aircraft applications based on locally reinforced nonwovens made from recycled carbon fibers with associated sustainable thermoforming and joining process to final shape (resistance welding)
- ThermoRep3D – 3D repair of high-performance thermoplastic fiber composites using CFRP structures based on continuous fiber reinforcement by using an induction welding process
- SelfReCab – Self-reinforced thermoplastic composites from PES and PESU which are joined via ultrasonic welding and conduction welding, utilizing tailored fiber placement and ultrasonic induced load integration

Equipment

- Resistance welding machine, designed by CTC GmbH. (Bolle & Cords Elektrotechnik GmbH)
- Static Induction welding setup. (msquare GmbH)
- Static Ultrasonic welding machine GSX-E1. Coming 2024. (Branson Ultrasonics)
- Continuous Ultrasonic welding machine for weld-lines up to L=75 cm. Coming 2025.
- High Speed Camera and additional zoom lens. Coming 2025. (Photron S20)
- High-Speed Infrared-Camera. Coming 2025. (FLIR A6751)
- Flash DSC for calorimetry of fast cooling processes. Coming 2025. (Mettler Toledo Flash DSC 2+)
- Phased array ultrasonic inspection for NDT of weld-lines. Coming 2025. (OmniScan X3)
- Digital microscope with polarization filter and Hot-Stage for crystallization and melting analysis. Coming 2025. (Keyence VHX & Resultec THMS-600)

Contact
Prof. Dr. David May (may@faserinstitut.de)
Jan Yorrick Dietrich (dietrich@faserinstitut.de / Phone +49 421 218 59703)
Lorenz Seeßelberg (seesselberg@faserinstitut.de / Phone +49 421 218 59689)

Project HIOS:
Highly Integrated Organic Sheets

PROJECTS

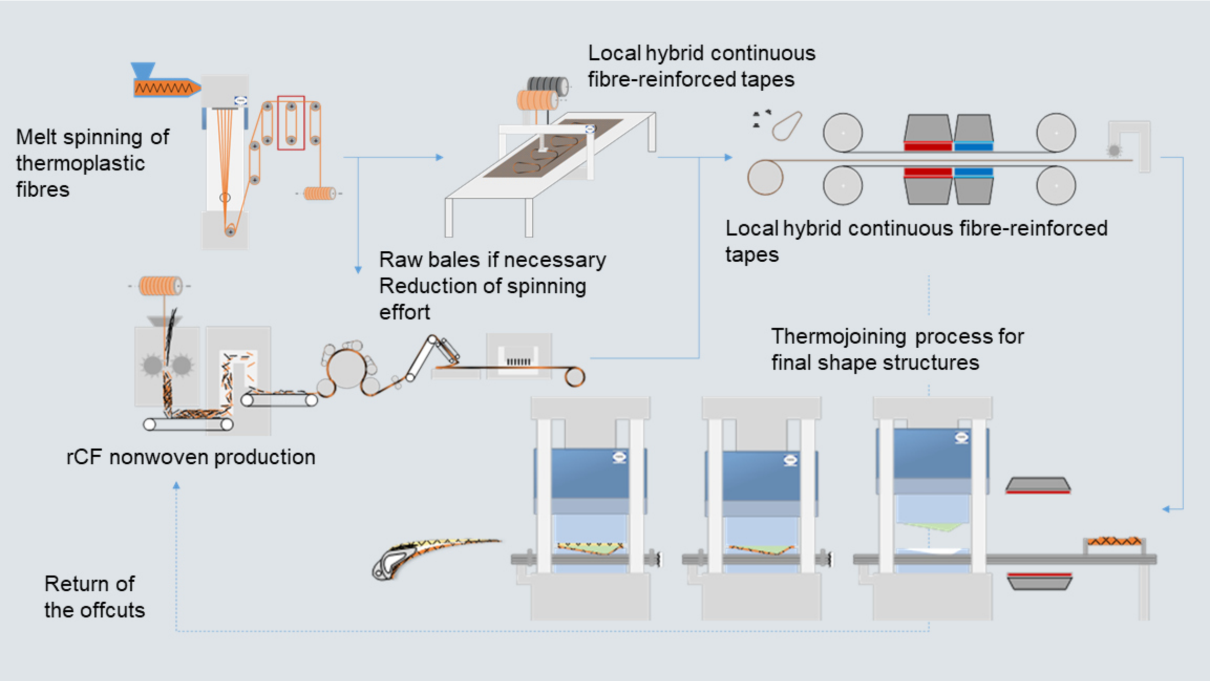
Motivation

Recycling potential and the increasing use of thermoplastic FRPs are forcing the development and combination of new manufacturing technologies for this type of material. Industrial processes for the recycling and reprocessing of carbon fibres (CF) already exist, but there is a lack of suitable technologies and applications on a broad scale.

The objective is the continuous production of component-specific organosheets for secondary structures such as spoilers, rudders or cabin parts in the aerospace industry as the basis for a sustainable and competitive overall concept. The basis is formed by hybrid nonwovens made of rCF and PEI for the interior and PPS for secondary components. These are locally reinforced in a continuous process according to mechanical predetermination and component requirements, functionalized. In the subsequent thermoforming process, which is suitable for series production, application-optimized components are produced on the final contour, which can be functionalized into box structures in-situ or in the subsequent joining process. and consolidated into organosheets.

Approach

In the project, the complete process chain including melt spinning, nonwoven fabrication, interval hot pressing and final contour pressing is considered as a demonstrator using the example of an aircraft spoiler.



Innovative solutions are to be developed for several technology stages. The challenges lie mainly in the continuous production in interval hot pressing, which according to the state of the art is carried out with a constant tool gap.

Local reinforcements with laminated layers of fabrics, scrims and TFP segments, as well as functionalization through the semi-automated application of inserts local thickness differences and locally varying fiber volume contents. The subsequent integral complex structures require evolutionary process and tool designs and thus represents the second disruptive technological approach for innovative, highly functional organo-sheets.

Main tasks

Semi-finished product and preform development

- Melt spinning of fine titre fibres from high performance thermoplastics
- Development of local hybrid continuous fibre-reinforced tapes adapted to the application structure (e.g.: TFP: Roll-to-Roll)

Component and process design

- Development of co-consolidation process with localized heating of the joining areas and thermoforming-tool for final shape production of TP-box structures

Future Applications

Reduction of manufacturing costs and times through a generic process model for predicting the optimal process parameters for the production of high-performance composite components based on hybrid thermoplastic yarn-based textiles

Contact Person

Dipl.-Ing. Richard Vocke· Phone: +49 (0)421 218 59668
vocke@faserinstitut.de

Funding

The *HIOS* research project is funded by the German Federal Ministry of Economic Affairs and Climate Action as part of the national aeronautics research program (LuFo VI-2), for which we are expressly grateful.

Funding code: 20E2116A

Project Partners

Sächsisches Textilforschungsinstitut e.V. (STFI)
An-Institut der Technischen Universität Chemnitz
Annaberger Str. 240 | 09125 Chemnitz

Associated Project Partners

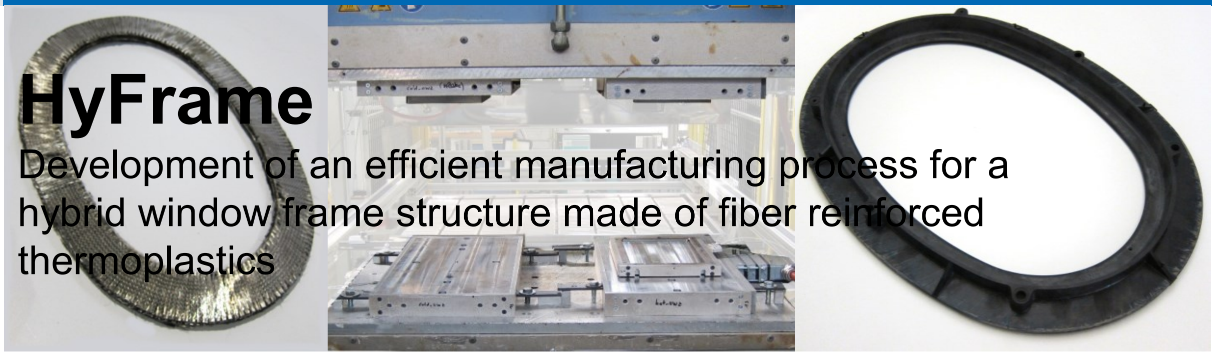
- Rucks Maschinenbau GmbH, Glauchau
- Tenowo GmbH, Hof
- CTC GmbH, Stade
- BÜFA Thermoplastic Composites GmbH & Co. KG, Oldenburg

Faserinstitut Bremen e.V.

Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.

FASERINSTITUT FIBRE BREMEN

PROJECTS



HyFrame

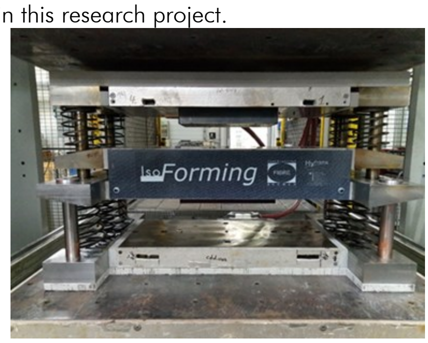
Development of an efficient manufacturing process for a hybrid window frame structure made of fiber reinforced thermoplastics

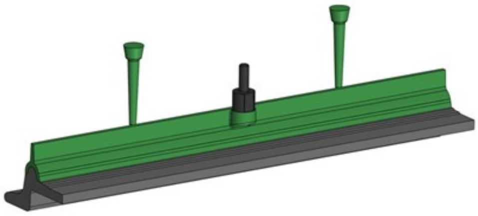
Motivation and goal

In HyFrame, a manufacturing process is being developed that will make it possible to produce load-bearing lightweight structural components more efficiently. The developed process chain should reduce the manufacturing time significantly (-50%), consume significantly less energy (-50%), and increase the geometric complexity at lower costs and the same mass. Design and manufacturing windows are narrowed down by innovative simulation methods for components and processes. Textile and preform development is supported by a consolidation model and drape studies. The innovative manufacturing processes for thermoforming, overmoulding and inductive welding are co-developed and optimized on the basis of test specimens and then raised to component level together with the partners. In summary, FIBRE is pursuing the goal of more efficient and effective aviation in the project.

Approach

The development of adapted hybrid yarns and the textile-technical processing to load-suitable designed preforms, the optimization of processes for the production of the structural continuous fiber reinforced inserts and the stiffening as well as functionalization of these in overmoulding, up to the connection by means of induction welding are the starting points, which are examined in this research project.





At Fibre, the development of the connection of inserts for the transfer of structural loads with injected mold elements and subsequent welding is being investigated. This should enable cost and weight savings. Central to this is the reduction of component distortion in the manufacturing process, which is conceptually taken into account in the design of the structure and the process. For insert production, both MAG and TFP preforms based on adapted hybrid yarns are used, thus achieving a high degree of automation and online quality assurance. The preforms are then isothermally pressed, which enables short cycle times and high laminate quality.
Overmolding is used to stiffen the overall structure and integrate functions (integration of load introduction elements and sensors). The basis for the necessary connection strength of the individual components is the use of special PEEK variants from Victrex.
Weight and costs are to be achieved in particular by welding the window frame to the fuselage structure, which is implemented in currently used window frames by Hi Lock connections.

Potential applications

Structural components for aerospace applications are the central focus, further applications in aerospace or medical technology are possible based on the development. By using more

FASERINSTITUT FIBRE BREMEN

favorable matrix materials, application scenarios in the automotive or agricultural machinery industry can also be created.

Contact person

Eike Krull · Phone: +49 (0)421 218 59659 krull@fasernstitut.de

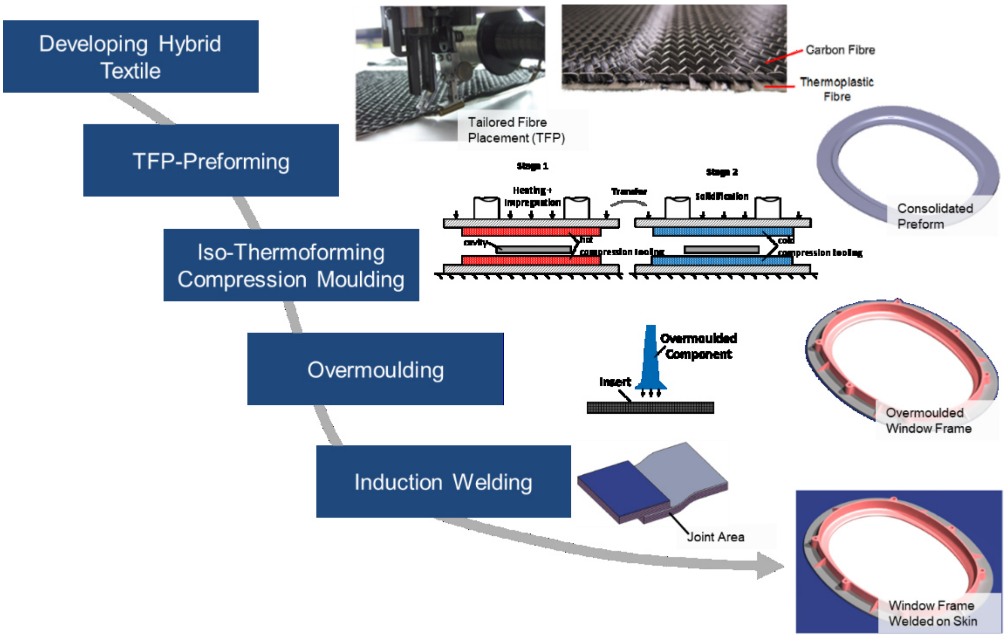
Funded by

Federal Ministry for Economic Affairs and Energy

The research project HyFrame was funded by the Federal Ministry of Economics and Energy as part of the LuFo program, for which we would like to thank the Federal Ministry of Economics and Energy.

Projeckt partner

- ACE Composites GmbH
- Hightex GmbH
- Megatherm Elektromaschinenbau GmbH
- MERKUTEC GmbH & Co.KG
- SAERTEX GmbH & Co. KG
- Faserinstitut Bremen e.V.



Faserinstitut Bremen e.V.

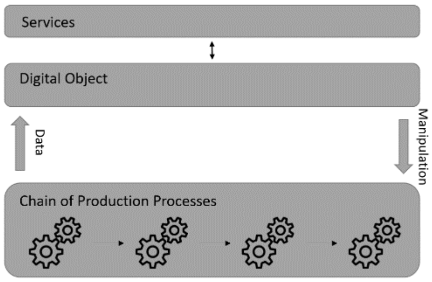
Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.

Faserinstitut Bremen e.V. · Am Biologischen Garten 2 (IW3) · 28359 Bremen · Germany
Phone +49 (0)421 218 587 00 · Fax +49 (0)421 218 587 10 · www.faserinstitut.en

ThermoTwin / ConTwin

Development of an online-monitored consolidation process for hybrid thermoplastic preforms for the production of aerospace-specific components and investigation of joining processes to reduce emissions.

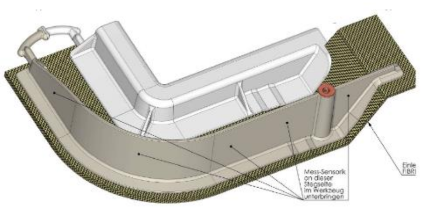
Motivation and Goal



In the global competition, the aviation industry is facing steadily increasing demands regarding the cost-effectiveness and resource efficiency of its products. One response to these demands is the use of fiber-reinforced composites for structural applications in aircraft. The significantly higher lightweight potential compared to metallic materials, combined with the suitability for functional integration, makes fiber-reinforced composites an attractive material for aviation and justifies their growing use. However, the economic potential of operating lighter aircraft is counterbalanced by the complex and expensive production processes for manufacturing composite components. In recent years, a widespread application of thermoplastic-based fiber-reinforced composites has been observed to make the production of composite components more economical. These offer clear advantages in terms of shorter production times and improved impact properties, but still need to make progress in terms of geometric variability, semi-finished product costs, and quality assurance in the respective sub-processes along the production chain. The development of a digitally connected process chain and a digital twin for the components to be produced serves quality assurance as well as scrap reduction, and can utilize the material's inherent advantages through adaptive process control for each individual component. The development of hybrid components is a key element that ideally fits into Airbus' strategy for a significant increase in load-bearing elements made from thermoplastic fiber-reinforced composites. This ensures interest in such solutions within the aviation industry and provides good prospects for the utilization of partial solutions by all partners.

Solution Approach

As part of this research project, the textile processing of hybrid yarns into load-optimized preforms, the optimization of processes for the production of structural continuous fiber-reinforced inserts, the functionalization of these inserts via overmolding, and the bonding through welding are being investigated.



ACE Composites GmbH is involved as a Tier 1 supplier in the creation of the demonstrator structure. OFFIS e. V. will map the entire process chain in a digital twin, capturing and modeling system data from the individual process steps. This will enable component-specific process control. The preforming of hybrid yarns will be carried out by Hightex Verstärkungsstrukturen GmbH, forming the starting point for the process chain under consideration. FIBRE focuses on the development of a consolidation process for hybrid-yarn-based preforms, utilizing mass-reduced molds to lower energy consumption. In addition, the welding of the manufactured structures for aerospace applications will be investigated using different techniques in collaboration with CTC GmbH. Construction methods tailored to the requirements of welding processes and the corresponding equipment will be developed.

FASERINSTITUT FIBRE BREMEN

Thermo Twin

The recording of process parameters and the control of the processes will be investigated for both consolidation and welding. The networking of processes via the digital twin is intended to create an interaction capability that allows access to quality characteristics of the preceding process. By individually adapting the manufacturing process for each component, scrap production will be reduced, thus lowering resource consumption.

The overmolding of the structural inserts will be carried out by MERKUTEC GmbH & Co. KG, with a focus on local overmolding, optimization of temperature control, and monitoring of the manufacturing process. The entire process chain will be ecologically assessed in parallel by e-hoch-3 eco impact experts GmbH & Co. KG and compared with the state-of-the-art methods for manufacturing the respective components.
Weight and cost reduction of the components under consideration are to be achieved primarily through the welding connection, which is currently predominantly implemented in aircraft construction using Hi-Lock fasteners.

Possible Applications

Structural components for aerospace applications are the central focus, with additional applications in space or medical technology being possible based on the development. By using more cost-effective matrix materials, application scenarios in the automotive or agricultural machinery industries may also arise.

Contact

Lorenz Seeßelberg. · Phone: +49 (0)421 218 59689 · seesselberg@faserinstitut.de

Supported by

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

The research project ThermoTwin is funded under the LuFo program from the resources of the Bundesministeriums für Wirtschaft und Klimaschutz, for which we would like to express our sincere gratitude.

Project Partners

- ACE Composites GmbH
- Hightex Verstärkungsstrukturen GmbH
- Faserinstitut Bremen e.V
- MERKUTEC GmbH & Co.KG
- OFFIS - Institut für Informatik
- e-hoch-3 eco impact experts GmbH & Co. KG

Faserinstitut Bremen e.V.

Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.

FASERINSTITUT FIBRE BREMEN

PROJECTS

SelfReCab

Self-reinforced thermoplastic composites from PES and PESU which are joined via ultrasonic welding and conduction welding, utilizing tailored fiber placement and ultrasonic induced load integration.

Motivation and Goal

For reasons of lightweight construction, the cabin components visible to passengers in wide-body aircraft today are mainly sandwich structures. Aramid fibre honeycombs impregnated with phenolic resin are often used as the core material. The skin layers consist of glass fibre-phenolic resin prepregs. The semi-finished products are usually processed using crush core technology. There are also components manufactured by prepreg pressing or hand lay-up. Phenolic resin based matrix systems are also used for fire protection and cost reasons. The long process times required, particularly due to the high level of reworking, and the sensitive synthesis of phenolic resins (use of formaldehyde) are two key aspects that make it necessary to replace current structures in future cabins with more environmentally friendly and cost-effective materials and production processes. Therefore, materials used in aircraft interiors should have adequate mechanical properties, exceptional fire, smoke and toxicity compliance to FAR 25.853, and contribute to space savings and weight reduction. Thermoplastics with essential flame, smoke and toxicity (FST) resistance, durability and ease of manufacture, such as polyetherimide (PEI), polyphenylene sulphide (PPS), polyethersulphone (PESU) and polyetheretherketone (PEEK), are attracting interest for use in aircraft interiors.

Solution Approach

The aim of the project is therefore to develop an aircraft interior component (galley box, "Standard Unit 3") based on a mono-material approach and designed for circularity. Based on a self-reinforced polymer material that meets the high flame, toxicity and smoke (FST) requirements, a sandwich structure will be developed in combination with local reinforcement processes based on the "Tailored Fibre Placement" technology (Bionic Composite Technologies AG) with special load introduction elements (MultiMaterial-Welding AG). An efficient production process will be established using hot forming and welding (Wegener International GmbH) as well as Ultrasonic Welding (Faserinstitut Bremen e.V. & FHNW) and the component will be implemented in existing systems (CompriseTec GmbH).

Possible Applications

As the first point of contact with the customer, the cabin interior is a key aspect of any aircraft, providing passengers with a comfortable, safe and aesthetically pleasing environment in the sky. Many passengers sometimes feel uncomfortable due to the high altitude, resulting in a poor travel experience. As a result, airlines regularly update their cabin interiors to improve passenger comfort and the travel experience. The interior of an aircraft cabin consists of various components such as cabin seats, a galley, aircraft interior linings, storage compartments, in-flight entertainment and connectivity systems, windows and lavatories.

Contact

Jan Yorrick Dietrich. · Phone: +49 (0)421 218 59703 · dietrich@faserinstitut.de

Supported by

The research project SelfReCab is funded under “Zentrale Innovationsprogramm Mittelstand, ZIM” from the resources of the Bundesministeriums für Wirtschaft und Klimaschutz, for which we would like to express our sincere gratitude.

Project Partners

- CompriseTec GmbH
- Wegener International GmbH
- Bionic Composite Technologies AG
- MultiMaterial-Welding AG
- FHNW University of Applied Sciences and Arts Northwestern Switzerland, School of Engineering, Institute of Polymer Engineering

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Faserinstitut Bremen e.V.

Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.

Faserinstitut Bremen e.V. · Am Biologischen Garten 2 (IW3) · 28359 Bremen · Germany
Phone +49 (0)421 218 587 00 · Fax +49 (0)421 218 587 10 · www.faserinstitut.en

FASERINSTITUT BREMEN

ThermoRep3D

Development of hybrid curved patch structures for the repair of thermoplastic CFRP structures

PROJECTS

Motivation and Goal

The future of the aviation industry will be more efficient and eco-friendlier. This can be realized with materials such as thermoplastic composites. The respective components can be made lighter and more cost-effective. Along with the use of these materials, there is a demand for repair solutions.

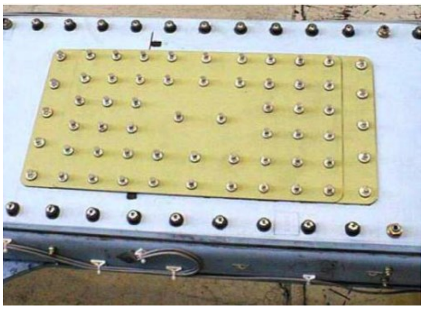


Figure 1: Repair by riveted plate

More and more fibre-reinforced plastics are being used in the manufacturing of aircraft components in order to maximize lightweight potential. Currently, the repair of aircraft parts is inspired by the processes used to repair damaged metal parts. In the corresponding procedures, the damaged areas are repaired with riveted or bonded sheet metal. This results in a disturbed material structure, reduced aerodynamic performance and increased weight. This technology for repairing aerial structures with rivets is shown in Figure 1. A new strategy for repairing fibre reinforced aircraft surfaces is needed to address the mentioned disadvantages of riveted structures. The aim of this project is to develop an efficient repair technology for aerostructures made of fibre reinforced components with a thermoplastic matrix. For this purpose, a repair patch with load-optimized fibre orientation and a 3D geometry adapted to the damage area will be integrated into the structure to be repaired.

Solution concepts

In the future, damaged fibre-reinforced aircraft structures will be repaired with thermoplastic fibre composite patches that are precisely matched to the damaged area. That allows the reconstruction of the original surface geometry to maintain aerodynamic properties. This includes the development and manufacturing of load-adapted three-dimensional patches made of hybrid yarn using Tailored Fibre Placement (TFP) and UD tape material for Automated Fibre Placement (AFP) as well as the development of a fast and high-quality laser-based ablation process for the repair preparation of three-dimensional components. By using AFP or TFP and laser ablation, highly variable processes are used so that components with a wide variety of geometries can be repaired. Before the adapted fibre-reinforced repair patch can be integrated, the damaged material is ablated by laser at the project partner Laser Zentrum Hannover e. V.

After the damaged material has been detected, measured and removed. The resulting shaft geometry is scanned afterwards. The design of the repair patch is load- and geometry-optimized for this shafted structure. Prior to integration into the structure, the patches are laser trimmed close to the shape of the shaft contour to create an ideal bond between the material of the original part and the repair patch. The thermoplastic fibre composite patches are integrated by inductive heating of a susceptor material. The inductive heating is achieved via inductive heating mats which are connected to the hot bonder.

The entire process chain for repairing a damaged fibre-reinforced composite structure in the project ThermoRep3D is shown in Figure 2.

University of Bremen

FASERINSTITUT FIBRE BREMEN

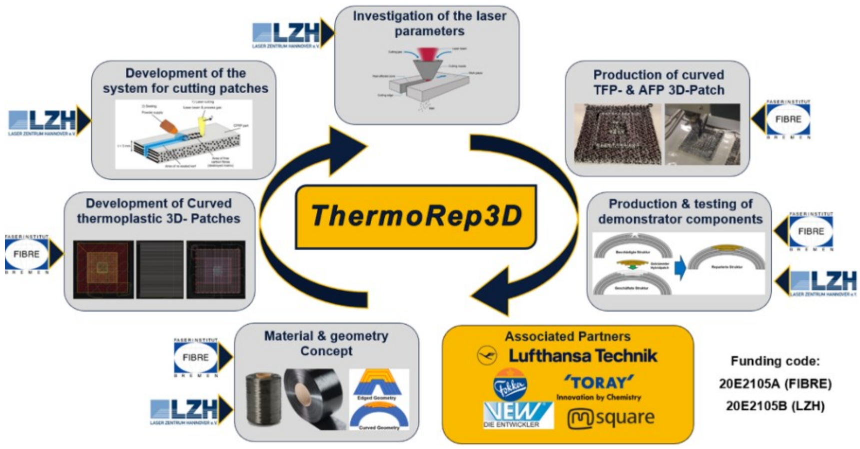


Figure 2: Process chain

Possible applications

In case of damage, the individual load-path optimized patches adapted to the structure to be repaired can be integrated into various aerospace structures. Possible applications include damaged parts of fuselage shells, wings and winglets, tail units or other aircraft structures. Existing manufacturing technologies are used to produce the patches. Various companies have the potential to include adapted fibre-reinforced repair patches in their product portfolios. Manufacturers and operators of components and aircrafts will be able to repair thermoplastic composite structures effectively and cost-efficiently.

Contact @ Faserinstitut Bremen e. V.

- Markus Geiger, M.Sc | Tel.: +49(0)421 218-59660 | Mail: geiger@faserinstitut.de

Funding

Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

The ThermoRep3D research project is funded by the German Federal Ministry of Economic Affairs and Climate Action as part of the national aeronautics research program (LuFo VI-2), for which we are expressly grateful.

Funding code: 20E2105A

Project partner

- Faserinstitut Bremen e. V.
- Laser Zentrum Hannover e. V

Faserinstitut Bremen e. V.

Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.

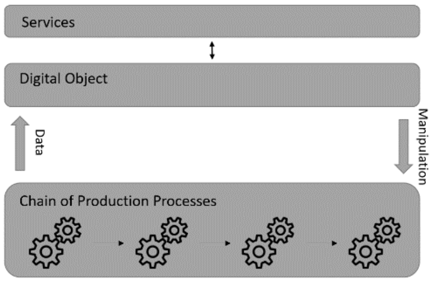
FASERINSTITUT FIBRE BREMEN

PROJECTS

ThermoTwin / ConTwin

Development of an online-monitored consolidation process for hybrid thermoplastic preforms for the production of aerospace-specific components and investigation of joining processes to reduce emissions.

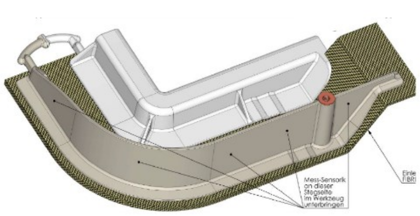
Motivation and Goal



In the global competition, the aviation industry is facing steadily increasing demands regarding the cost-effectiveness and resource efficiency of its products. One response to these demands is the use of fiber-reinforced composites for structural applications in aircraft. The significantly higher lightweight potential compared to metallic materials, combined with the suitability for functional integration, makes fiber-reinforced composites an attractive material for aviation and justifies their growing use. However, the economic potential of operating lighter aircraft is counterbalanced by the complex and expensive production processes for manufacturing composite components. In recent years, a widespread application of thermoplastic-based fiber-reinforced composites has been observed to make the production of composite components more economical. These offer clear advantages in terms of shorter production times and improved impact properties, but still need to make progress in terms of geometric variability, semi-finished product costs, and quality assurance in the respective sub-processes along the production chain. The development of a digitally connected process chain and a digital twin for the components to be produced serves quality assurance as well as scrap reduction, and can utilize the material's inherent advantages through adaptive process control for each individual component. The development of hybrid components is a key element that ideally fits into Airbus' strategy for a significant increase in load-bearing elements made from thermoplastic fiber-reinforced composites. This ensures interest in such solutions within the aviation industry and provides good prospects for the utilization of partial solutions by all partners.

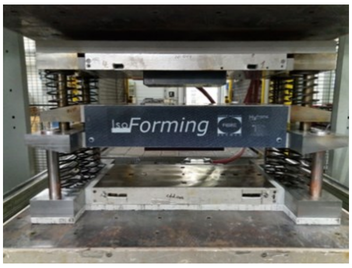
Solution Approach

As part of this research project, the textile processing of hybrid yarns into load-optimized preforms, the optimization of processes for the production of structural continuous fiber-reinforced inserts, the functionalization of these inserts via overmolding, and the bonding through welding are being investigated.



ACE Composites GmbH is involved as a Tier 1 supplier in the creation of the demonstrator structure. OFFIS e. V. will map the entire process chain in a digital twin, capturing and modeling system data from the individual process steps. This will enable component-specific process control. The preforming of hybrid yarns will be carried out by Hightex Verstärkungsstrukturen GmbH, forming the starting point for the process chain under consideration. FIBRE focuses on the development of a consolidation process for hybrid-yarn-based preforms, utilizing mass-reduced molds to lower energy consumption. In addition, the welding of the manufactured structures for aerospace applications will be investigated using different techniques in collaboration with CTC GmbH. Construction methods tailored to the requirements of welding processes and the corresponding equipment will be developed.

The recording of process parameters and the control of the processes will be investigated for both consolidation and welding. The networking of processes via the digital twin is intended to create an interaction capability that allows access to quality characteristics of the preceding process. By individually adapting the manufacturing process for each component, scrap production will be reduced, thus lowering resource consumption.



The overmolding of the structural inserts will be carried out by MERKUTEC GmbH & Co. KG, with a focus on local overmolding, optimization of temperature control, and monitoring of the manufacturing process. The entire process chain will be ecologically assessed in parallel by e-hoch-3 eco impact experts GmbH & Co. KG and compared with the state-of-the-art methods for manufacturing the respective components.
Weight and cost reduction of the components under consideration are to be achieved primarily through the welding connection, which is currently predominantly implemented in aircraft construction using Hi-Lock fasteners.

Possible Applications

Structural components for aerospace applications are the central focus, with additional applications in space or medical technology being possible based on the development. By using more cost-effective matrix materials, application scenarios in the automotive or agricultural machinery industries may also arise.

Contact

Lorenz Seeßelberg. · Phone: +49 (0)421 218 59689 · seesselberg@faserinstitut.de

Supported by

The research project ThermoTwin is funded under the LuFo program from the resources of the Bundesministeriums für Wirtschaft und Klimaschutz, for which we would like to express our sincere gratitude.

Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Project Partners

- ACE Composites GmbH
- Hightex Verstärkungsstrukturen GmbH
- Faserinstitut Bremen e.V
- MERKUTEC GmbH & Co.KG
- OFFIS - Institut für Informatik
- e-hoch-3 eco impact experts GmbH & Co. KG

Faserinstitut Bremen e.V.

Founded in 1969, the Faserinstitut Bremen e.V. (FIBRE) is a non-profit scientific institute specializing in fibre-polymer compounds and synthetic and natural fibres for technical textiles. The aim of the research is to support the industrial use of these material classes and to contribute to the sustainability of products by exploiting their outstanding property potential. To this end, a fundamental understanding of materials is used for the development of new materials, process technologies, (lightweight) designs as well as testing, measuring and monitoring methods. The basis for this is an interdisciplinary team of over 60 international employees who combine diverse specialist knowledge in the engineering sciences with expertise in chemistry, physics and computer science. Research is carried out in publicly funded basic and application-oriented research projects. FIBRE cooperates with its network of outstanding regional, national and international partners from industry and science. The Fiber Institute also offers industry partners direct support for materials science studies and individual development services.