RESEARCH HIGHLIGHTS
DEUTSCHE INSTITUTE FÜR TEXTIL- UND FASERFORSCHUNG DENKENDORF
DITF REPORT
September 2019 – Nr. 3

Carbon fibers made of wood

Minister of Agriculture Peter Hauk arranges research cooperation

Beech wood is a versatile and carbon-neutral resource. Although it is abundantly available, the range of potential applications has not been recognized yet. The state of Baden-Württemberg wants to change this and become a pioneer of using hardwood-based resources in the future. On time is ripe for large-scale application", said Minister Hauk highlighting the project.

The research center will interconnect eight research teams from different institutes and serve as a touch point for industry. The DITF is tasked to develop economic and environmentally friendly production made of polyacrylonitrile and very expensive. Researchers expect a significant reduction in production costs and an improvement of the ecological balance for carbon fiber manufacturing based on cellulose and lignin fibers. Beech wood is a suitable resource for this purpose. On a laboratory scale, the

Minister of Agriculture Hauk visits DITF's Carbon Fiber Technology Centre

August 9, the state's Ministry for Rural Areas and Consumer Protection Baden-Württemberg entered into a research cooperation agreement with the DITF. In the planned research center for hardwoods, the DITF will research carbon fibers from beech wood. "I am impressed by the variety of potential and existing processes for the production of carbon fibers. The processes for cellulose and lignin fibers made from beech wood for technical applications. Due to being simultaneously highly resilient and lightweight, materials reinforced with carbon fibers are becoming increasingly important in vehicle construction and aerospace, as well as in the construction industry and many other sectors. So far, these fibers are primarily DITF have already succeeded in producing carbon fibers from beech cellulose and beech lignin using a new, energy- and cost-saving process. This means that using beech wood not only makes sense ecologically but also economically. The DITF will integrate this research focus into the research team 6 of the "Technical Center Hardwood".

CONTENTS

DITF are members of Techtera

Global challenges demand joint action. The DITF have therefore taken a further step to expand cooperation with international partners. We have been members since August of the French cluster Techtera, based in the Auvergne-Rhône-Alpes textile region. The DITF are an ideal partner for French industry as they are recognized as a public research institution by the "Crédit d'Impôt Recherche" of the French Ministry of Higher Education, Research and Innovation. This initiative grants French companies tax breaks of up to 30% on research and development expenditures. The accreditation allows companies to double their expenditure and hence receive a tax credit amounting to 60% of their costs.

Recycling of fibers in our new technology center

Nonwovens line and spinning mill join forces in service

DITF have commissioned a production line for nonwovens from the company Dilo Machines GmbH financed by the state of Baden-Württemberg. Both the nonwovens line and the modernized technology center are designed to allow for the processing of electrically conductive carbon fibers.

Fiber-reinforced composites are being used more and more frequently in energy-saving, lightweight vehicles. In order to be able to manufacture these in a resource-saving and cost-effective manner, the carbon fibers used must be recycled as efficiently as possible. Suitable processing technologies for recycled carbon fibers can be explored on the industrial nonwovens line.

One special feature of the new nonwovens line is that an intermediate product required for yarn production, the fiber sliver, can be fabricated as an alternative to manufacturing nonwovens by means of carding machines, compensating stackers and needling machines.

Cleaning work on the fiber-covered working organs of the carding machines

The working width of the nonwovens line is one meter and is therefore suitable for carrying out processing tests with small quantities of material (starting at 10 kg) as well as for developing plant or technology components. It consists of a flake opener with feed table followed by a vibrating shaft feeder which separates the fiber flakes from the process air and produces a wadding which is fed to the carding machine. The wadding passes through a belt scale before it is dissolved into individual fibers by the compact carding machine (KC11) with pre and main tambour. The nonwoven pile produced by the carding machine is paneled off by a compensating stacker (DLAK 11) and needled with the aid of a needling machine (OUG II), either from above or below, simultaneously or alternately to a nonwoven fabric.

The compensating stacker is designed to be movable by means of a rail system and can be pushed away from the card for belt production in order to create space at the outfeed of the card for a belt pick-up and a can stock provided by Rosink GmbH + Co. Maschinenfabrik. For nonwovens or fiber sliver, the line comes with a complete adapter set of worker and turner rollers with different garnishing depending on the application.

Among other things, producing fiber slivers by means of carding allows for the processing of long stacked fiber materials and thus research and development on natural long fibers such as flax or hemp.

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DITF are members of the French innovation cluster Techtera

Being CIR accredited makes us an ideal partner for the French industry

The competition cluster for textiles and flexible materials "Techtera" was founded in 2005 and today counts some 162 companies, associations, and institutes among its members. Their aim is to jointly develop textile solutions for future challenges such as sustainability, urbanization, health, and demographic change. They accompany, consult, and support companies and research centers in the implementation of their projects. Techtera also carries out market analyses and offers a wide range of marketing measures and tools to ensure that research outcomes also succeed as products on the market.

As members of this cluster, the DITF are interconnected with many different organizations – not just in France.

Techtera sees itself as a European innovation cluster and is constantly expanding its network. The network is one of the most successful and effective in Europe and has been awarded the "Cluster Management Excellence Label GOLD" from the European Cluster Excellence Initiative supported by the European Commission. This made Techtera the first European textile innovation cluster to be awarded the Gold Label. Subsequently, only 69 of the 2,000 European clusters have been certified with gold.

The network's priorities correspond to the strategic research fields of the DITF, such as Automotive and Health, but also Recycling and Smart Textiles. The "Club Smart Textiles & Wearables" was founded within the cluster initiative, which also researches the same issues as the DITF such as the Internet of Things, energy management, data transfer, and new business models.

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Connecting Textiles: Project ConText launched

Intelligent textile surfaces for Smart Homes

In the new ConText project, a consortium involving the DITF and the German Research Center for Artificial Intelligence (DFKI) is developing user-friendly and intuitive technology for smart textile surfaces enabling the use of walls and floors in living areas for cable-based power supply and communication.

Nowadays, due to the so-called Internet of Things (IoT), devices in living spaces can be interconnected to make our everyday lives easier in many ways. Generally, private households lack comprehensive low-voltage and communication connections to install IoT devices such as temperature sensors, microphones. or light signals at the desired locations. Environmentally problematic and unreliable batteries or unaesthetic power cables are currently used to power these systems.

In addition, the devices require energy-intensive and interference-prone radio technologies to communicate with each other.

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ConText aims at a flexible solution that can be used easily and without great effort in the living area. To this end, the project partners are developing an IoT infrastructure consisting of smart wallpapers, carpets, and textile surfaces, so-called Connecting Textiles. These surfaces can be used not only to supply IoT devices with low-current electricity on a cable basis, but also to communicate with each other via standardized Smart Home protocols. The devices can be attached by the users themselves according to their individual needs, for example by simple gluing, stapling or plugging. In addition, the electronic textiles enable an intuitive, haptic user interface such as pressing or swiping, which can be used to control and configure the devices.

The research focus of the DITF concentrates on the fields of integrating sensor and actuator technology in textiles. The development of redundant textile sensor technology is another one of the DITF's research areas. Accordingly, within ConText, the DITF are responsible for providing safe electronic textiles that enable robust and reliable communication between Smart Home centers and IoT components.

In addition, the DITF are developing software that uses AI to recognize fundamental patterns in gesture interactions on textile surfaces and thus enables intuitive control and configuration of Smart Home devices. Thusly developed technologies will be thoroughly evaluated, for example in the Bremen Ambient Assisted Living Lab (BAALL), an apartment for testing intelligent assistance systems.

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Changing contaminated protective suits safely

Development of a docking and locking system

There is no end in sight for the Ebola epidemic that broke out last year in the Congo. In order to prevent its further spread, it is of great importance that aid workers are protected from infection. Even if suitable protective equipment is available:

Taking off a medical suit contaminated with life-threatening viruses is the most dangerous and complicated procedure in crisis areas.

For this reason, DITF and the Thermo-Pack company have developed a docking and locking system for contamination-free entry and exit into and out of medical protective suits in a joint project. With the introduction of this system, the aid workers are able to get out of the protective suit in a contamination-free room without touching the contaminated exterior surface of the suit by docking to an airlock partition wall.

Docking to the partition wall is achieved by welding the seams of two PE foil tubes together. The peel coating of the foil tube on the suit side ensures that operators can safely get out of the suit. The innovation of this system is that safe entry and exit from a contaminated protective suit are possible without the assistance of another person.

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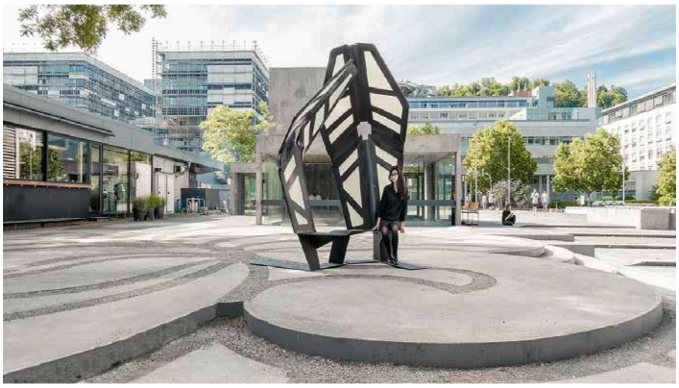
Before starting the mission, the aid worker welds shut the peelable foil tube nozzle in the chest area of the protective suit. After the mission, the aid worker pushes the nozzle into the foil tube of the airlock partition wall. Both will be welded together, the aid worker then opens the foil tube, and steps out of the protective suit through it into the airlock entering the contamination-free area.

Inspired by beetle wings

New research pavilion demonstrates bio-inspired architecture

As part of the ITECH Master Program at the University of Stuttgart, a research pavilion was developed in cooperation with the institutes ITFT, ITKE, and ICD. The research demonstrator is inspired by the folding pattern of the wings of a ladybird and consists of two adaptive folding elements (1.70 meters wide and 3.00 or 2.50 meters high) made of composite plastics reinforced with carbon and glass fibers.



ITECH Research Demonstrator 2018-19 © ICD/ITKE/ITFT University of Stuttgart

The project was designed and implemented by an interdisciplinary team of students together with scientific staff from the fields of architecture and engineering. In addition to the three supervising institutes of the University of Stuttgart, biologists and paleontologists from the University of Tübingen were also involved.

Inspired by nature

Like many other beetle species, ladybirds cover their thin and fragile hind wings with more robust forewings. In order to pack them as compactly as possible under the forewings, these wings fold along precisely defined, flexible joint zones with specifically defined mechanical properties. The folded wings store elastic energy in the joint zones, which allows rapid opening and unfolding if the insect has to escape from danger. Using mathematical-geometric descriptions of the folding movements of the beetle, the project team was able to demonstrate the kinematic behavior of the different joint zones. The folding movement of the pavilion elements is achieved by flexible joint zones with integrated pneumatic actuators.

In addition, the team used a special laying technique, which is widely used in industrial mass production, for the first time for the automated production of large-format carbon and glass fiber reinforced composite plastics.

Adaptive Architecture

The kinetic system used in the research pavilion makes it possible to close and open the folding elements. The demonstrator thus represents an intelligent robotic architecture system capable of reacting to and communicating with its users through spatial adaptation: on the one hand by touching sensory areas, on the other hand via a mobile and web-based interface that allows the user to control the movement of the demonstrator via smartphone or tablet PC.

Following the presentation on the University Campus Stadtmitte (City Center), the research demonstrator will be set up at the Institute for Textile and Fiber Technologies (ITFT) in Denkendorf.

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High-end simulations at the DITF

SAURER uses numerical simulation to develop high-tech textile technology

Textile machine construction often involves components that are subject to intense wear and tear, which are constantly being improved in line with increasing demands regarding productivity and product properties. Numerical simulation is an important tool for process and product optimization and for a deep understanding of complex processes. The DITF have been using this approach for many years with state-of-the-art hardware, software, and testing technology that is out to work during publicly funded research projects.

This potential is also applied profitably by companies using a temporary industrial license, as shown by the flow simulations successfully carried out for SAURER Technologies GmbH & Co KG.

SAURER is a leading, globally active technology company with a focus on machines, components, and software for processing fibers and yarns. In the Temco product range, SAURER offers high-quality CoolFlow texturing discs.

The air flows between the discs rotating at over 10,000 rpm are of central importance for the emerging temperature load of the contacting filament yarn. There are numerous factors influencing the air flows between the discs; however, the disc geometry plays a central role. The simulations of the texturing process carried out at the DITF showed that the air flow between the discs is improved with the optimized CoolFlow geometry, resulting in an improved heat removal. This has been confirmed by numerous field tests under real production conditions around the globe.

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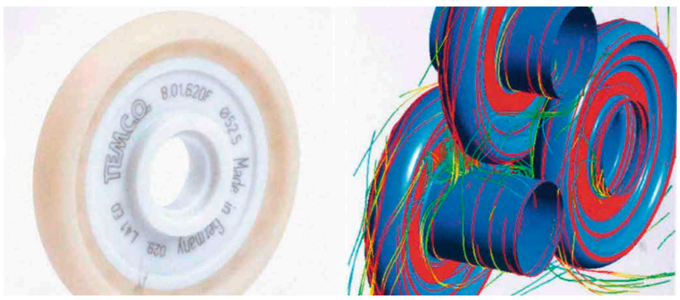


Simulation of air flows on Temco CoolFlow texturing discs

Individualized 3D compression textiles for scar therapy

From diagnostics to industrial production

One of the consequences of any serious skin injury is scarring, which already starts during the regeneration phase of wound healing and can last up to two years. In the treatment of scars, compression therapy using medical compression textiles is an established method. This type of treatment makes high demands on both fit and wearing comfort, which often cannot be fulfilled by standardized product sizes. The production of individualized medical compression textiles, on the other hand, is time consuming and costly. Treatment parameters and patient measurements result in a large number of treatment options that cannot be met by standardized compression textiles.

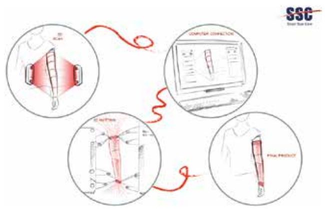
As part of the BMBF's "Smart-Scar-Care" project, this problem was addressed and a workflow was developed to provide each patient with a compression textile for scar treatment within 24 hours, which is adapted to the type of injury, healing process. and individual body measurements.

The developed workflow consists of the following steps:

> Capturing individual dimensions using 3D scanning
> Creation of patient-specific configuration with regard to geometry, material, and compression pressure using an interactive treatment front end
> Automated interpretation of configuration data and calculation of a custom-fit knitting pattern
> Simulation-supported monitoring of the induced compression pressure
> Data transmission to the production site and manufacturing facility

The workflow was successfully applied in the production environment and validated in a clinical study.

The project consortium consisted of compression textile manufacturer BSN medical, flat knitting machine manufacturer Stoll, software provider for measuring humans Avalution, software provider for clothing simulation Assyst, University Hospital Schleswig-Holstein, and DITF.



Workflow for manufacturing an individual, medical compression textile within 24 hours

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Completion of the WiMaH project

Development of a knowledge-based method for the determination of case-specific knitting and warp knitting machine settings in the stitch production process

At the end of July, the AiF project "WiMaH" was completed, which examined specific aspects of the development of knowledge-based methods in application projects in four use cases with companies from the project committee:

Manufacturers of socks and stockings:
Method and tools for recording product faults and changes in the process (machine settings). The DITF developed a model and corresponding software for this. Faults and changes are recorded with a tablet. An intelligent analysis brings faults and corrective measures together. As a result, knowledge is generated, documented, and made available for use.

Manufacturer of knitted and warp-knitted fabrics:
Improved selection of suitable articles from the product database in response to customer enquiries. This is where DITF comes in with the concept of similarity search. The scientists first developed suitable similarity functions for material similarities as well as for article width, article weight, and other article properties. In addition, a suitable weighting for the overall similarity was found. In order to make this knowledge available for article selection, an easy-to-use, web-based user interface was created. This interface now also lists articles in search queries, which may not be exactly identical, but nonetheless suitable.

Manufacturers of fashionable flat knits (sweaters):
Examination of the relationship between yarn properties of actually used yarns and the finished knitted fabric – a step towards digital engineering.
A bobbin was selected from a batch of bobbins and extensively tested by the laboratory at the DITF, while the rest of the batch was knitted. In this way, it was possible to systematically establish correlations between knitted fabric properties such as length, width, etc., and yarn properties such as elasticity, etc.

Manufacturers of circular knitted fabrics:
Creation of a kind of digital twin of the real product. For the first time, yarn tensions were measured and recorded directly at the inlet to the knitting machine. The resulting large amounts of data were examined for irregularities and patterns. It became apparent that events such as day/night shift, bobbin set change, cut-off of a piece, etc. were clearly recognizable and attributable. In this way it is possible to create a kind of digital twin of the real product, which can then be referenced in the event of quality fluctuations and possible problems.

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Substantial energy savings in the production of carbon fibers

First development project with the new low-pressure stabilization furnace from centrotherm international AG shows promising results

A year ago, a new, energy-saving production concept for manufacturing carbon fibers was introduced to the public at the DITF. In cooperation with centrotherm international AG in Blaubeuren, DITF developed a low-pressure stabilization furnace.

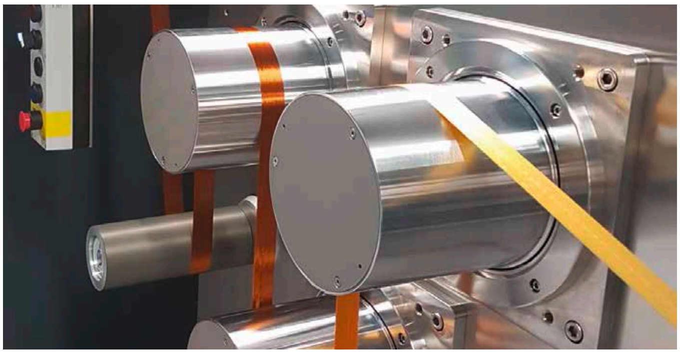
The high costs in the production of carbon fibers are mainly attributable to the energy costs incurred during stabilization (oxidation) and subsequent carbonization at high temperatures.

With the aid of low-pressure technology, the new furnace enables the process atmosphere to be controlled for the first time. This allows the oxygen atmosphere to be precisely adjusted. The results are not only qualitatively improved, particularly homogeneous fibers, but above all high energy savings of up to 50% compared to the standard process.

These savings were also the focus of the development of the low-pressure furnace, as the fibers are to be made more cost-effective for use on an industrial scale.

The development project funded by the Baden-Württemberg Ministry of Economics, Labor and Housing will end in autumn 2019 and it is already apparent that the project goals will be achieved:

The successfully commissioned facility is running smoothly. The energy saving targets have been achieved. In the most recent laboratory tests, we were able to stabilize six fiber bundles simultaneously in the system. A first industrial 50k precursor (a bundle of 50,000 filaments) also ran faultlessly through the system. This means that the practical hurdles for upscaling to industrial scale have been overcome.



Pre-cursor fibers at the outlet of the stabilizing furnace

This development project impressively demonstrates how a current problem in industrial fiber production can be solved in a practical way through close cooperation between the DITF research facilities and the industrial partner centrotherm.

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Brand protection – a textile solution

Invisible security coding with Transparency™

Large quantities of counterfeit brand name goods enter the EU mainly by sea from China or other Asian countries. Textile products make up a large proportion of the products illegally reaching consumers with clothing, handbags and shoes, mostly counterfeit bearing the names of renowned manufacturers.

An invisible infrared ink for inkjet printing was developed with the intention of marking textile products in a counterfeit-proof way. The new Transparency™ ink consists of a system of tiny IR-active particles in an aqueous dispersion. Additives and absorbents adjust the properties of the ink to give it the appropriate viscosity and surface tension for perfect, sharp-edged printing results of high permanence on textile surfaces. However, the ink itself is invisible to the human eye. It can be superimposed with colored prints within one printing process.

A textile printed with this ink could display a security code under IR light. However, this code would still be invisible to the human eye at that point. It can only be read with an IR-sensitive camera. In this way, the print samples can conceal information about the goods, e.g. in the form of a machine-readable barcode or a QR code.

The latest development of this anti-counterfeiting technology at the DITF is a complete package consisting not only of Transparency™, but also complemented by a smartphone with infrared-sensitive lenses and a self-programmed app which is able to recognize the QR code printed on textile surfaces. One area of application is to help customs verify the authenticity of goods directly at the point of import without any major technology requirements.

The system has been developed to market maturity and is currently being presented at international trade fairs.

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Smartphone with DITF app for decoding the security code

Self-healing fiber composite materials

Newly developed repair method using a hollow glass fiber fabric to fill and seal any occurring cracks completely autonomously

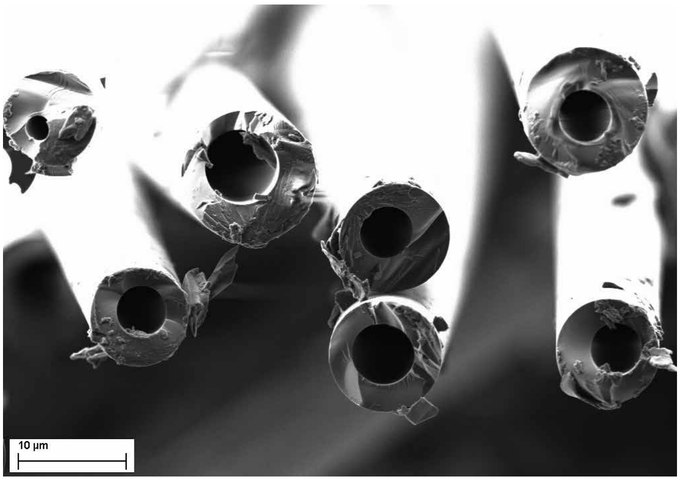
The heavy metal cylinder hits the test specimen with a loud bang. In a DITF drop test bench, a fiber composite material is deliberately damaged. Delaminations form at the site of the damage, which are recognizable as white, locally limited defects. In addition, microscopically small cracks appear. "Even the smallest damage to a material often triggers the so-called total failure of a fiber composite component, which can have catastrophic effects in practice," explains Thomas Lehr, who is working on a research project designed to prevent such scenarios. "We are working on slowing down or even completely preventing crack growth, meaning the way and speed at which a crack spreads spatially within a material."

Fiber-reinforced composites are used wherever materials are exposed to high stress and at the same time need to be as light as possible. The high tensile strength of this group of materials is achieved by the interaction of reinforced fibers with a surrounding matrix component. In the event of damage to the matrix, these reinforcing fibers prevent sudden break-up up to a point. However, once cracks are present, they can grow so rapidly that the fiber reinforcement also reaches its limits and the component fails. "One can try to saturate cracks from the outside with liquid resin and seal them with it. But this does not fix the damage further below the surface," explains Thomas Lehr. "That is why we start inside the material and heal cracks as soon as they appear."

As part of a research project, Dr. Frank Gähr's research group has been working on self-healing, fiberglass-reinforced fiber composites and has achieved impressive results: Individual layers of the glass fiber fabric used in a component are exchanged for hollow glass fiber fabric. In an elaborate process, the hollow channels of the fibers are filled with liquid chemicals.

The capillaries in the fibers absorb a mixture of polyethylene glycol (PEG) and tin catalyst in the warp direction. The fibers in the weft direction of the fabric are filled with diisocyanate. Several hollow glass fiber fabrics filled in this way can be placed in different arrangements and layers in the component. Due to the spatial separation of the chemical components (warp and weft), both monomers on their own remain chemically stable and liquid over long periods of time. However, if the components mix, they react to form solid polyurethane within a very short time.

For the novel fiber composite material, which contains such filled hollow fibers, this means that if damage occurs from the outside, the hollow fibers also break. PEG and diisocyanate are released, quickly penetrate the crack system into the finest branches, and then react to form solid, low-molecular polyurethane. The self-healing process is autonomous because the monomers already react with each other at room temperature. The component tempering in a furnace required for triggering the polymerization reaction in previous repair processes is no longer necessary. The generated polyurethane fills in the crack without needing anyone to recognize the damage and actively intervene in repairing it. Therefore, this material can justifiably be called "self-healing".



Hollow glass fibers in cross section

Glass hollow fiber fabric with dyed monomers

The fact that the self-healing process actually occurs as hoped for can be proven with the help of colored monomers. After the damage, blue PEG emerges from the hollow fiber and penetrates the crack system. The damaged area turns blue inside the component. Under a microscope, the process can be easily followed and documented photographically. The diisocyanate can be colored with a fluorescent dye. The crack filling is thus also visible by means of UV light. Self-healing glass fiber-reinforced fiber composites can be used wherever mechanically stressed components have to perform reliably. Wind power plant construction, aerospace, and automotive engineering are typical fields of application, and increasingly also mechanical and plant engineering.

The next step is to transfer the laboratory process to the production of larger work pieces.

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DITF events at a glance

Preview

IFAI EXPO 2019
After the successful performance in 2017 and 2018, DITF will once again be exhibiting at IFAI EXPO (Industrial Fabrics Association International), the leading textile trade fair in North America. As part of the DITF's internationalization strategy, this is an important step towards expanding international contacts and promoting Baden-Württemberg as an innovation hub. From October 1–4, DITF will present its developments in the field of Technical Textiles and take part in the lecture program. The highlight at our stand will be the presentation of the invisible security coding Transparency™ – a current DITF development for protection against counterfeiting.

Micro Factory at the TV TecStyle Visions
The Digital Textile Micro Factory, which was already exhibited with great success at Techtextil and ISPO in 2019, will again be presented in a modified form by the DITF at the beginning of 2020 – at TV TecStyle Visions, Europe's leading trade fair for textile finishing and promotion in Stuttgart. The complete digital production chain from design and digital printing to automatic cutting and ready-made clothing integrated into the workflow will be on show.
Visitors can explore the Micro Factory at leisure or take part in one of the free guided tours. Under the motto Print.Produce. Promote, TV TecStyle Visions offers an international information and inspiration platform for the textile and fashion industry with over 200 exhibitors from the fields of textile finishing (technology and accessories), promotional wear, corporate fashion, and workwear.

DITF present the first AI trainers for medium-sized textile companies
In order to strengthen Germany's competitiveness in the field of digitization, the federal government is using AI trainers to promote the use of artificial intelligence in important areas of German SMEs. The first AI trainers for SMEs in the textile and clothing industry as well as in textile machine engineering started their work on September 1, 2019 via the Mittelstand 4.0 Competence Center *Textile Interconnected*. The DITF provide two trainers for this initiative of the Federal Ministry of Economics and Energy, thereby supporting small and medium-sized enterprises (SMEs) in the application of artificial intelligence (AI).
The AI trainers go directly to the companies, offer informational talks and training courses free of charge, and show ways in which AI can be introduced into the company. They illustrate the technological and economic potential of AI and provide specific advice for the development of suitable fields of application.
In addition to imparting the basics, the companies themselves should above all be enabled to recognize applications for AI.

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Trade fairs & events

	2019
September 23–27	IHK Theme Week 100 Hours Tomorrow, Info Booth SME 4.0 – Competence Center *Textile Interconnected* on September 24.
October 1	LabTour – Integrated Digital Engineering, SMEs 4.0 Competence Center *Textile Interconnected* at the DITF
October 1–4	IFAI Expo, Orlando, USA – DITF booth
October 16–17	Nonwovens Innovation Academy of edana at the DITF
October 24	11. Innovation Forum Medizintechnik, Tuttlingen – booth ITVP Denkendorf
November 6–7	34. Hofer Nonwovens Days, Hof – DITF booth
November 13	SmartX Workshop, DITF in cooperation with AFBW e.V.
November 18–21	MEDICA Düsseldorf – ITVP booth
November 28–29	Aachen Dresden Denkendorf International Textile Conference, Dresden
	2020
Jan 30 – Feb 2	TV TecStyle Visions, Messe Stuttgart – Exhibition of the Micro Factory
February 5	Denkendorf Innovation Day, DITF
February 25–26	8th SMART TEXTILES User Forum with guided tour at Airbus, Hamburg – TITV e. V. in cooperation with DITF and FKT e. V.
March 3–5	JEC World 2020, Paris – DITF at the AFBW joint stand
May 5–7	T4M trade fair for medical technology, Stuttgart – booth DITF and ITVP Denkendorf
May 12–14	Techtextil North America, Atlanta – DITF booth

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