RESEARCH HIGHLIGHTS

DEUTSCHE INSTITUTE FÜR TEXTIL- UND FASERFORSCHUNG DENKENDORF

DITF REPORT

May 2023 – No. 2

ITMA 2023

Visit us at the fair in Milan – Booth H3 A311

For the DITF as a leading research partner for the industry in the fields of textile process engineering as well as textile and fiber chemistry, the ITMA, which takes place every four years, is one of the most important trade fair dates. We are pleased to be present again with our own booth from June 8 to 14 and would like to welcome all visitors already on this way.

latter two topics in particular are the focus of many projects at the DITF – due to the digital transformation process and the enormous challenges posed by climate change – and will be presented at the trade fair with many demonstrators. "Sustainability & Circularity" is also the topic of the two presentations that Lea Zimmermann (Self-cooling textiles) and Gabriela

machinery and will present the most important trends and highlights of the trade fair for the industry on June 29. The leading German textile research institutes will come together for this renowned review. In addition to the DITF, the research institutes STFI Chemnitz, ITM Dresden, ITFT University of Stuttgart, TITV Greiz, TFI Aachen and ITA Aachen will be rep-

### In this issue: Focus on Digital Future

In the last DITF Report, we focused on sustainability projects across all pages and received a great deal of positive feedback. What could be more natural than to once again focus our reporting on an overarching topic? This issue is therefore (almost) all about digitization and AI. And for good reason. Currently, there is hardly a project that does not address this topic. Digital technologies of the future, such as AI processes, machine learning and neural networks, must be considered as a matter of principle – be it to optimize production processes through "digital engineering" and to develop solutions for digital transformation, or to advance the functionalization of textile products through the integration of electronic components.

At the world's largest international trade fair for textile and apparel technology, the DITF will present its development work and product innovations along the textile value chain. The thematic focal points and selected exhibits of the DITF trade fair presentation are oriented to the trade fair's guiding themes Advanced Materials, Innovative Technologies, Automation & Digital Future, Sustainability & Circularity. The

Maestri (Innovative Textile Circularity Assessment) will bring to the ITMA program (for dates, see page 8).

ITMA wrap-up
Traditionally, the ITMA Nachlese takes place a few days after ITMA. In 2023, the DITF, together with the Forschungskuratorium Textil e.V., will again invite you to Denkendorf for this informative review of the world's largest trade fair for textile

resented with presentations. Along the textile production chain, they will present relevant product innovations and developments from fiber and fabric production to coating and finishing (nonwoven, woven, knitted, warp-knitted technologies) and digital production. A guided tour through the DITF pilot plants and laboratories after the lecture program will show some of the technologies and new developments in practice.

Cooling capacity of self-cooling textiles

Predictions by determining the absorption curve of materials

As a result of the past and future expected development of global warming, a simultaneous population growth as well as industrial growth, energy-free cooling solutions will play an increasingly important role. Technologies such as radiative cooling offer a sustainable and energy-free solution by using the wavelength regions of the atmosphere that are transparent to electromagnetic radiation, the so-called atmospheric window (8–13 µm), to emit thermal radiation into colder space.

Radiative cooling is a ubiquitous process in which a surface facing the sky loses heat through thermal radiation. The largest object that gives off heat by radiative cooling is the Earth itself. The cooling effect can be seen, among other things, on clear mornings by the
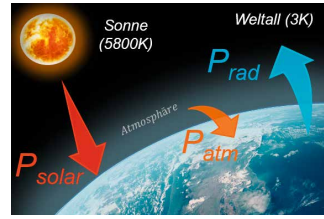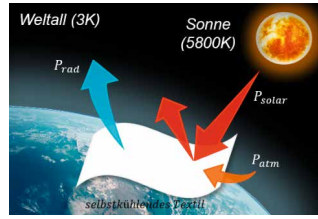

(P_{solar}: solar radiation; P_{atm}: atmospheric back radiation; P_{rad}: thermal radiation between 8-13µm)

Thermal radiation fluxes at the terrestrial surface

Functional principle of a self-cooling material

formation of frost and dew. By using the principle of operation of radiative cooling, cooling can be achieved without external energy input and CO_2 can be saved at the same time.

By radiating heat through the atmosphere to the universe at extremely low temperatures (about −270 °C) rather than to the immediate environment, terrestrial surfaces produce cooling below ambient temperature. If a material in the mid-infrared range (preferably between 8–13 µm) emits more radiation than it absorbs through the sun and the atmosphere, cooling occurs even during the day under full solar radiation.

The cooling performance here depends strongly on the physical properties of the material and the surrounding weather conditions. Spectral analyses can be used to determine the absorption pattern of materials over a wavelength range of 0.25 – about 25 µm, and cooling performance can be sim-

ulated based on this data. The atmosphere is predominantly composed of nitrogen (N_2), oxygen (O_2) and noble gases. In addition, there are aerosols, i.e. solid and liquid suspended particles in a gaseous envelope, as well as trace gases such as water vapor, carbon dioxide (CO_2), methane (CH_4), ozone (O_3), which influence the transparency of the atmosphere and thus the possibility of heat dissipation to cold space. Through the computational model, settings such as solar irradiance, cloud density or humidity can be varied, so that clear statements can be made about the theoretical cooling potential of materials under different external weather conditions.

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Invest BW – Focus on digitalization and AI

DITF launched three projects

In the second mission-oriented funding round of Invest BW, the largest single-company funding program in the history of Baden-Württemberg, the DITF are participating with three projects. The focus in this round is on projects in the field of digitalization and artificial intelligence. The DITF started the following projects here:

Project AutoCut
Project partner: erler gmbh
Development of a fully automated textile cutting and sorting system for the apparel industry. Development of a service-oriented production system that reliably recognizes fabric textures, creates layer patterns, optimizes cutting parameters and determines gripper coordinates for the textile gripper. Additional further development of gripper and han-

dling kinematics for previously non-grippable, flexurally limp textile qualities.

Project DigiFlamm
Project partner:
diemietwaesche.de gmbh + co. kg
Development of a non-destructive test method for protective clothing against heat and flames. Verification of the protective effect in the regular process of cleaning and reprocessing; use of AI models for the

classification of quality with a few significant key figures.

Project TexScan
Project partner: BRÜCKNER Trockentechnik GmbH & Co. KG, Detagto GmbH, Hahn-Schickard
Development of a new type of textile scanner to record textile properties for process control in the stenter frame. Integration of different sensor data to determine textile properties such as weight, optics, light transmission, thickness, topography, water retention, heating time to predict textile processes such as thermal treatment.

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Textile sample   **Textile scanner**   **AI analysis**   **Process control**
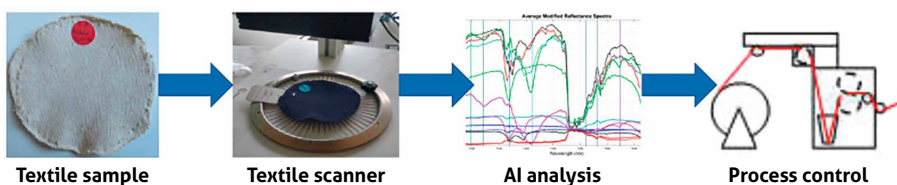
Process chain in the TexScan project

Energy saving on the stenter frame

ExPerTex: Development of a knowledge-based assistance system

Drying and fixation processes on the stenter frame are among the most energy-intensive processes in the textile industry. Energy price increases and political requirements for minimizing emissions of climate-damaging greenhouse gases inevitably demand savings in stenter frame treatment in finishing plants. Cost savings are possible in electricity consumption as well as in heat management. What has been lacking so far are systems linked to the plant control system that combine process sensor technology and process data acquisition with quality control. This would allow machine settings and production parameters to be flexibly adapted to frequently varying processes and ensure maximum energy efficiency.

The core innovation of the BMWK project "ExPerTex" consisted in the development of a knowledge-based assistance system as a web application,

Stenter frame of the company BRÜCKNER in the technical center of the DITF

which textile finishers can access to create a recipe and machine setting optimized for their specific application and machine. DITF's project partners were BRÜCKNER Trockentechnik GmbH & Co. KG and PLEVA GmbH. By integrating adapted sensor technology in

the stenter frame, essential characteristic data of a process can be recorded in the form of drying progress curves (TVKs). In the project, the DITF analyzed such TVKs depending on various characteristics such as type of textile substrate, finishing or coating agent. From this, suit-

able AI algorithms determine the best process parameters for new textiles. For a previously not treated textile, each finishing process can now be calculated in advance through the physical, mathematical modeling and thus makes it possible to predict how much time and energy a process will require. The work forms an important basis for end-to-end digital twins of products and processes in the textile value chain.

In parallel, the DITF are working on models for evaluating the sustainability of products and processes. Here, too, the results of the project provide the starting point for further work, enabling companies, for example, to determine the product carbon footprint of their product range.

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Electrically highly conductive tracks

Laser sintering of digitally printed metal dispersions

The development of textile products with integrated electronics offers a broad field of activity for SMEs. With new functions and possible applications, smart textiles offer promising development and sales prospects for the textile industry. The electrical connection of electronic components is still done by complex integrated metallized fibers or microcables, since the production of printed electrically conductive structures on textiles has not yet been satisfactorily solved. Until now, multiple printing with extremely expensive silver inks and subsequent thermal

sintering at high temperatures has been necessary.

As part of a joint project funded by the state of BW, a new process for the printing-based production of highly conductive structures for smart textiles is now being developed by the project partners dp-solutions, GSB-Wahl, ilm Ulm and DITF Denkendorf. For this purpose, digital printing is combined with laser sintering and inks based on inexpensive metals are developed using easily pyrolizable stabilizers. This, together with the development and elaboration of suitable application and sintering pa-

rameters as well as through specifically adapted pre- and post-treatment of fabrics, will make it possible for the first time to produce particularly low-resistance electrically conductive structures by digital printing and to use them for the production of intelligent textiles.

The innovation of the project can be seen in the novel combination of digital printing and laser treatment and the development of easily pyrolizable inks, which makes it possible for the first time to use the digital printing process economically for the production of smart tex-
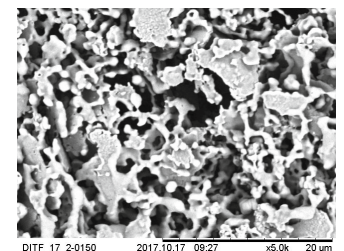
SEM image of a printed and laser-treated metal dispersion

tiles. As a result, flexurally flexible and highly conductive thin metal layers are realized, which can be used as low-resistance conductor paths and for electrical contacting.

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Mittelstand-Digital Zentrum Smarte Kreisläufe

The DITF support SMEs in their orientation in the field of digitization

On March 1, 2023, the new Mittelstand-Digital Zentrum Smarte Kreisläufe started at the DITF. Under the management of the Confederation of the German Textile and Fashion Industry textil+mode and together with the partners ITA Institut für Textiltechnik of RWTH Aachen University, Sächsisches Textilforschungsinstitut in Chemnitz (STFI) and DER MITTELSTANDSVERBUND – ZGV, the DITF offer support for small and medium-sized enterprises across all industries and make them fit for the future. At the DITF in Denkendorf, digital engineering can be experienced with a focus on supply chain, circular economy and artificial intelligence.
With events and publications, the DITF helps with orientation in the field of digitization and

finding initial approaches for tangible digitization projects. The center's scientists provide neutral and free information on future-relevant technologies and familiarize SMEs with the potentials of digitization.
For more information:
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The Mittelstand-Digital Zentrum Smarte Kreisläufe as demonstration centre and Innovation Hub is part of the nationwide Mittelstand-Digital network.
The AI instructors based at the Hubs also offer special support on all issues relating to the use of artificial intelligence – for beginners through to experienced users.

Mittelstand-Digital Zentrum Smarte Kreisläufe

What is Mittelstand-Digital? Mittelstand-Digital offers guidance for small and medium-sized enterprises and the skilled crafts as they embrace the digital transformation, informs them

about the opportunities and challenges of digitization and provides financial support for digitization projects. The Federal Ministry for Economic Affairs and Climate Action makes it possible for all of these services to be rendered free of charge.
For more information, visit www.mittelstand-digital.de.

The team of the Mittelstand-Digital Zentrum Smarte Kreisläufe at the DITF: Project Manager Alexander Artschwager, Dr. Heiko Matheis, Christine Schoch, Bastian Baesch, Christoph Riethmüller, Tobias Hecht, Dr. Michael Haupt (from left to right).

Digitally controlled yarn coating

Spatial resolution coating for sensory yarns with length information

For private consumers, smart textiles have so far mainly been visible in the areas of health and fitness, for example in sportswear for monitoring pulse rate. In order to achieve greater market penetration of smart textiles, the product functionalities must be increased and the manufacturing processes implemented more cost-effectively, among other things. Currently, sensory yarns can already be functionalized well for various purposes with the help of wrapping technology. This is done, for example, by helically wrapping a conventional yarn with one or more fine wires. In an IGF research project, wrapping yarns with different capacitive-sensory areas within a yarn were investigated. This means that it is no longer only

possible to measure whether the yarn has been touched, but also in which section.
The length-dependent yarn coating required for this purpose was successfully implemented by modifying common application methods. By raising and lowering the yarn using the kiss-roll method, yarn sections were left out during coating. Alternatively, a roller with partial recesses was applied. An automated process

for location-dependent coating is available with the aid of digitally controllable nozzles for water-based solutions as well as for thermoplastic materials. This allows yarn lengths to be left uncoated, to receive a low coating or a completely enveloping coating in a very flexible manner. The variability of the capacitive properties on the yarn sections is achieved by conductive additives.

The yarns produced in this way were processed into textile sheet structures, with the textile structure being designed in such a way that several sensor yarns run towards each other and, when touched or loaded, sensor signals can be picked up at the respective crossing points. These signals can then be assigned to a specific area in the textile surface. In this way, the detection of complex contact and load patterns is possible. It has been shown that the capacitive sensitivity of the sequential areas can be adjusted in steps with different coating formulations and the variation of the number of wraps as desired.

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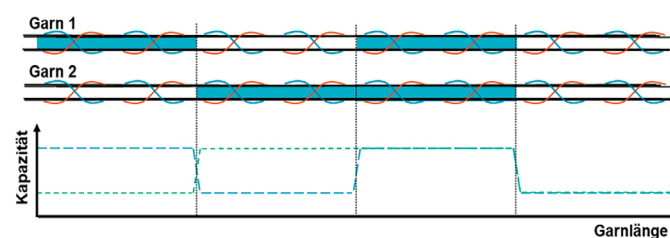
Functional principle of position-sensitive sensor yarns. Blue: electr. conductive coated yarn length – white: uncoated

Energy efficient air jet weaving

Numerical simulation makes it possible

Air jet weaving is the most productive weaving technology with a speed of up to 1,200 weft insertions per minute. Since there are no moving parts in the weft insertion process, this technology is very reliable. However, the high productivity comes at the price of high energy consumption for weft insertion with compressed air. In view of rising energy costs and the carbon dioxide emissions associated with energy production, it is important to reduce compressed air consumption and also increase productivity.

One of the most important components for weft insertion is the main nozzle system, and weaving machines are usually always equipped with several main nozzles. The problem here is that with several main nozzles, only one is arranged parallel to the reed channel, while the others are inclined to
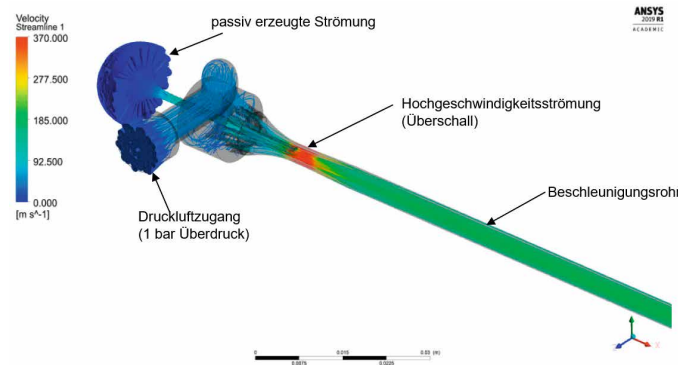
CFD simulation of air flow during shot insertion at the reference nozzle

the reed channel. As a result, a lot of compressed air is lost to the rear or above the reed and, at the same time, weft insertion errors are caused by unfavorable flow conditions.

In the IGF project "Energy saving nozzle", a new main nozzle system with a single nozzle and multiple feed pipes is being developed. This nozzle has only a single acceleration tube, which is optimally positioned for weft

insertion parallel to the reed channel, providing the basis for significant advantages:

> higher energy efficiency due to lower compressed air consumption

> lower material costs by avoiding the need for special reeds, and

> higher productivity due to the possibility of double weft insertion.

Due to the retrofittability, a very large market can be addressed. Numerical simulation is used as the central development tool. Computational Fluid Dynamics (CFD) simulations are used to analyze the mode of action and flow conditions of the reference nozzle and to simulate and evaluate different variants of the proposed main nozzle design. Furthermore, a simulation model will be developed to calculate the weft insertion of a yarn with consideration of the yarn-air flow interaction. By using state-of-the-art measurement techniques (particle image velocity and high-speed camera technology), the CFD simulations will be verified. The most promising variant will be produced and tested as a functional sample.

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Development of textile floor coverings

Use of Digital Material and Process Twins and AI

The development of textile products typically comes along with high material, time, personnel and cost consumption. The corresponding development processes are characterized by an empirical approach based on the know-how of experienced specialists. Their experience is often hardly documented and thus cannot be retrieved and reproduced at any time. Due to the age structure of employees in the textile industry and the general shortage of skilled workers, the long-term transfer of knowledge is thus at risk. This applies in particular to the development and manufacture of textile floor coverings, which are character-

ized by long product life cycles. The challenge here, in addition to the efficient development of new designs, is therefore to ensure consistent product quality. This applies in particular to established products, provided that the raw materials/semi-finished products that can be supplied vary and may consist of recycled materials.

In an IGF project, the DITF together with the TFI at RWTH Aachen University are developing Digital Material and Process Twins that can be experimented with and used in combination with AI methods to realize digital product development. This digital development process supported by AI enables accel-

erated adaptation to uncertain material properties and varying product designs, as well as rapid stabilization of processes, especially when using recycled materials. This reduces waste and ressource consumption,

thus increasing process efficiency – even for small batch sizes. Overall, a reduction in development costs of up to 60 % is expected.

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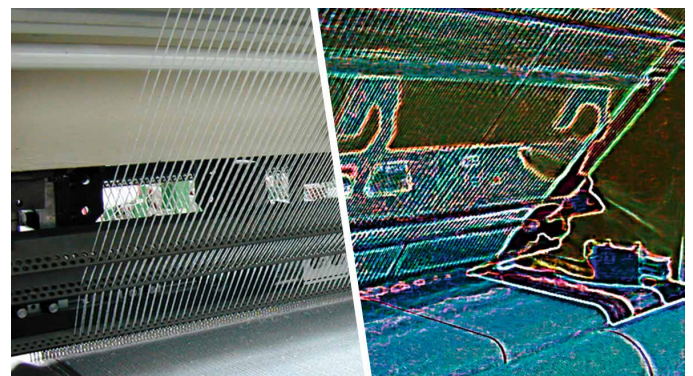
Tufting machine and its digital twin – symbol image

CELLUN

A new fiber composite made from biopolymers

In collaboration with the project partners CG TEC, Cordenka, ElringKlinger, Fiber Engineering and Technikum Laubholz, the DITF are developing a new fiber composite material (CELLUN) with reinforcing fibers made of cellulose. The matrix of the material is a thermoplastic cellulose derivative that can be processed using industrial processing methods such as hot pressing or pultrusion. CELLUN made from renewable biopolymers enables the replacement of glass or carbon fibers in the production of industrial molded parts.

Organosheets are increasingly being used in the fast-growing segment of lightweight fiber composite construction. Organosheets are pre-consolidated semi-finished sheet products with a matrix of thermoplastics and various reinforcing fibers in a wide variety of textile designs. The thermoplastic matrix allows the organosheets to be processed using "fast" processes established in the industry, such as hot pressing, thermoforming, injection molding with organic sheet inserts or pultrusion. These processes produce highly recyclable, highly functionalized components with reproducible quality.

The textile reinforcement of the organosheets consists mainly

Starting materials for the production of sustainable composites

of glass, carbon, basalt or aramid fibers. These fibers have high stiffnesses and tensile strengths, but are energy-intensive to produce and recycle and can only be recycled in an increasingly low-grade condition. In contrast, the CELLUN composite developed at the DITF is a much more sustainable alternative. For the production of CELLUN, the reinforcing component is combined from nonfusible cellulose fibers and thermoplastic derivatized cellulose fibers as matrix to form a hybrid roving. Regenerated fibers from Cordenka and HighPerCell® cellulose fibers developed at the DITF are used as cellulosic reinforcing fibers.

CELLUN is now being further developed to industrial maturity as part of a joint project funded by the BMWK. The tasks of the DITF in the CELLUN joint project are primarily the production of suitable cellulose-based reinforcing fibers and the embedding of the fibers in the thermoplastic cellulose derivative matrix. The material is further processed into technical hybrid rovings and hybrid textiles in the company's own technical facilities. Finally, pultrusion and thermoforming processes or injection molding can be used to produce molded parts that illustrate the technical applications of the new material.

In the further course of the project, the focus will be on the complete recycling of the CELLUN material after the end of life (EOL). Two different approaches are being researched for this purpose. On the one hand, it is possible to thermally reshape CELLUN molded parts without any loss of quality. A second possible approach is to chemically separate the CELLUN material into its individual components again. These can then be used again as 100% new starting materials.

Hybrid textile made from a hybrid yarn

As an environmentally friendly, resource-saving and cost-effective alternative to established composite materials in the lightweight construction and automotive sectors, the novel CELLUN materials will offer a real advantage in the market for semi-finished technical products. By using renewable biopolymers, CELLUN will make a significant contribution to environmental and climate protection: on the one hand, conventional crude oil-based plastics can be substituted, and on the other hand, CELLUN reinforcing and matrix fibers can be produced with only low energy input and from natural raw materials.

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Project partner of the joint project CELLUN:

CG TEC — Innovative Faserverbund Technologie

CORDENKA®

elringklinger

DITF — DEUTSCHE INSTITUTE FÜR TEXTIL+FASERFORSCHUNG

FIBER ENGINEERING — FIBER BLOWING TECHNOLOGIES

TLH TECHNIKUM LAUBHOLZ

Associated partner:

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manaomea

Climate protection in textile production

Polyester fibers bind CO_2

Start for an EU-wide collaborative project: Under the leadership of the French company Fairbrics SAS, 17 project partners from seven European countries are coming together. The common goal is to produce end products from polyester in a closed cycle using industrial CO_2 emissions and to bring them to market maturity. In the process, the DITF produce synthetic fibers from plastics of non-fossil origin.

In order to achieve the European climate targets, a long-term and sustainable reduction of greenhouse gases is aimed for. To achieve this, CO_2 emissions must be reduced in the energy sector, in industry, and in households and small consumers. This is the starting point for the EU-wide collaborative project "Threading CO_2", which is funded under the EU's Horizon funding program. The project involves bringing products made of environmentally friendly polyester (PET) to market maturity. The technologi-

Polyester fibers and granules from DITF

cal basis has been developed by Fairbrics SAS from France. It involves the production of monoethylene glycol (MEG), the starting material for the manufacture of polyester, using CO_2 extracted from industrial waste gases. This is a completely new approach, because in the classic process fossil raw materials are consumed for the production of polyester.

In this way, not only is the release of CO_2 into the atmosphere directly prevented but the CO_2 also contributes to increased added value by being incorporated into the production of high-quality textile products. The core of the project is the technological upscaling of the new MEG synthesis process in pilot plants, paving the way for industrial production.

Within the consortium, the DITF will take on the task of accompanying the upscaling and taking the step "from molecule to material": From the sustainably produced monoethylene glycol, polyesters are synthesized in our own laboratories, spun into fibers, textured and further processed. The aim is to test whether the quality of the polyester and its spinnability and processability are comparable with conventional polyester.

The project partners Faurecia and Les Tissages de Charlieu process the fibers and textiles into car seats and clothing so that the quality can also be assessed in the end product. The subsequent recyclability of the products will also be tested at the DITF. In addition, a security marking for this CO_2-based polyester will be developed to protect it from product piracy.

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"Best CO_2 Utilisation 2023" Innovation Award

DITF award for the "CellCO$_2$" project

Around 250 participants from 30 countries around the world attended the Innovation Award ceremony at the Conference on CO_2-based Fuels and Chemicals 2023 in Cologne. New and innovative research approaches in the fast-growing field of CO_2 capture and utilization were presented at the established event on "Carbon Capture and Utilization" (CCU).

The Innovation Award presented at the conference honors outstanding research results that enable new ways of capturing climate-damaging CO_2

from the atmosphere. One of these "direct air capture technologies" is the technology presented by the DITF under the name "CellCO$_2$". It involves textile, cellulose-based materials for capturing CO_2 from the air. Highly efficient CO_2 capture is achieved by means of textile-fixed amines bound to the surface of cellulose fibers and nonwovens. Installed in air filters, these materials can be used in a particularly energy-saving way: First, they bind the CO_2 from the air, then they release it again with a relatively

low energy input for subsequent use or permanent storage.

The Innovation Award was sponsored by YNCORIS Industrial Services. The award was

presented with their partners and event organizers, the "nova-Institute" and "CO_2 Value Europe".

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Dr. Marc Vocht accepts the 1st prize for the DITF

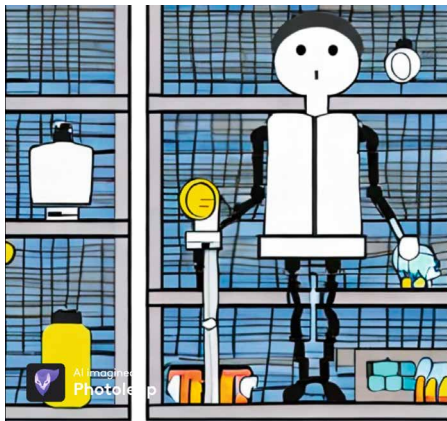# ChatGPT – Understanding, potentials and risks

Training and sensitization of employees at the DITF

The current media coverage presents ChatGPT very ambivalently, from the savior to the end of the world caused by AI. In these portrayals, there is usually too little explanation of the underlying technology and the resulting strengths and weaknesses. This is precisely where the training and awareness lecture by in-house specialists from the areas of IT and AI and the DITF data protection officer came in.

First, Dr. Heiko Matheis, who has been active as an AI trainer

AI-generated image for "AI works in a research institute" (www.photoleapp.com)

for SMEs for many years, explained machine learning in its various forms. In particular, he clarified that AI solutions are already being used in several research and consulting projects at the DITF.

He vividly demonstrated that ChatGPT builds on the repeatedly used model of the generative pretrained transformer (GPT) and extends it with a user interface, so that an almost human dialog (chat) is created. For this purpose, techniques from the AI fields of natural language processing and machine learning are combined.

Guido Grau then used concrete examples to demonstrate the potential of ChatGPT. The tool can be used in many areas to simplify and accelerate routine activities. Whether it is a matter

of answering standard mails or creating the basic framework for an agenda, a presentation or a social media post, in all cases ChatGPT immediately provides the first concrete result texts on which the user can build.

However, it is essential to check generated texts for correctness. Supposed facts provided by ChatGPT can quickly turn out to be false and invented. This is because the strength of AI models to work with uncertainties and possibly compensate for them poses a problem here.

This was illustrated by Guido Grau's request to ChatGPT for assistance with a literature search. The result was deceptively real looking literature list, none of which really existed.

Carsten Linti, the data protection officer, pointed out further risks and dangers in dealing with ChatGPT. He made it clear that many legal questions have not yet been answered. He urged users not to enter any personal data at ChatGPT. Also, no information about company and business secrets should be included in the communication, because all data entered by the user would be stored on servers outside the EU, as IT specialist Ralph Stoltz explained. The great interest of the employees and their participation in the subsequent discussion round

made it clear how important events of this kind are. With this presentation, the DITF seamlessly continue the events of a similar nature previously held at the partner institutions AFBW and innBW.

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Fairs & Events

June 08 – 14	ITMA, Milan – DITF booth and presentations Innovator Xchange, Hall 3: Lea Zimmermann, Self-cooling textiles – energy-free method using radiative cooling technology, 10.06.2023 Gabriela Maestri, Innovative Textile Circularity Assessment through a Business-to-Business Webservice with Blockchain Technology, 06.13.2023
June 15	Innovation Day for SMEs of the BMWK, Berlin – DITF booth
June 29	ITMA-Nachlese, Denkendorf – DITF in cooperation with Forschungskuratorium Textil e.V.
September 13 – 15	Dornbirn Global Fiber Congress GFC – DITF: lectures, booth in the foyer exhibition
October 17 – 19	ESMA Academy, Digital Printing on Textiles, Denkendorf – DITF: organization, lectures
November 01 – 03	IFAI Expo 2023, Orlando, Florida, USA – DITF booth
November 08 – 09	36th Hofer Vliesstofftage, Hof, Germany – DITF: lectures, booth in the foyer exhibition
November 13 – 16	Medica/Compamed, Düsseldorf Germany – DITF booth together with ITVP
November 21	GoTex 2023 Reutlingen University – DITF booth
November 30 until December 01	Aachen-Dresden-Denkendorf International Textile Conference 2023, Dresden – DITF booth in the foyer exhibition

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