TECHNISCHE UNIVERSITÄT DRESDEN

Research Report 2020

Institut für Leichtbau und Kunststofftechnik

List of Abbreviations

TUD	Technische Universität Dresden
ILK	Institut für Leichtbau und Kunststofftechnik der TU Dresden

General Funding Information

Projects of the Institute for Lightweight Engineering and Polymer Technology are cofunded from

- the European Regional Development Fund (ERDF),
- the European Social Fund (ESF),
- the Federal Ministry of Education and Research (BMBF),
- the Federal Ministry for Economic Affairs and Energy (BMWi),
- the German Research Foundation (DFG),
- the Excellence Initiative of the federal and state governments,

and from tax revenues on the basis of the budget enacted by the members of the German Bundestag or the Saxon State Parliament.

Content

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Structural Assessment
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Prof. Dr.-Ing. Niels Modler

Chair of Function-integrative Lightweight
Engineering

Introduction

The year 2020 was largely determined by the Corona pandemic and undoubtedly represents a caesura; on a global and national societal as well as economic level. But the last 12 months have also brought radical changes to our daily work. New forms of teaching, research, cooperation and communication had to be found, implemented and adopted ad hoc. Within a few weeks, we managed to digitize all courses, learn unfamiliar forms of practicals and exams, and advance research work almost entirely in the digital space. Unfortunately, however, we also had to cancel the Dresden International Lightweight Engineering Symposium for the first time.

The initial paralyzing feeling gave way over the summer to a dull sense that we will be working as a "team at a distance" for a long time to come. In this context, the – from the point of view of the ILK board – successful emergency response of the TU Dresden should be emphasized, which served as a practical guideline and ensured a maximum of safety for us and our employees. Despite all the downsides, the situation also shows that the competence profile that has been successful in science corresponds well with what the pandemic demands of us – the ability and willingness to communicate as well as the ability to organize ourselves. This is certainly also the reason why the year 2020 again held many successes in store for the ILK. In addition to the extremely successful acquisition of several fundamentals oriented DFG research projects and the application-oriented research within the framework of numerous EU, BMBF, AiF and SAB projects, the technology transfer program for lightweighting of the BMWi is particularly worthy of mention this year. We were able to place our topics with extraordinary success, which is not least a recognition of our practice-oriented competences and the high topicality of our ready-to-transfer technologies. This success was crowned in December with the approval of the "National Lightweight Engineering Validation Center" by the BMWi and the PTJ. Here we will pave the way – associated with the term "neutral lightweight engineering" – to a resource-neutral production of sustainable lightweight solutions and open up new research and application (transfer) fields together with proven partners. Following on from this, research work in the field of hydrogen technologies for climate-friendly mobility at the ILK, in particular on H2 storage and conduction, which is also implemented in the context of the hydrogen strategy of the TU Dresden, should also be mentioned.

At this point, we not only invite the partners of our approximately 100 current research projects to proactively support us on the way to "neutral lightweight engineering" or to contribute together with us to master this global effort. Because the pandemic is currently showing the positive but also destructive forces in our society as if under a burning glass. So how would it be if there were a similarly energetic race to overcome climate change as there has just been in the development of vaccines?

With this positive thought, we wish you a successful and healthy 2021 and hope you will find some starting points for solving our global challenges in this year's ILK research report as well.

The Year 2020

For Corona help: recyclable face shields in record time from design to product

Within just three days, engineers and students from the Institute of Lightweight Engineering and Polymer Technology at TU Dresden, together with the research association DRESDEN-concept e. V. and biosaxony e. V., the charity Kunststoffschmiede* and the company 1st Mould GmbH, have realized a mount for face shields from design to finished product. The component is manufactured by injection molding and can thus be produced in a significantly higher number of units than previously comparable 3D-printed solutions.

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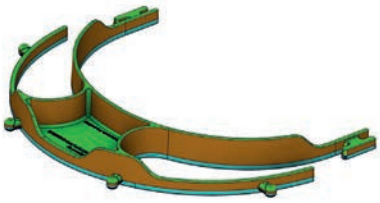

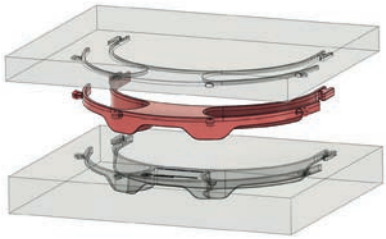

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Following the first reports of demand for medical protective equipment from the Dresden clinics, a design was developed for a face shield, which was initially implemented using the 3D printing process and made available to the medical staff for testing. However, the subsequent sharp increase in demand could not be met with the quantities that could be achieved using the 3D printing process. ILK employees therefore brought up the idea of an injection molding process that could increase the production of urgently needed face shields many times over. Within only three days, a design suitable for injection molding could be developed together with Kunststoffschmiede* and 1st Mould GmbH and was implemented as a real component with a very high quantity of currently approx. 35,000 pieces. The special concern of Kunststoffschmiede* is that with the solution developed, recycled plastic waste can also be used to manufacture the face shields. The closed material cycle achieved in this way not only protects the environment, but is also very resource-efficient.

The data for the production of the injection-molded components was deliberately made open source by the partners involved so that other facilities and companies can also start production and thus contribute to meeting demand. Interested facilities can download the data from the following link and use it for their production: https://github.com/Kunststoffschmiede/Kuss-Faceshield-Frame/wiki/Injection-moulding.

* Kunststoffschmiede im Konglomerat e. V.

Innovative hydrogen pressure storage systems for optimized integration into the vehicle structure

At the start of the "Decade of Hydrogen" proclaimed by the Hydrogen Council at the beginning of 2020, the Institute of Lightweight Engineering and Polymer Technology at the TU Dresden is making a significant input into making road traffic emission-free in the long term through its participation in the BRYSON project (BauRaumeffiziente HYdrogenSpeicher Optimierter Nutzbarkeit) funded by the Federal Ministry of Economics and Energy.

The aim of the project consortium (BMW AG, ILK, Leichtbau-Zentrum Sachsen GmbH, WELA Handelsgesellschaft mbH, Munich University of Applied Sciences) is to develop new types of hydrogen pressure storage systems. These should be designed in such a way that they can be easily integrated into universal vehicle architectures. The project therefore focuses on the development of tank container systems in flat design.

For this purpose, the ILK is developing chained tubular storage tanks in close cooperation with LeichtbauZentrum Sachsen GmbH and herone GmbH, which are manufactured from semi-finished thermoplastic fibre composite products using braiding processes. The use of highly productive braiding technology offers the possibility of reducing the manufacturing costs of hydrogen tanks for fuel cell vehicles and improving competitiveness compared to battery electric vehicles.

The use of semi-finished thermoplastics also allows easy recycling of the tank structures after their use, further improving the overall ecological balance of the Dresden approach.

Technological leap innovation from Dresden – Fibre composites and metal sheets joined by laser welding

Researchers at TU Dresden have succeeded for the first time in permanently joining fibre composite structures to metal sheets by laser welding. The scientists were able to completely dispense with additional joining elements. With the novel technology developed in the AiF-funded project "Metal-FRP Joint", hybrid structures can be produced easily and functionally in the future using this industrially established joining process.

Hybrid structures made of metal and fibre-reinforced plastic (FRP) composites are what make intelligent lightweighting possible in the first place, since area-specific material and component properties can be adjusted. An essential prerequisite for this are economical solutions for joining the individual components that are suitable for the stresses and materials involved. To this end, the Institute of Lightweight Engineering and Polymer Technology of the TU Dresden has developed a novel technology based on laser welding in its joining techniques group. The plant technology for this was provided by the Steinbeis Innovation Center Dresden.

The development approach is based on hybrid reinforcement textiles, which were developed at the Institute of Textile Machinery and High Performance Material Technology (ITM) of the TU Dresden. Here, the metallic elements are incorporated by textile technology. These form metallic surfaces in the FRP component, which are used for welding technology joining with metal sheets. So far, the feasibility has been demonstrated using steel sheet and epoxy resin-based composites as examples. However, the technology is in principle transferable to a wide variety of material combinations. The process offers the potential to achieve increased joint strengths and benign failure behavior. In addition, the researchers are convinced that this innovative solution approach will enable series-production-ready and also economical integration of FRP components in metal bodies.

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

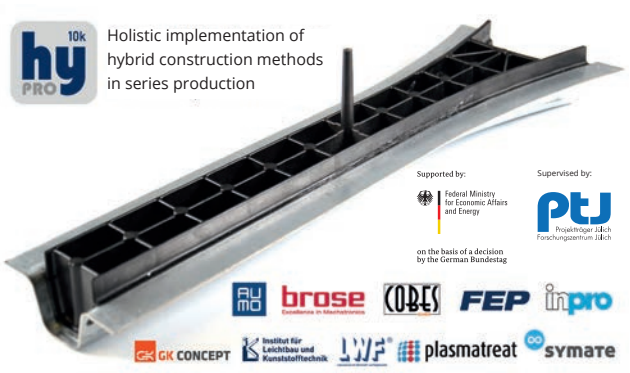
The IGF project (No. 18930 BR) of the research associations Forschungskuratorium Textil e. V. (FKT) and Europäische Forschungsgesellschaft für Blechverarbeitung e. V. (EFB) was funded by the Federal Ministry for Economic Affairs and Energy via the AiF as part of the program to promote joint industrial research and development (IGF) on the basis of a resolution of the German Bundestag.

The goal: series production of hybrid structures

Together with ten project partners under the coordination of Brose Fahrzeugteile SE & Co. KG, Bamberg, scientists from the Institute of Lightweight Engineering and Polymer Technology at TU Dresden are developing a combined physical and virtual process chain for fibre composite plastic-metal hybrids in the project "hypro – Holistic Implementation of Hybrid Structures in Series Production". The aim is to make the production of hybrid components industrially suitable for series production and at the same time competitive.

Hybrid structures made of metal, thermoplastic-fibre composite and plastic offer considerable lightweighting potential, but have not yet been established on a large-series scale. Existing uncertainties with regard to process capability and the effective process-structure-property relationships are to be specifically eliminated in hypro. The core of the process chain to be developed will be a flexible manufacturing cell based on injection molding combination technology, which will allow fully automated plasma-based pretreatment of a wide range of metallic materials. The continuous inline acquisition of process data in the tailored plant, mold and handling technology will provide a comprehensive database for process analysis. Proof of process capability and comprehensive data acquisition are carried out in a unit number range of 10,000.

The hybrid structures are also to be digitized throughout the development, characterization and production processes. The merging of real and simulation data will then enable calculation-based non-destructive inline quality assurance and the prediction of component properties.

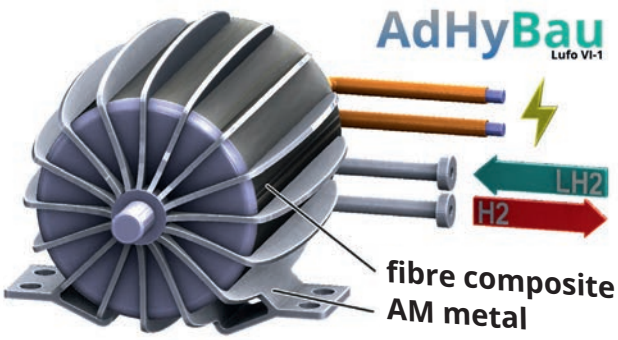


In the project, the researchers and developers also want to develop methods for the efficient design and layout of hybrid structures based on the virtual mapping of the process chain. In particular, their ability to be integrated into assembly lines for series production will be investigated using established joining technologies, and disassembly and repair concepts will be developed.

The scientists will demonstrate the practical readiness of the developed process chain using a safety-relevant structural component. In doing so, the team led by Prof. Maik Gude and Dr. Robert Kupfer intends to demonstrate the predictive capability of the process and structure simulation and its suitability for industrial practice.

The joint project hypro, funding code 03XP0284J, is funded by the Federal Ministry of Education and Research on the basis of a resolution of the German Bundestag under the supervision of the Project Management Agency Jülich PTJ.

Hybrid designs with generative metal structures and fibre composites for high-performance electric motors



Generative manufacturing technologies enable optimized cooling systems and a specific coil design to increase the power density of next-generation electric motors.

As part of the AdHyBau research project, SIEMENS AG, MT Aerospace AG, the Fraunhofer Institute for Mechanics of Materials (IWM), the Institute for Technical Physics (ITEP) at the Karlsruhe Institute of Technology (KIT) and the Institute of Lightweight Engineering and Polymer Technology at the TU Dresden are developing new additive processes and fibre composite-metal hybrid designs for use in cryogenic environments. End-to-end design, simulation and material qualification processes are being developed to put a novel electric drive into operation as a virtual prototype.

The main objective of the work to be carried out at the ILK is to explore novel fibre composite-metal hybrid designs. The combination of high-performance fibre composite materials with additively manufactured metallic elements enables structures that are significantly enhanced in terms of their functionality and performance.

This key technology contributes to power-dense, efficient and low-noise drives and is thus a central component of the mobility of the future.

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

The project is funded under the first call of the sixth civil aviation research program of the German Federal Ministry for Economic Affairs and Energy for three years until 2023.

Final colloquium

Under the motto "Sustainable Innovations for Materials, Components and Production Processes", the partners of the Saxon Alliance for MAterial- and Resource-Efficient TechnOlogies – AMARETO presented their research results in the areas of targeted material design, linked development processes and resource-efficient production.

The colloquium, designed as a web conference, offered scientists and users from industry and research a platform for practical information and professional exchange.

European Union
Europe funds Saxony.
EFRE
European Regional Development Fund

This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.

Institute of Lightweight Engineering and Polymer Technology held successful industry project workshop on hydrogen-based hybrid electric drive systems for civil aviation – potentials for the economy in Saxony

Aviation is facing the major challenge of minimizing the impact of air traffic on people and the environment and making an appropriate contribution to achieving the goals of the Paris Climate Protection Agreement. Already at the 1st National Aviation Conference in Leipzig on August 21, 2019, representatives of the German aviation industry and politicians spoke out in favor of better climate protection and formulated corresponding goals in the position paper "Leipzig Statement for the Future of Aviation". In this way, German aviation is to become more environmentally friendly and sustainable in the future, while remaining internationally competitive and offering secure jobs.

In mid-September 2020, the Institute of Lightweight Engineering and Polymer Technology of TU Dresden, together with Rolls-Royce Deutschland (RRD) and the Saxony Economic Development Corporation (WFS – Wirtschaftsförderung Sachsen GmbH), organized a project workshop on the topic of "hydrogen-based hybrid electric propulsion systems for civil aviation – potentials for the economy in Saxony" to have a look at initiatives for hybrid electric flying. The TU Dresden and Rolls-Royce Deutschland have already enjoyed a long and successful cooperation – the TU Dresden is home to one of the world's 29 Rolls-Royce University Technology Centers (UTC) with a focus on lightweight materials and structures and robust design.

The aim of the workshop was to identify players in Saxony and Brandenburg who are involved as partners in corresponding research projects or who could be considered as suppliers in the field of hybrid electric drive systems. For this purpose, research and development topics that go beyond the current and planned activities in Brandenburg and Saxony were discussed in a video conference. The focus is on technologies for hydrogen-based hybrid electric drive systems for aviation.

In view of the above-mentioned challenges and in the course of the structural change in the coal-mining region of Lusatia, an initiative for the development and implementation of hybrid electric drive systems in Brandenburg had already been launched, with the engine manufacturer Rolls-Royce Deutschland (RRD) playing a major role in this initiative. The industry workshop will extend this initiative to Saxony, thus laying a major foundation stone for establishing eastern Germany as a leading, future-proof aviation location in the field of flying with sustainable propulsion systems.

New board elected – Leichtbau-Allianz Sachsen e. V. bundles the scientific expertise of Saxony's lightweight engineering sector

After the three-year founding phase, the general meeting of the Leichtbau-Allianz Sachsen e. V. (LAS) on December 3, 2020, the board of directors was newly elected. The future board of directors will consist of Hubert Jäger (Institute of Lightweight Engineering and Polymer Technology at TU Dresden), Lothar Kroll (Institute of Lightweight Structures at TU Chemnitz), Rudolf Kawalla (Institute of Metal Forming at TU Bergakademie Freiberg), Jens Ridzewski (IMA Material Research and Application Technology GmbH) and Robert Böhm (HTWK Leipzig). In the immediately following constituent meeting of the board of directors Hubert Jäger and Lothar Kroll were jointly elected as chairmen. Gerhard Rödel (TU Dresden) did a very good job in the founding phase of the LAS and did not rerun for the board elections due to his age. The new board of directors appreciated his merits in the structuring phase of the association and wishes him for his further life way all property and much health.

To the Leichtbau-Allianz Sachsen e. V.

The aim of the Leichtbau-Allianz Sachsen e. V. is to further bundle the experts based in Saxony and researching in the field of lightweight engineering technologies, because this networking strengthens science and increases Saxony's visibility as a leading international lightweight engineering research region. As the scientific contact for the Saxon economy, we cooperate closely with companies in the relevant sectors and existing associations and networks. The Leichtbau-Allianz Sachsen e. V. invites all scientific institutions, centers and clusters active in lightweight engineering research to benefit from this Saxon networking and to help shape Saxony's position in lightweight engineering.

The Leichtbau-Allianz Sachsen e. V. was initiated in the summer of 2016 as a network of the three technical universities in Chemnitz, Dresden and Freiberg. This was followed at the end of 2017 by the founding of the association of the same name, which now has over 50 institutional and personal members. The members of the association are comprehensively supported both in establishing contacts and transfers as well as in the representation of interests, public relations work, research and advice on public financing possibilities and numerous events. About the association, its goals as well as current projects, members and events the website www.leichtbauallianz-sachsen.de informs.

Key technology lightweight engineering: Leichtbau-Allianz Sachsen provides recommendations for action for business, science and skilled workers

Saxony is Germany's formative state in the field of lightweight engineering. Already today, around 75,000 jobs in Saxony are directly related to lightweight engineering. This is one of the impressive results of the study "Masterplan Excellence in Lightweight Engineering" commissioned by the Saxon State Ministries of Economics, Labour and Transport and of Science, Culture and Tourism, which the Leichtbau-Allianz Sachsen 2020 was able to hand over as part of the LightSax project.

"Particularly in the aerospace, automotive and transportation sectors, lightweight engineering offers many opportunities to open up new markets. The dependence of Saxony's economy on the automotive sector, which is currently undergoing major changes, could thus be countered and sustainable value-added and growth potential could be created," says Prof. Rudolf Kawalla, Prorector for Research at TU Bergakademie Freiberg and Chairman of the Leichtbau-Allianz Sachsen, summarizing the conclusions of the master plan. According to the study, lightweight engineering research and the transfer of knowledge and technology to Saxony's economy are to be strengthened and additional training opportunities created in order to increase Saxony's expertise and visibility in this key technology.

Compared with the rest of Germany, research institutions in Saxony are very successful in attracting third-party funding for lightweight engineering research. There are currently more than 500 current or planned research projects involving lightweight engineering. However, about two-thirds of the respondents stated that the lightweight engineering competencies are not sufficiently perceived outside of Saxony. It is therefore also important to further increase the visibility of lightweight engineering in Saxony, e. g. by bundling initiatives and facilitating transfer to industry: "Lightweight engineering means researching and developing at the limits of physics. This requires a profound understanding in many fields of knowledge, such as materials mechanics, design methodology and process design and life cycle analysis. A technological lead can only be achieved with an interdisciplinary team

that transfers the results directly into practice," clarifies Prof. Lothar Kroll, Head of the Department of Lightweight Structures and Polymer Technology at Technische Universität Chemnitz. Science minister Sebastian Gemkow adds another aspect: "Not only the development of lightweight products or materials is an important concern of Saxon research and companies, but also the disposal and recycling is increasingly coming into focus. That is why recycling management in lightweight engineering has also become a key issue. I anticipate numerous new research projects in this area on the part of the Lightweight Engineering Alliance, supported by its partners in non-university research and industry."

Networking of small and medium-sized enterprises beneficial

Around 90 percent of the business representatives surveyed as part of the study consider the expansion of the lightweight engineering product portfolio to be central to opening up new markets. Nevertheless, the mostly small and medium-sized enterprises (SMEs) in lightweight engineering identify clear challenges in market access. The respondents see a need for optimization particularly with regard to the application of new findings from research, but also with regard to central coordination and the external presentation of the industry. In addition, according to the study, risks in the company's own research and development are difficult to calculate from the company's point of view, so that the transfer of research results from research institutes and universities plays a special role. This, according to the study, represents a central starting point for the future approach of the Free State in the area of lightweight engineering.

Saxony's minister of economics and labor, Martin Dulig, emphasizes: "Lightweight engineering is a key technology that is particularly important in view of the greater energy and material efficiency that is being sought in many areas. In Saxony, we have the best prerequisites for exploiting this potential. The master plan shows ways in which this potential can be exploited even better in the future. The exchange between companies, as well as between industry and research, is important in order to generate added value in Saxony and create jobs in the medium and long term as well."

More training opportunities for professionals

As the study also shows, Saxony already lacks skilled workers with specific lightweight engineering knowledge. In contrast, the respondents rate the training of both skilled workers and university graduates in the state as comprehensive. The SME representatives in the sector also agree that the migration of skilled workers to other regions should be counteracted. They also say that continuing education programs for immigrants do not yet meet the needs of the business community.

Prof. Hubert Jäger, board member of the Institute of Lightweight Engineering and Polymer Technology at the TU Dresden, emphasizes that "even in times of high ecological social orientation, lightweight engineering is not a matter of course across all corporate hierarchies and

is difficult to communicate. Successful implementation is therefore only possible if everyone works 'hand-in-hand' to achieve an ecological result. Training and continuing education programs must therefore be expanded as a matter of urgency. Special consideration must be given to recyclability, digitalization for production and use in the construction industry for building, civil engineering and bridge building, the future market with the highest global growth potential."

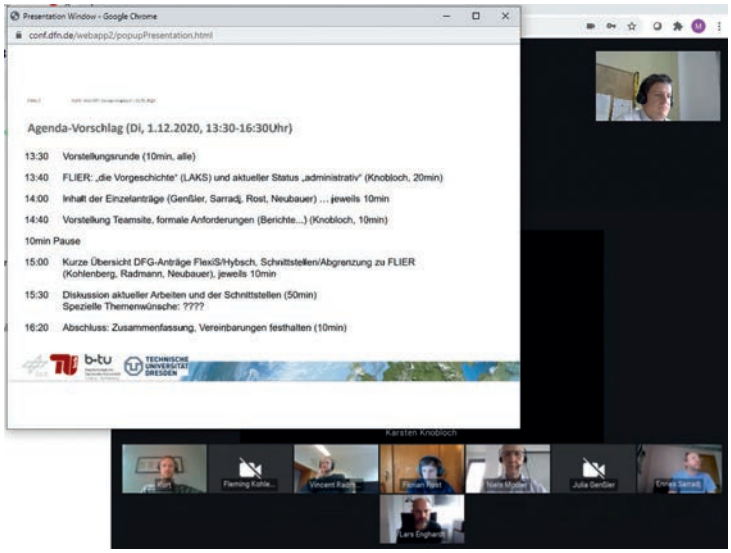
Background: "Excellence in lightweight engineering" master plan

The master plan, which was presented in Freiberg on October 12, 2020, was developed by scientists from the technical universities in Chemnitz, Dresden and Freiberg. The joint project "Potentials of Lightweight Engineering in Science and Industry in Saxony (LightSax)" was implemented with the participation of the Institute of Lightweight Structures at TU Chemnitz, the Institute of Lightweight Engineering and Polymer Technology at TU Dresden and the Institute of Metal Forming at TU Freiberg taking on the role of coordinator. The Leichtbau-Allianz Sachsen supported the project in its organizational activities.

Masterplan Excellence in Lightweight Engineering

https://leichtbau-allianz-sachsen.de/lightsax/

Light, quiet aviation – project launch of the FLIER joint project



As part of the joint project "Flexible Wall Structures for Acoustic Liners" (FLIER), employees of the Technische Universität Berlin (Institut für Strömungsmechanik und Technische Akustik, FG Turbomaschinen- und Thermoakustik and FG Technische Akustik), the Brandenburgische Technische Universität Cottbus-Senftenberg (Lehrstuhl für Flug-Triebwerksdesign) and the ILK are researching and developing noise-absorbing plastic structures for use in aviation.

Currently, liner structures based on the well-known Helmholtz resonator principle are used in engines for noise damping and are thus primarily effective in a narrow frequency range. Future generations of engines will be characterized above all by larger diameters combined with reduced length, and will therefore have comparatively less usable surface area for noise damping measures. The aim of the FLIER project is to use new liner technologies both to increase their acoustic effectiveness and to greatly extend the effective frequency range.

In the previous project, LAKS, the first test specimens were designed and manufactured to demonstrate the basic effectiveness of the new liner technology. In the recently approved follow-up project FLIER, the ILK will focus on developing suitable manufacturing strategies for the production of curved or curvable liners. The aim of the joint project is to create a comprehensive design concept, develop the manufacturing process, implement it in terms of production technology and carry out functional tests on a laboratory scale.

Supported by:
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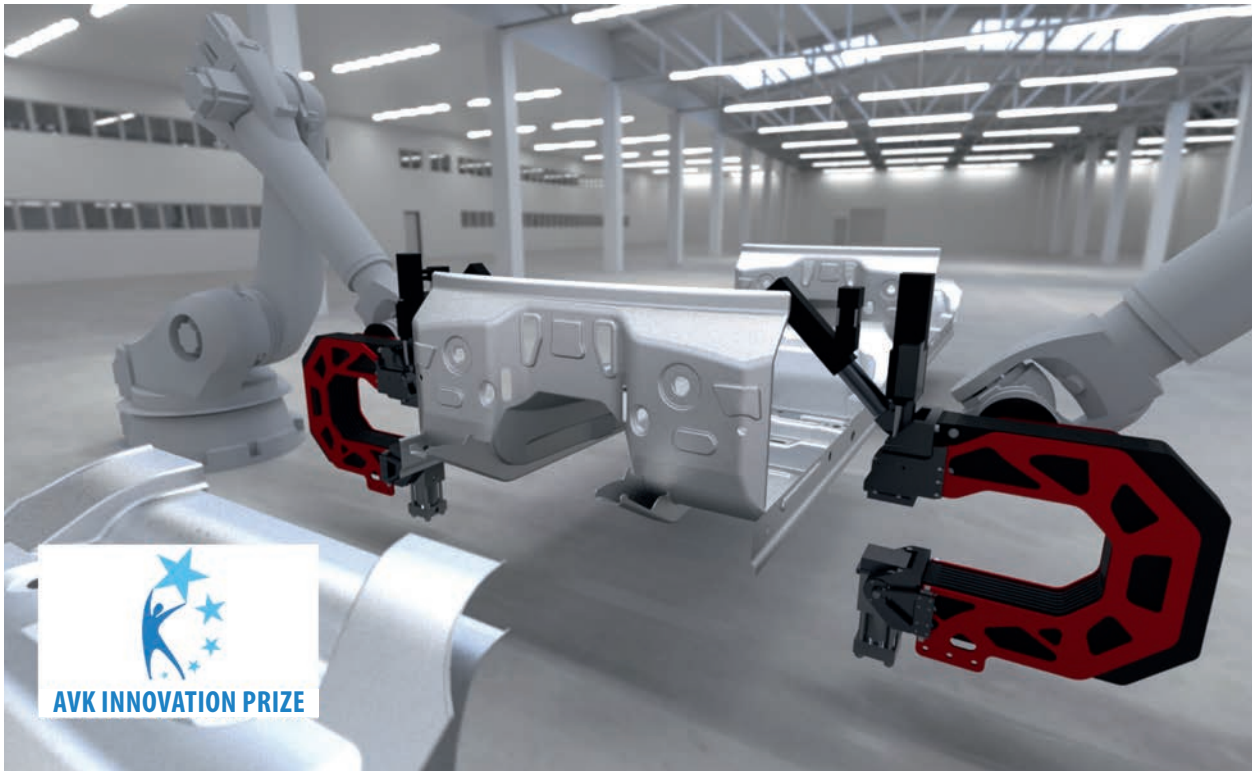
on the basis of a decision by the German Bundestag

The project is funded under the Federal Republic of Germany's aeronautics research program (LuFo VI-1) for 3 years until 2023.



ROBIN process technology and scenario for the use of several systems in assembly lines was awarded the AVK Innovation Prize

Multiple awards for ILK-StartUp ROBIN

After the successful start of the EXIST research transfer in March 2020, the founding team around Dr. Michael Krahl has received awards in several innovation competitions with their idea of mobile injection molding. By using carbon fibres in a composite C-frame of an injection molding machine, it was possible for the first time to build the machine with a weight of less than 140 kilograms. This means that it can be attached to a robot, for example, and moved freely in space. This mobility and flexibility in system technology will revolutionize injection molding in the production of hybrid components. In addition to the silver award of the IQ Innovation Award Central Germany in the automotive category, the idea of "Robotised Injection Moulding" (ROBIN) was able to convince the jury of the AVK Innovation Award in the Processes and Procedures category, which is why it awarded the founding team first place. In the evaluation criteria of the AVK Innovation Award, special emphasis is placed on the sustainability of the submissions. "We see the award as confirmation and further incentive on our way to bring the new way of thinking of mobile injection moulding to the market", Dr. Michael Krahl emphasizes in his acknowledgement.

The founders can currently rely on the ideal conditions for start-ups at the Institute of Lightweight Engineering and Polymer Technology at TU Dresden. In the context of this close partnership between StartUp and university, Prof. Dr.-Ing. habil. Maik Gude confirms "With our strategy at the ILK we want to promote technology transfer in Saxony through spin-offs with high-tech lightweight solutions and sustainable business models".

The multitude of possibilities to produce components with a unique variability and to integrate them into existing production lines is the big advantage and the biggest challenge at the same time. After all, this procedure turns production upside down to such an extent that completely new ways of thinking are required. In order to master this, the founding team accompanies the first customers in the product development process from the early stages of pre-development. Ultimately, it is the declared goal of the founding team to integrate ROBIN systems technology into modern production lines in such a way that the comprehensive advantages can be exploited to the maximum.

Presentation of the certificate by WAK member Prof. Dr. Maik Gude to Dr. Michael Stegelmann

WAK Award 2020 for ILK scientist

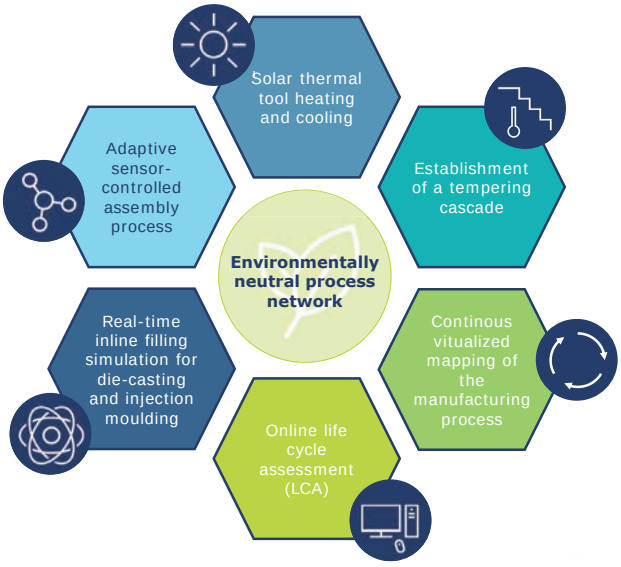
The Scientific Alliance of the University Professors of Plastics Technology (WAK) annually awards prizes for the best scientific work in the field of plastics technology. This year, ILK scientist Dr. Michael Stegelmann was delighted to receive the Brose Prize for new processes and techniques in plastics processing. In his dissertation entitled "On the extrusion of amorphous high-performance thermo-plastic pipes with variable wall thickness", Dr. Stegelmann made a significant contribution to enabling extrusion technology for the variable production of aerospace piping systems.

In high-tech fields of application, such as aviation, lightweight engineering technologies based on high-performance polymers create enormous potential for sustainable mass reduction. In connection with the increasing volume of aviation and the associated production of aircraft, there is a need for completely new production architectures with levels of automation that have not been common in this industry until now. This is why classic, highly automated and mass-producible plastics processing methods such as injection molding or extrusion are becoming increasingly interesting. The challenge here is the implementation of a component manufacturing process that meets the high demands of aviation and offers a wide range of variants, as well as the reproducible processing of high-performance polymers.

In this context, Dr. Michael Stegelmann has developed novel, analytical design models which for the first time allow to predict the process limits for variable process control on the basis of the polymer's extensional rheological properties. This makes it possible to cover the high product variety of piping systems in the aviation industry with economically reasonable utilization of the plant technology. The resulting increase in the variability of production technology is a major trend in mechanical and plant engineering in the plastics industry, in order to achieve a higher degree of individuality of the products while exploiting the high output rates.

A METEOR has hit

On 16.12.2020, the kick-off of a very special research project took place in the currently typical context of a video conference. The aim of the joint project METEOR (Methods and Technologies for Validating and Optimizing the Resource Efficiency of Process Networks in the Production of Lightweight Structures) is nothing less than to demonstrate ways of reducing CO2 emissions by up to 80 percent in the production of lightweight structures by 2030. Under the leadership of the Institute of Lightweight Engineering and Polymer Technology at the TU Dresden, numerous, proven partners from industry and research have come together to initially explore new avenues in solar-assisted temperature control (gwk Gesellschaft Wärme Kältetechnik mbH – Meinerzhagen), online life cycle assessment (ILK) and inline simulation (KraussMaffei Technologies GmbH – Munich; Institute for Product Engineering (IPE) of the University of Duisburg-Essen) of production processes as well as the robot-assisted joining of plastic/metal composite structures (Böllhoff Verbindungstechnik GmbH - Bielefeld; Laboratory for Materials and Joining Technology (LWF) of the University of Paderborn). This first stage is funded by the Technology Transfer Program Lightweighting (TTP Leichtbau) of the German Federal Ministry for Economic Affairs and Energy (BMWi) and accompanied by the Project Management Agency Jülich (PTJ) .



"METEOR is the first of a whole series of projects with which we want to make a noticeable contribution to reducing CO2 emissions in the industrial production of sustainable lightweight structures" said Prof. Dr. Maik Gude from the ILK. "This project is of outstanding importance for Saxony and in particular for Dresden as a location for lightweight engineering, as it forms the basis for the National Lightweight Engineering Validation Center (LEIV) on Zwickauer Strasse." In this center, a hitherto unique, largely environmentally neutral production network is to be realized by 2030. The LEIV will thus become an incubator on an international level that will significantly simplify and accelerate the transfer of know-how to the real economy through the demonstration on an industrial scale of economically and ecologically sensible solutions. "Dresden has been a recognized center for modern lightweight system design among excellent researchers since the early 1990s. "The fact that we can now also establish such an application-oriented center at the University of Excellence TU Dresden, supported by the BMWi, is the logical consequence and has long been expected by our international industrial and research partners" said Prof. Dr. Maik Gude.

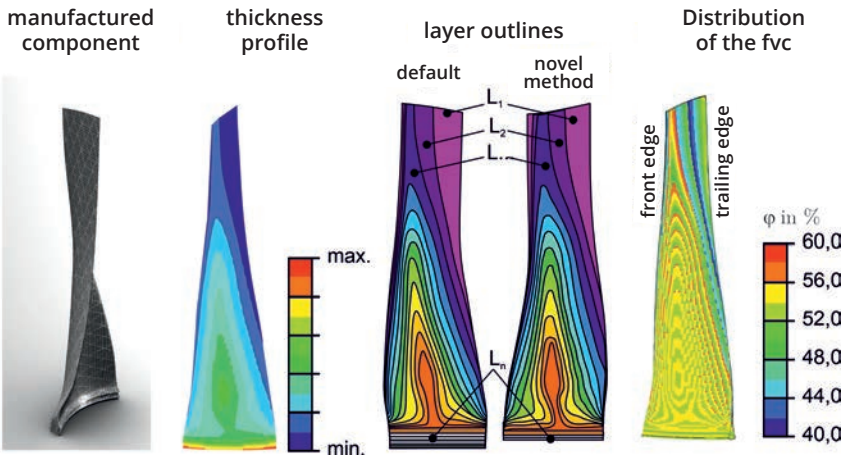
Institut für Leichtbau und Kunststofftechnik
LWF
KraussMaffei Pioneering Plastics
ipe
gwk
BÖLLHOFF
Supported by: Federal Ministry for Economic Affairs and Energy on the basis of a decision by the German Bundestag
Supervised by: ptj Projektträger Jülich Forschungszentrum Jülich

Doctorates

Doctorate Dr.-Ing. Roman Koschichow

On the design of fibre composite components under Consideration of the variable fibre volume content

Supervising Professor: Prof. Dr.-Ing. habil. Maik Gude



The ever-increasing demands on structural components in terms of resource-efficient handling of the materials and energy-efficient use are leading to the increased use of high-performance materials with high lightweight engineering potential, such as fibre-reinforced composites.

The utilisation of the full performance of this materials requires the use of adapted development process the use of suitable design tools. Innovative methods for increasing the achievable quality of an FE analysis can contribute to significantly reducing the development times of these components. However, reliable modelling methods must be integrated into the numerically structure analyses in order to achieve the desired comparability between virtual and behaviour of composite components. Particularly for fibre reinforced polymers (FRP) components with varying component thicknesses and complex geometry, relevant material-specific parameters, such as fibre and matrix properties, local fibre properties, local fibre volume content and compactness of the textile semi-finished products cannot be neglected. The same applies to production-related factors in the preforming process, such as layer design, compaction and fibre volume content change. Many of these parameters influence each other and often interact.

Within the scope of the work, a new method for the design of FRP components was developed, which includes the material-specific and manufacturing-technical aspects into the design process and thus specifically addresses deficiencies of existing approaches are specifically addressed and remedied. In particular, the fibre volume content, which is the key parameter of every FRP component, plays a central role in the the method that has been developed.

Using the example of an FRP turbine blade, it was possible to show, that the consideration of the non-constant distribution of the of the fibre volume content significantly increases the quality of the results. By the physically justified assumption of the locally variable stiffness values in the structure under investigation, the percentage deviation of an average of 12.7 % with a scatter of 3 % to only 5.2 % with a scatter of 0.63 % in relation to the experiment. The results of the numerical and experimental analyses impressively show a significant improvement of the design process of FRP components. With regard to the accuracy and efficiency of numerically efficiency of numerically supported component analyses, this approach is of high practical relevance.

Doctorate Dr.-Ing. Thomas Behnisch

On the influence of transverse pressure-induced damage on the mechanical properties of textile reinforced ceramics matrix composites

Supervising Professor: Prof. Dr.-Ing. habil. Maik Gude

Textile composite ceramics have very high density-specific stiffnesses and strengths that remain almost constant well into the high-temperature range. The direction-dependent properties of these fracture-tolerant ceramic composites can be tailored and advantageously adapted to specific application characteristics. Therefore, textile composite ceramics offer enormous potential for applications in high-temperature lightweight engineering.
The understanding of materials for these composite materials with predominantly planar textile structures has been steadily improved in recent years, so that a description of the material behaviour in the plane of the textile reinforcement structure is possible with the existing mathematical models. However, there are reservations about unrestricted use, primarily for safety-relevant components, as uncertainties remain regarding the complex material behaviour under stresses in the direction of the composite thickness (out-of-plane). In particular, there is currently limited experience with so-called transverse compressive stresses and their effects on the in-plane behaviour.
Within the scope of this work, a comprehensive, scale-spanning in-situ structure investigation (fig. 2) as well as an analysis of the damage and failure behaviour under transverse compressive stress, which is still pending for textile composite ceramics, could be carried out. For the first time, the correlation between the textile composite ceramic material structure and the material behaviour under transverse compressive stress was demonstrated. The knowledge gained on damage phenomenology and failure behaviour thus contributes to a significantly improved understanding of the material. Based on this, a damage and failure model validated for in-plane loading was extended to predict the transverse pressure-induced property degradation, so that in addition to the mathematical description of the influence of transverse pressure-induced damage on the mechanical properties of textile composite ceramics, an improved prediction of the deformation, damage and failure behaviour is possible.

Fig. 1: PhD Commission (from left to right): Prof. Modler, Prof. Kästner, Dr. Behnisch, Prof. Michaelis, Prof. Gude, Prof. Ullrich

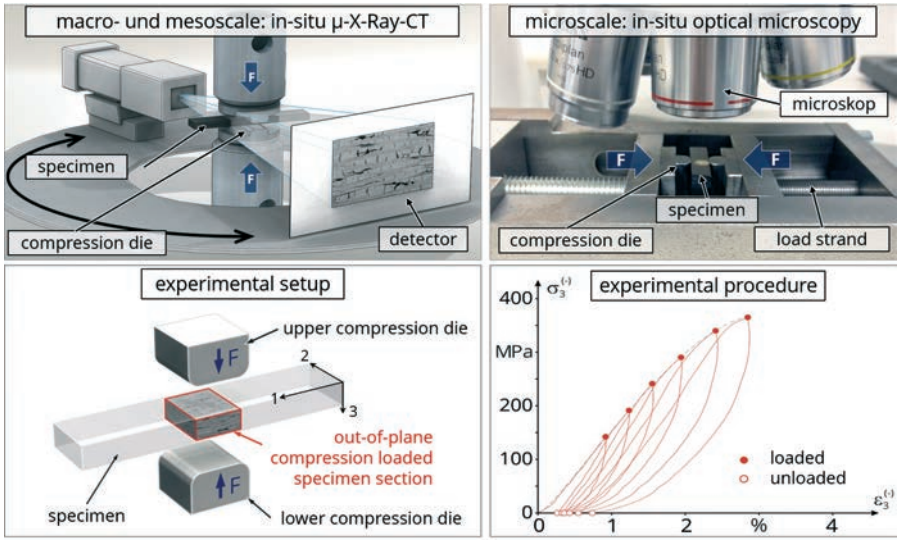


Fig. 2: Experimental procedure for cross-scale in-situ structure investigation under transverse pressure loading

Doctorate Dr.-Ing. Oliver Weißenborn

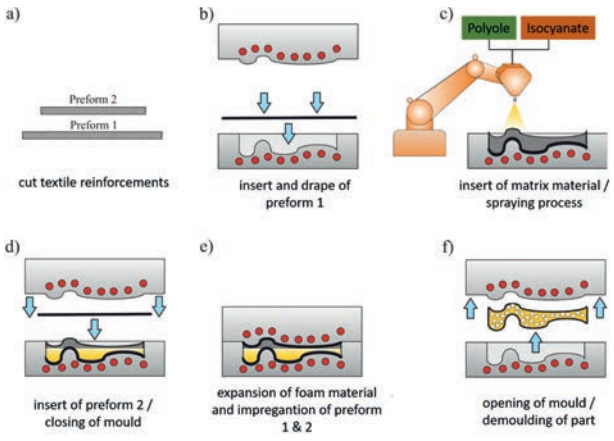
Development of a novel foam impregnation process for the manufacturing of textile-reinforced polyurethane based sandwich structures with complex geometry

Supervising Professor: Prof. Dr.-Ing. habil. Maik Gude

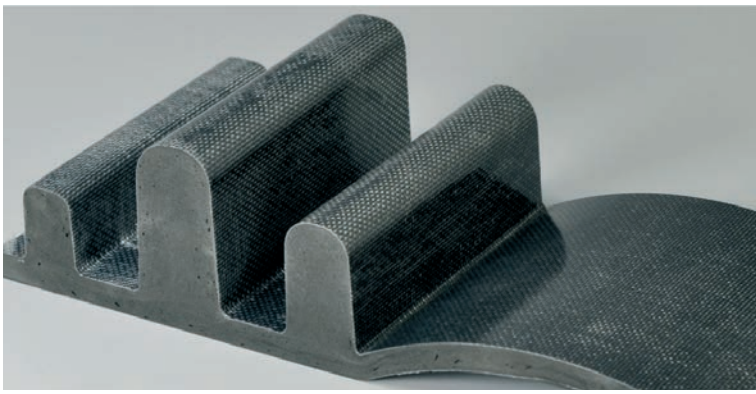
The sandwich construction method with the separation of the component cross-section into highly rigid and high strength cover layers and a shear resistant core with low density represents an established principle for the design of lightweight structures. Due to their high density-specific mechanical properties, continuous fibre-reinforced plastics in the outer layers and polymer foams in the core of the sandwich structure are of outstanding importance for cross-industry applications.

Classical manufacturing processes for complex geometries using thermoset matrix systems are usually based on multi-stage and thus discontinuous process steps, whereby the sandwich core and core layers are often manufactured separately from each other, partly manually and with separate moulds. In the present work, a novel manufacturing process based on foamable polyurethane is developed in which a simultaneous production of sandwich cover layers and core takes place. The scientific basis for the foam impregnation process has been laid in comprehensive process studies. In order to identify significant parameters influencing the degree of impregnation and the morphology of the textile-reinforced sandwich cover layers, methods in the framework of statistical design of experiments were applied and thus test specimens manufactured following optimized production parameters. Based on this, an experimental analysis of relevant material- and structural-specific mechanical parameters was conducted. The results built the input for the development of suitable models, predicting the deformation behaviour under bending and impact loads. The comprehensive results were transferred into application-oriented design guidelines for the design of sandwich composite structures manufactured using the foam impregnation technology. The high amount of material-specific degrees of freedom, such as the resulting core layer density, the fibre type and the fibre mass content in the area of the semi-finished reinforcements, offer a wide range of possibilities for designing tailor-made composite structures.

By implementing a prototypical demonstrator structure with high geometric complexity, the developed models for predicting the degree of impregnation in the cover layers were validated. At the same time, the high potential for cross-industry applications in the field of robust and complex shaped structural components can be demonstrated.



Schematic representation of the foam impregnation process



Prototypical demonstrator structure with complex geometry consisting of foam impregnated textile-reinforced cover layers and polyurethane core layer

Doctorate Dr.-Ing. Tilman Orth

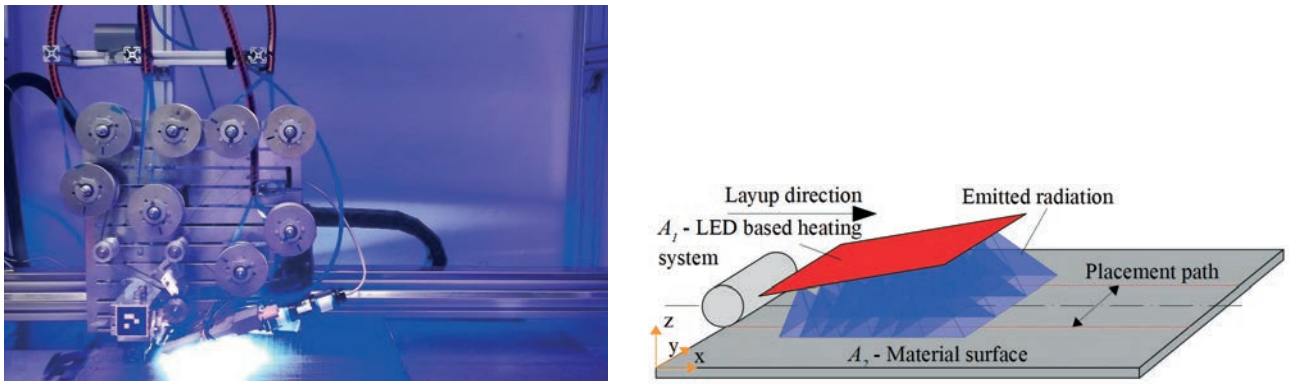
LED-based heating system for Automated-Fibre-Placement

Supervising Professor: Prof. Dr.-Ing. Niels Modler

Automation is a key enabler for the widespread structural application of carbon fibre reinforced plastics in civil aircraft construction. Nonetheless, several components of the applied automated-fibre-placement (AFP) machinery in thermoset layup still offer room for optimisation. This is especially true for the typical infrared lamp based heating system which is significantly less understood and well developed than in layup of thermoplastic material where diode lasers are utilised. Those lasers offer a short reaction time, precise control and a homogenous heat up, while the infrared lamps are less bulky, considerably cheaper and do not require sophisticated safety precautions.

Therefore, a new heating system based on the use of a multitude of LEDs as radiation source has been developed with the aim to combine the advantages of both pre-existing systems. An analysis of the process and the material allows choosing the most suitable LEDs which have been arranged into a heating device that is capable to actively control the profile of the emitted radiation to enable an adaption to different processing situations. A test campaign in a dedicated laboratory environment has proven the reliable heating according process specifications as well as demonstrating short reaction times. To further profit from the new heating system a numerical model of the heat transfer has been developed to accurately calculate the heat up in the material. By taking into account the impact of each LED individually, the model also predicts the spatial distribution of the occurring heat transfer and thus allows an active control of the temperature field during the process. Thereby, a parameter set that provides a very homogenous temperature field without any additional components has been determined and validated experimentally.

Through the combination of the advantages of infrared and laser systems, the innovative LED-based heating system offers significant improvements for the optimisation of the industrial AFP. Cost reduction can be achieved by utilising off the shelf components as well as their flexible arrangement and integration into newly developed layup systems. Improved energy efficiency and lower maintenance costs further reduce the cost of ownership. The quality of the layup process profits from a more reliable surface temperature measurement, allowing for more robust control loops which are also benefiting from the LEDs short reaction times ultimately allowing faster overall cycle times especially for complex parts.



Laboratory placement unit with LED-based heating system (left), irradiation and heat transfer model (right)

Doctorate Dr.-Ing. Maximilian Schadhauser

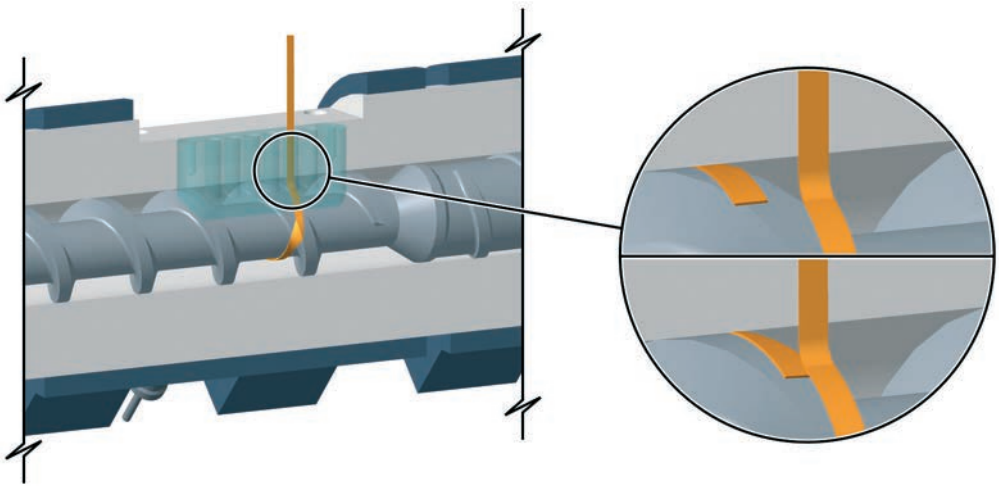
Injection Molding with Continuous Fibre Feed – Method, Model Design and Model Validation

Supervising Professor: Prof. Dr.-Ing. Niels Modler

Driven by cost pressures of international markets and an upcoming urge to preserve limited resources, an increasing demand can be observed regarding new cost-efficient and sustainable methods for manufacturing long-fibre-reinforced thermoplastic parts. Such cost-efficient and sustainable methods may relate to the concept of direct-processing, which is characterized in that the formerly separate steps of compounding and molding are merged into one single processing step. As a result, a reduction of process-related costs and CO2 emissions may be achieved. Yet, on the other hand, process-related savings going along with direct-processing are commonly offset by additional costs relating to a rather complex manufacturing equipment. Hence, especially in the context of manufacturing low-mass plastic components, a balance between process-related savings and additional equipment costs may arise merely in cases in which equipment costs are decreased to a reasonable level.

In the present thesis, a novel direct-processing method is proposed. This method may be associated with low equipment costs and can thus be utilized profitably even in manufacturing low-mass plastic components. A characteristic feature of the novel method resides in that continuous fibres are directly fed into an injection-molding plasticizing unit. Due to this configuration, a preprocessing step utilizing, e.g., a twin-screw extruder is no longer necessary. However, directly feeding continuous fibres into an injection-molding plasticizing unit goes along with difficulties regarding, i.a., fibre impregnation, fibre length structure and fibre-melt homogenization. To overcome these difficulties, a variety of new measures and components has been introduced.

Core aspects of the present thesis relate to obtaining new knowledge about particular sub-processes associated with the novel method. Specifically, issues regarding impregnation, fibre cutting and homogenization have been investigated in line with the difficulties discussed above. Moreover, phenomena related to fibre-melt-conveying and -processing have been analyzed (see fig.). The investigation includes a theoretical approach by means of model design and simulation. The theoretical approach has been supplemented with experimental investigations so as to evaluate a validity thereof. Finally, the novel method has been compared to a conventional method for producing long-fibre-reinforced plastic components.



Fibre conveying inside of an injection-molding plasticizing unit

Expert Groups

Lightweight Design

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The realisation of new ideas, such as neutral lightweight engineering, demands a strategy of holistic product development. Modern lightweight engineering solutions are therefore more than just a matter of simply substituting the material used for an individual component. With this in mind, scientists in ILK's Expert Group on Lightweight Design apply a methodical development approach which focuses on overall systems and functional space in order to ensure the identification of every single opportunity for weight reduction.

Material-specific design and engineering concepts combine with methodical concept analysis to deliver lightweight components and systems – including prototypes – for cross-sector applications developed in close cooperation with international industrial partners. The resultant solutions go far beyond the state of the art. The group's development strategy is characterised by a material-oriented approach that makes it possible to take all potential materials and combinations thereof into consideration – thus paving the way for highly efficient hybrid lightweight components in multi-material design.

Numerical Methods

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The development of modern lightweight structures requires scientists to exhaust every ounce of potential a material has to offer while also enhancing the level of cost efficiency achieved. Computer-assisted methods have a decisive role to play in this regard, and are set to become an even more central element of the development process in the future. In particular, the synergistic connection of computational methods throughout the entire value chain is one of the keys to the development of efficient lightweight structures.

The work carried out by the Expert Group on Calculation Methods and Simulation focuses on the development and realisation of practical methods combining multi-process, multi-material, multi-scale simulation techniques which facilitate the design of efficient lightweight materials, structures and systems in multi-material design. We draw special benefit from ILK's broad-based expertise in the fields of experimental analysis, process engineering and design, which is incorporated directly into both the model development and results evaluation processes. Despite still being shaped by complex interactions between materials, manufacturing techniques, joining techniques and system behaviour, the resultant design and engineering process offers the benefits of enhanced robustness, precision and efficiency.

Our goal is to synergistically exploit the significant amount of relatively untapped material-specific potential offered by novel materials and design concepts for example by digital twins. This sees us combine simulation and analytical methods developed by us in-house with commercially available software solutions.

Thermoplastic Processing

The manufacturing of promising lightweight structures demands the availability of efficient and networked process chains. With this in mind, the research carried out by the Expert Group on Thermoplastic Processes targets maximum efficiency throughout the entire value chain and the ambitious goal of a closed material cycle with simultaneous reduction of energy requirements.

To this end, the expert group manages a complex process network starting with the development,manufacturing and characterisation of novel semi-finished thermoplastic goods with tailored characteristics, for example compounds, films, tapes and organosheets. The next step is to identify and refine new preforming technologies compatible with semi-finished goods, which to date include the near-net-shape wrapping of thermoplastic tapes onto a guide piece and the braiding of complex hollow structures. The process chain ends with the development of efficient manufacturing processes based on injection moulding, compression moulding, pultrusion, extrusion and generative techniques. The unique machine park available at ILK's Process Development Centre (PEZ) enables the group's scientists to set up and test fully automated networked, robust process chains under realistic serial manufacturing conditions. The activities engaged in by the Expert Group on Thermoplastic Processes draw on longstanding experience and extensive know-how gained in connection with the development of innovative tooling, automation and processing techniques for the efficient manufacturing of hybrid thermoplastic structures. The group's process development activities are supported by the use of continuous process simulation.

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Thermoset Processing and Preforming

The development of efficient manufacturing processes which factor in inter¬action between materials, processes and component properties has an increasingly significant role to play in the field of heavy-duty fibre-reinforced composite components based on thermosetting matrix systems. In addition to preforming solutions for textile reinforcement components, demand for robust processing techniques compatible with serial manufacturing technologies and rapid-hardening matrix systems is particularly high.

Research at ILK's Expert Group on Thermosetting Processes and Preforming focuses on the characterisation, modelling and simulation of reactive processes, the engineering of systems and processes for innovative preforming concepts and the development and refinement of novel materials, semi-finished products and corresponding processing technologies. The manufacturing of active composite structures represents another area of research emphasis, which focuses on the targeted exploitation of the moderate process conditions that characterise the processing of thermosetting matrix systems (and in particular polyurethanes). A comprehensive technological equipment enables the group's scientists to make use of both prototypical and serial processing technologies. Areas of focus include braiding, prepreg processing, infusion and injection techniques, and foaming / spraying processing and pultrusion. Interdisciplinary cooperation with ILK's other expert groups is the basis for consistent research in the different subject areas.

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Joining Technologies

The Expert Group on Joining Technologies is an interdisciplinary working and communication platform at the ILK. The aim of the team is to identify the relevant problems in the field of joining technology at an early development stage especially with regard to multi material design. Based on this, application-oriented joining solutions are identified and investigated scientifically.

Therefore it focusses on two approaches: On the one hand established techno¬logies are modified and applied for specific joining tasks, material combinations and load cases. On the other hand novel material-adapted joining methods are developed, analysed and evaluated concerning the application potential. The Expert Group pursues a holistic, material-independent development approach. It includes the technological basics, the material-structural phenomena in joining zones and the modelling of both the joining process and the load-bearing behaviour.

One research focus are intrinsic joining zones which are formed in hybrid structures during component manufacture, e. g. when overmoulding laser-structured or plasma-treated surfaces. Extrinsic joining zones, which enable the integration of hybrid structures into the system environment, are another focus, e. g. the new form-fit joining processes thermoclinching and hotclinching. For the design and dimensioning of joining systems, new methods for the analysis and description of the local material structure in composite materials are developed, e. g. for inserts embedded by warm forming.

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Testing Methods and Experiments

For the design of lightweight structures and systems, the knowledge and mathematical description of the process-specific material properties as well as the deformation, damage and failure processes is essential. Due to the testing equipment at the ILK, it is possible to comprehensively record the material and component characteristics. The characterization can be carried out starting with the determination of the thermomechanical properties of the materials, through the analysis of the stiffness and strength properties of the semi-finished products and substructures, to extremely complex load tests on structures and systems. For the correct use and further development of the experimental methods and the implementation of the findings in material models and validation strategies, the experience and competences are bundled in the specialist group Testing Methods and Material Models.

We thus see ourselves as an open forum for all issues relating to scientific experimentation and description - from the choice of methodology and statistical data evaluation to interpretation and mathematical description. In the area of material models, we therefore concentrate on the elucidation and description of the process-structure-property relationships of reinforced and unreinforced materials. In the area of materials and component testing, we devote ourselves to standardized and specially developed methods of destructive and non-destructive materials and component testing and meet the testing challenges of new materials and hybrid functional structures. We place particular emphasis on structure elucidation and damage detection, mechanical material characterization and rotor testing.

Function Integration

Scientists at ILK see function integration as a physical expression of their interdisciplinarity. Our well-coordinated, multidisciplinary team unites experts from a variety of disciplines including lightweight engineering, electrical engineering, mechatronics and computer science. By ensuring the targeted combination of mechanical, electronic and software-based R&D activities, ILK is able to develop products and solutions that go far beyond the state of the art.

The institute's approach not only combines functions and reduces part numbers at component level, but also factors in system-level interactions that arise as a result of phenomena in a number of different "worlds". This includes the identi-fication and targeted application of cross-sector synergies between fields such as aviation, e-mobility, energy, mechanical and plant engineering, medical technology, consumer products, bespoke machine building and safety equipment. Through the successful cooperation of lightweight design, electronics and software experts and the associated "speaking a common language", the scientists meet the requirements placed on them. One special area of focus is the integration of mechanical, electronic, acoustic, haptic, actuatory and sensory functions into overall systems.

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Novel Materials and Processes

Neutral lightweight engineering is the further development of the previous ILK philosophy "Function-integrative lightweight systems engineering in multi-material design". Modern lightweight construction solutions go far beyond pure material substitution in order to achieve the greatest possible functionality of the component by using the characteristic properties of the materials.

The conscious combination of the outstanding controllability of additive methods with conventional technologies, high-performance fibrous materials, the adaptability of bionic structures, the predictable failure behaviour of metallic materials and the thermal resistance of ceramics makes it possible to tap into unimagined potential and develop components for an increasingly diverse range of applications. ILK's Expert Group on Special Materials and Special Processes has all the expertise required in order to blend technologies and material characteristics to create both generic and tailored solutions.

The Expert Group on Special Materials and Special Processes' main areas of research are metal matrix composites (MMC), ceramic matrix composites (CMC), magnetic hybrid materials (MHM), application of tailormade carbon fibres and interphase functionalities, as well as generative manufacturing techniques such as the 3D printing of components with continuous fibre reinforcement.

Our goal is to use the targeted development and refinement of novel hybrid manufacturing processes and highly loadable composites to establish our vision of "generative multi-material lightweight engineering" as one of the leading international manufacturing technologies for multi-layered composite structures with load-specific 3D fibre reinforcement.

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Selected Projects

SWING

Modelling and simulation of the manufacture-dependent shrinkage behaviour of glass-fibrereinforced 36epoxy resins for the improved prediction of surface-waviness and warpage

The aim of the project is to improve our understanding of the process-dependent shrinkage-induced volume change effects during the processing of thermoset fibre-reinforced plastics (FRPs). To date, the influence of processing pressure on the crosslinking reaction has not been the subject of systematic process-related investigations. Test methods are developed and used to analyze the phenomena occurring in the process on a laboratory scale.

Extensive parameter studies are used to investigate the influence of different process parameters on the formation of surface effects, using various 2D and 3D measurement methods. The structural analysis serves as an essential input variable for the numerical process simulation using material-adapted constitutive laws.

Period

01.02.2019 – 31.01.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

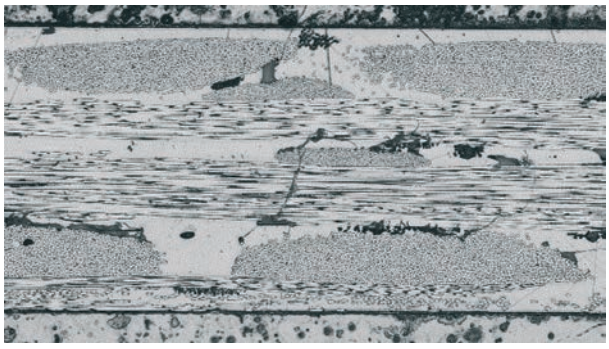
Michael Müller-Pabel
Dr.-Ing. Ilja Koch

Funding

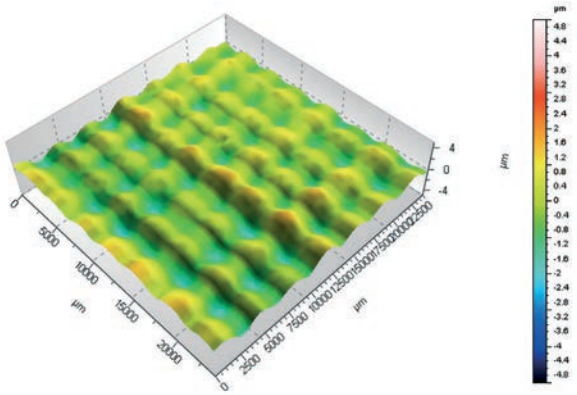
German Research Foundation (DFG)

Project Partner

IKV of RWTH Aachen



Micro-structure analysis of a glass-fibre (GF) reinforced epoxy resin



Topology of an GF-epoxy surface generated by 3D laserprofilometry

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

SFB/TRR 285 A03 – Material Phenomenology

Calculation and evaluation of process-induced material structure phenomena in FRP-metal connections

Fibre-reinforced plastic (FRP) composites with thermoplastic matrix enable the production of lightweight structures within very short cycle times. By exploiting the specific material properties, such as hot formability and anisotropy, joints of dissimilar joining partners with novel assembly interfaces can be realised. The joining processes are accompanied by local changes in the material structure.

Within the scope of the project, a simulation chain from the joining process to the evaluation of FRP/metal joints is being developed. For this purpose, an approach is being developed that allows the influence of process-related processes on the microscopic material structure to be taken into account. Phase I focuses on the process-related fibre deformations on the microscale. The different displacement behaviour of fibres and matrix in newly developed test environments will be investigated. The phenomenological understanding during a joining process is built up by simplified test environments and the FRP is evaluated by means of imaging methods.

The results are the basis for the numerical analyses that predict the material structure during the formation of a joint in the further course of the project.

Period

01.07.2019 – 30.06.2023

Project Director

Prof. Dr.-Ing. habil. Maik Gude

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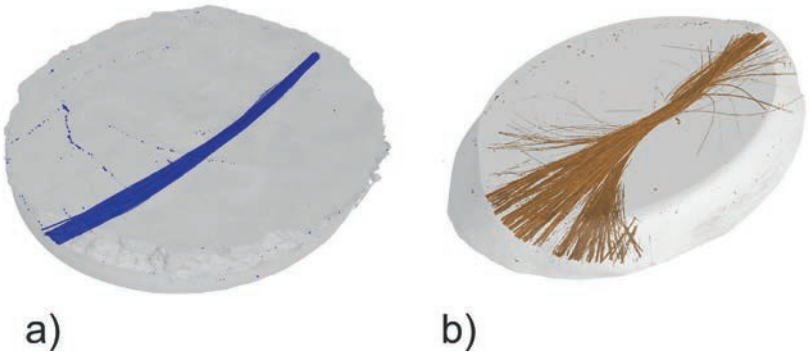
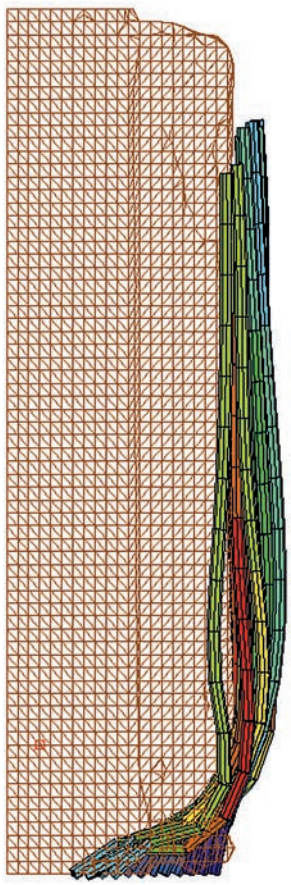
Dr. Andreas Hornig
Benjamin Gröger

Funding

German Research Foundation (DFG)



Investigation of fibre deformation under shear stress of the molten thermoplastic matrix: a) initial state, b) after shearing



Fluid-structure interaction studies for the prediction of fibre displacement behaviour using the example of a large number of flexible structures in a fluid stream

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

DIWA

Consistent analysis and evaluation of manufacturing-related fibre misorientations in thick-walled fibre-plastic composites

Braiding technology and the high-pressure resin transfer moulding (HP-RTM) process are suitable for the efficient production of thick-walled components made of fibre-reinforced plastic (FRP) composites. The stacking of a large number of textile reinforcement layers, the high infiltration speeds in the HP-RTM process and curing effects of the matrix material often lead to production-related composite imperfections such as fibre misorientations. These mainly manifest themselves in the laminate plane, but also become more pronounced in the laminate thickness direction as the laminate thickness increases. The resulting imperfections are detected, analysed and evaluated in this research project using the example of test panals and a generic test structure made of glass fibres and polyurethane resin. For this purpose, the sequential production steps from insertion of the dry preform into the infiltration tool, through high-pressure infiltration to curing are examined and documented in a research data management system. Furthermore, the direction-dependent impregnation behaviour of thick-walled mesh structures is characterised with a novel test method and described by representative volume elements. This provides information on the phenomenology of the formation of composite imperfections, the effects of which are evaluated by thermomechanical load tests. The results obtained serve as a basis for planned work on process simulation.

Period

01.04.2020 – 31.03.2023

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Richard Protz
Lukas Quirin

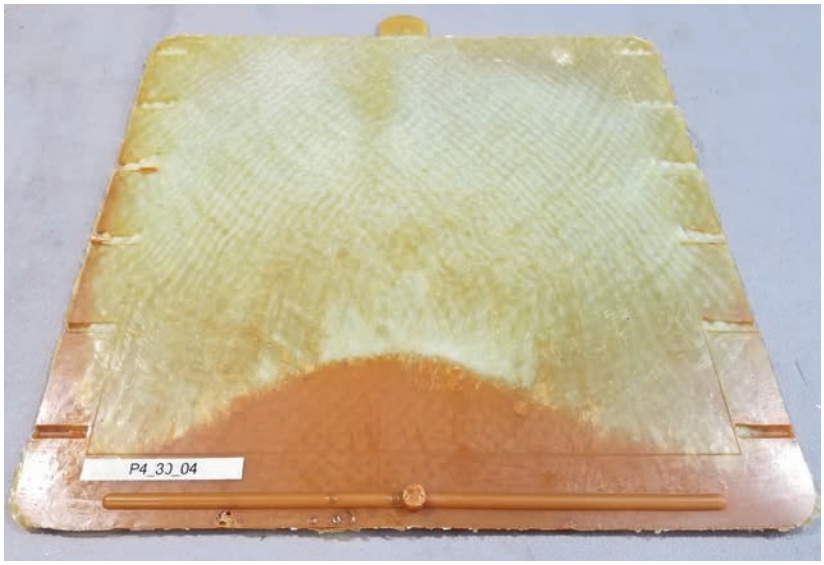
Funding

German Research Foundation (DFG)

Project Partner

- IFL TU Braunschweig
- IKT Uni Stuttgart
- IPC TU Hamburg

Radial braiding wheel (left) and HP-RTM infiltration system (right) from ILK are used to manufacture the test plates and structures



Test plate with conspicuous fibre misorientations and resin rich areas

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

PEM

Polymer electrolyte membranes for vanadium redox flow batteries

The increasing use of energy from renewable sources requires storage systems for this fluctuating energy. One possibility is the use of redox-flow-batteries (RFB). In Vanadium based RFBs polymer electrolyte membranes (PEM) are frequently used as separator. Particularly important is Nafion, which is a sulfonated fluoropolymer. Nevertheless, there are some shortcomings associated with Nafion and the development of new PEM materials with superior properties is of high importance. Within the interdisciplinary project novel PEM materials will be developed on the basis of commercially available fluoropolymer films and fabrics. The electron-induced activation of the fluoropolymers is followed by a graft copolymerization to incorporate functional groups allowing for sulfonation into the material. The influence of the irradiation conditions on type and concentration of trapped radicals as well as subsequently on the graft copolymerization is studied by electron paramagnetic resonance (EPR) spectroscopy. After sulfonation the PEMs are electrochemically characterized and application tests in Vanadium based RFBs are performed. The experimental results constitute the basis for establishing a correlation of process, polymer, structure and the PEM properties. Moreover, the experiments are accompanied by modelling with respect to determination of the radical types, optimization of the polymerization process and description of mass transfer through the membrane.

Period

01.06.2019 – 31.05.2022

Project Director

Dr. rer.-nat. Uwe Gohs

Contact Person

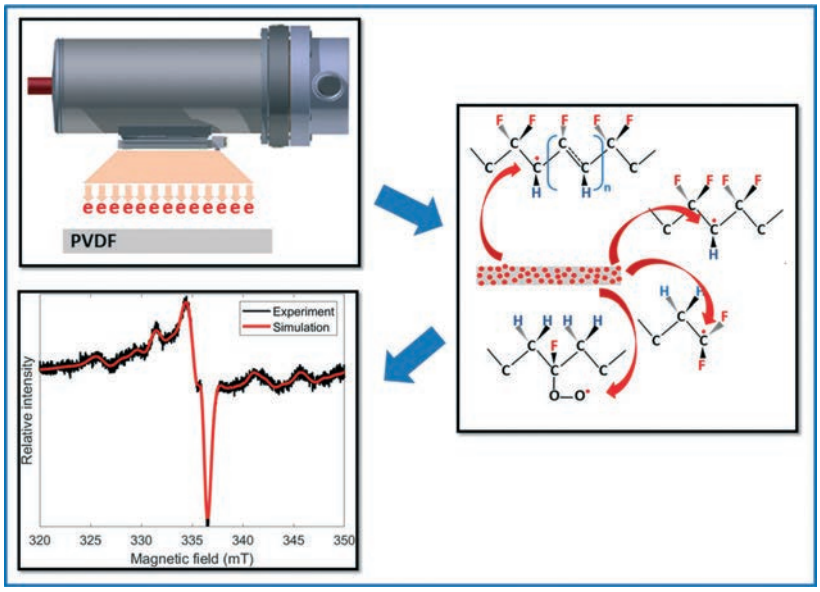
Mohsen Sadeghi Bogar

Funding

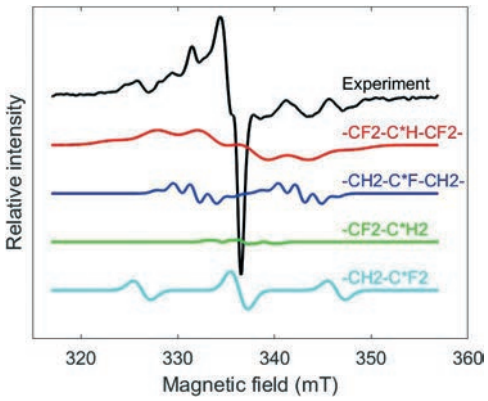
German Research Foundation (DFG)

Project Partner

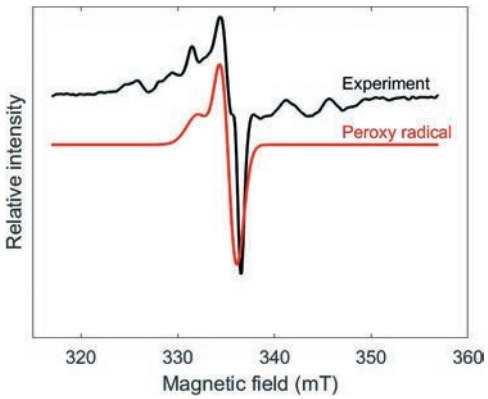
TU Clausthal



Overview on electron induced generation of radicals in PVDF and simulation of EPR spectra



Simulated EPR spectra of alkyl radicals (74,4 %) in comparison to the experimental EPR spectrum of irradiated PVDF



Simulated EPR spectra of peroxy radicals (20,7 %) in comparison to the experimental EPR spectrum of irradiated PVDF

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

Gescha

Development of the principles of foam structure formation in the freeze-foaming process of biocompatible ceramic foams

Freeze foams are novel and innovative cellular structures based on a direct foaming process, which can be generated from any material that can be processed by powder technology. The foam production process is influenced by a complex interaction of a wide variety of process and material parameters, which were previously selected empirically and were difficult to reproduce. For specific property design, there is a need to investigate phenomena occurring during foam formation and the effect of relevant process and material parameters in order to develop manufacturing principles. The possible applications of such foam structures cover a very diverse spectrum and range from biomedical applications to supports for catalysts. The diversity of these applications results from the range of starting suspensions and from the process parameter-dependent foam structure properties, such as cell geometry, cell size distribution and the nature of the cell webs. In the first project phase, a deeper understanding of freeze foam structure formation was achieved by performing analyses on the influence of selected suspension and process parameters on relevant structural properties. On the basis of the knowledge gained, the focus of current research is on the targeted tailoring of the macrostructure and microstructure to produce ceramic foams that are suitable for specific stresses and applications.

Period

01.01.2020 – 31.12.2021

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

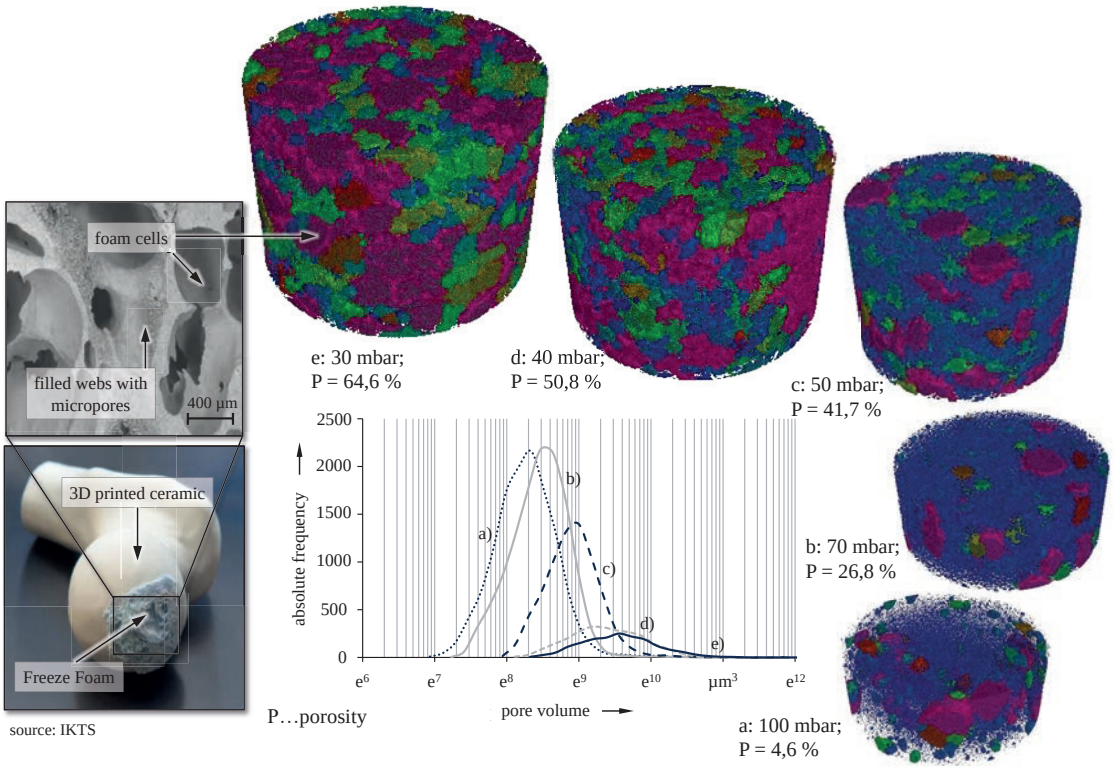
Johanna Maier
Tobias Kastner

Funding

German Research Foundation (DFG)

Project Partner

Fraunhofer-Institut für Keramische Technologien und Systeme (IKTS)



Pore size distribution during the foaming process at different pressure levels

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

ThoPoL

Thermally highly resistant polymer systems for lightweight propulsion systems

The overall objective of this project is to increase the permanent temperature range and the load limits of the polymer matrix system for fibre-reinforced plastics (FRP) to up to 250 °C as cost-neutrally as possible, while at the same time maintaining the reliability, safety and service life of the overall system. The common ground for the technology development in the various industrial sectors and drive systems are FRP windings of rotating parts of the drive that can withstand high temperatures, in order to achieve a reduction in overall weight, installation space and an increase in dynamics and performance. With an increase in the permanent thermal operating range, such a technology opens up the application in a multitude of other components, which are currently reserved for exclusively metallic materials. Within the scope of this project, thermoplastic matrix materials are investigated as well as thermoset high-temperature matrix systems are developed. The greatest innovation for high-temperature resin development in this project is expected in the development of hybrid resins. New hybrid resins are to be developed by combining coordinated silicone resin, cyanate resin and also epoxy resin components. Synergistic combinations of the advantages of the individual resins are expected to lead to novel resin systems with high-performance properties.

Period

01.02.2019 – 31.01.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

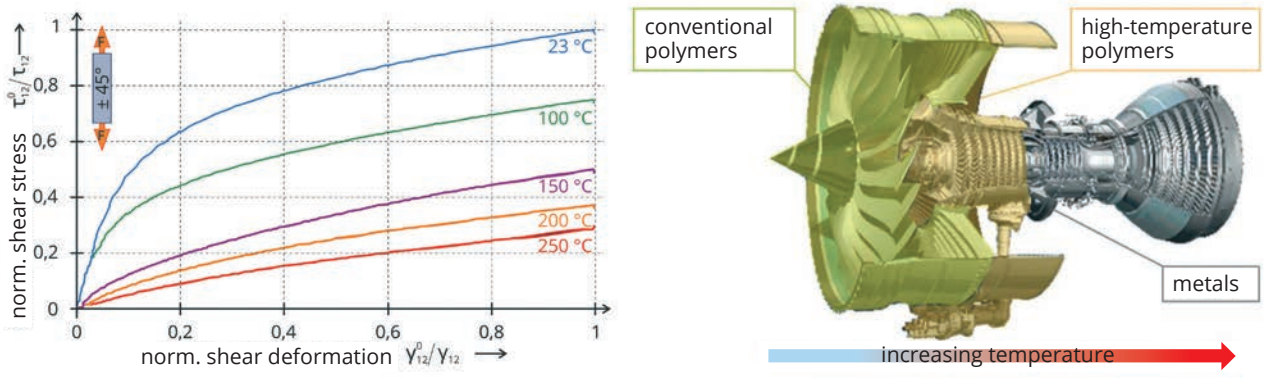
Tino Wollmann
Wikentij Koshukow

Funding

- Federal Ministry of Education and Research (BMBF)
- Project Management Jülich (PtJ)

Project Partner

- EVONIK Performance Materials GmbH
- Rolls-Royce Deutschland Ltd & Co KG
- Enrichment Technology Company Deutschland
- Wacker Chemie AG
- Hexion GmbH
- Teijin Carbon Europe GmbH
- EAST-4D Carbon Technology GmbH
- Fraunhofer – Institut für Angewandte Polymerforschung, Forschungsbereich Polymermaterialien und Composite



Measurement results from the tensile test on 45° laminates at different temperatures (left) for the design of turbine components (right)

Supported by:
Federal Ministry of Education and Research
on the basis of a decision by the German Bundestag

Supervised by:
Projektträger Jülich
Forschungszentrum Jülich

AI4DI

Artificial Intelligence for Digitizing Industry

The goal of the 40 international project partners involved in the EU project AI4DI, is the transfer and utilization of the latest generation of machine learning and artificial intelligence in applications in manufacturing, mobility and robotics. The partners come from a wide range of industries, such as machinery, automotive industry, semiconductor manufacturing, beverage industry and transport, which demonstrates the transferability and scope of the methods to be developed. To achieve the project goal, factories, processes, robots and devices will be connected to a digitalised industry. By incorporating machine learning and artificial intelligence, direct cooperation between humans and machines, the detection of changes and the identification of abnormalities or anomalies will become possible. For this purpose, the data collected in this way will be used and knowledge will be generated from it with the help of machine learning and artificial intelligence in order to change the semantics and logical levels with distributed system intelligence. In the project parts that are performed by the ILK and the ZIH of the TU Dresden, a novel sensor technology for robots is being developed. This is intended to improve human-machine interaction. The aim is to equip the robot surface with a sensory "sense of touch" and thus enable safe and interactive cooperation between man and machine.

Period

06.01.2019 – 30.05.2022

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

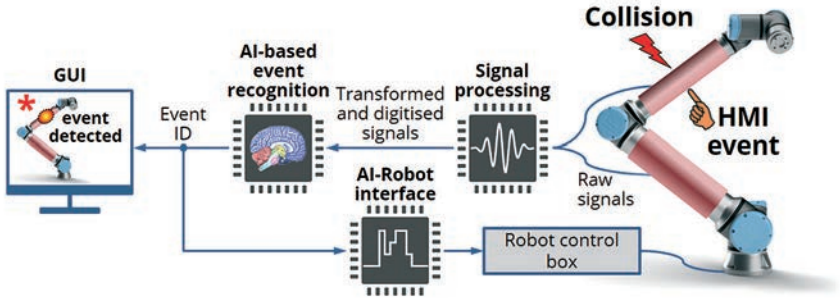
Dr.-Ing. Pawel Kostka

Funding

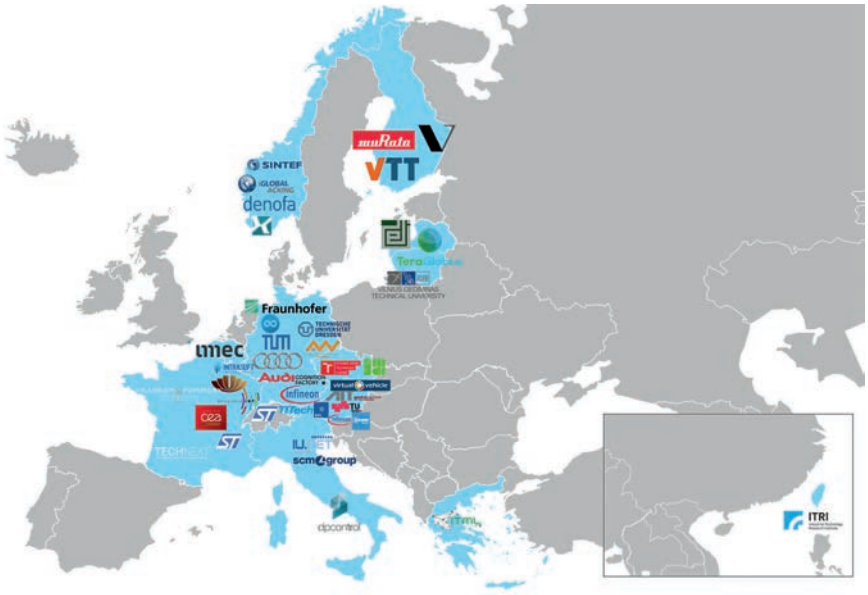
- European Union (ECSEL J, H2020)
- Federal Ministry of Education and Research (BMBF)
- Freestate of Saxony
- VDI/VDE Innovation + Technology GmbH

Project Partner

see map below



Schematic overview of the planned human-machine interaction with an intelligent sensor layer on robots



Map of the project partners involved in AI4DI

European Union

ECSEL Joint Undertaking

Supported by:

Federal Ministry of Education and Research

on the basis of a decision by the German Bundestag

This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.

This project has received funding from the ECSEL Joint Undertaking (JU) under grant agreement No 826060. The JU receives support from the European Union's Horizon 2020 research and innovation programme and Germany, Austria, Czech Republic, Italy, Latvia, Belgium, Lithuania, France, Greece, Finland, Norway.

Supervised by:

VDI|VDE|IT

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GeRusAM

Additive manufacturing technologies for functionalized lightweight structures

The global distribution of resources under fair conditions is the essential basis for the survival of societies worth living in. This means that the high-performance industrial nations in particular must find new ways of combining a high standard of living with a significantly reduced use of resources.

Against this background, the GeRusAM project expands the international partnership between Russia and Germany to jointly research future-oriented cutting-edge technologies in the field of additive manufacturing technologies for functionalized multi-material lightweight structures.

The bundling of the capabilities and capacities of the research cooperation are used to develop a profound understanding of novel functionalising lightweight construction technologies and their impact on the subsequent use and exploitation chain. Additive manufacturing processes and their high functionalization potential play a key role in this resource-efficient production.

Through the intensive exchange between the scientists, individual intersections within the partner institutions' fields of work can be identified, whereby the prevailing ways of thinking are understood and linguistic and cultural hurdles are overcome, thus forming the basis for efficient and consistent research cooperation between the partners involved.

Period

01.05.2020 – 30.04.2021

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

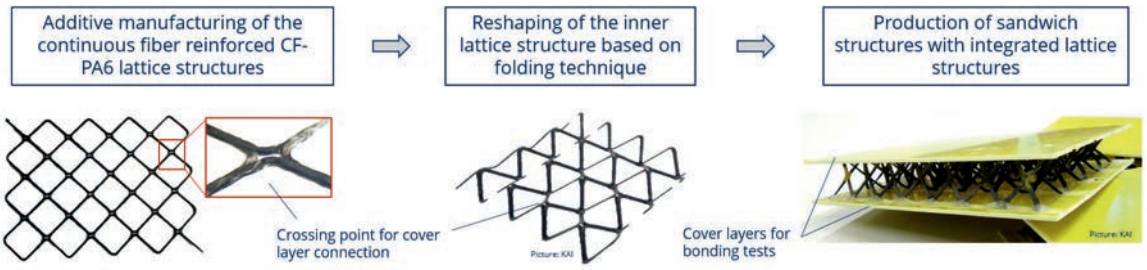
Christian Vogel

Funding

- Federal Ministry of Education and Research (BMBF)
- German Aerospace Center (DLR)

Project Partner

Kazan National Research Technical University (KAI)



Supported by:
Federal Ministry of Education and Research
on the basis of a decision by the German Bundestag

Supervised by:
DLR Projektträger

Kobra

Compact fibre-ceramic based X-ray tube for mobile computed tomography scanners

Today, computed tomography as an established procedure in imaging radiology is successfully used to make diagnoses for a wide variety of clinical pictures. In particular, the use of mobile computed tomography (CT) scanners installed in ambulances increases the chances of survival and recovery for stroke patients and accident and assault victims. To make this technically feasible, a drastic reduction in the volume and weight of the components installed in the CT is necessary. In the "Kobra" joint project, the volume and weight of the X-ray source, including the drive unit, is to be reduced by 40 % through functional integration and the use of new technologies. The focus here is on the X-ray tube's rotation unit and the associated electronics, which are to be integrated into the X-ray tube. At the ILK, the anode base body of the rotation unit is being designed and laid out. The base material used is carbon fibre-reinforced carbon, which is characterized by high thermal conductivity combined with high density-specific rigidity and strength, even in the high-temperature range. These properties are required because the compact design of the X-ray tube's rotating system means that the rotational frequency of the anode has to be increased significantly at constant short-term peak loads in order to avoid thermal overload of the focal track.

Period

01.10.2019 – 30.09.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

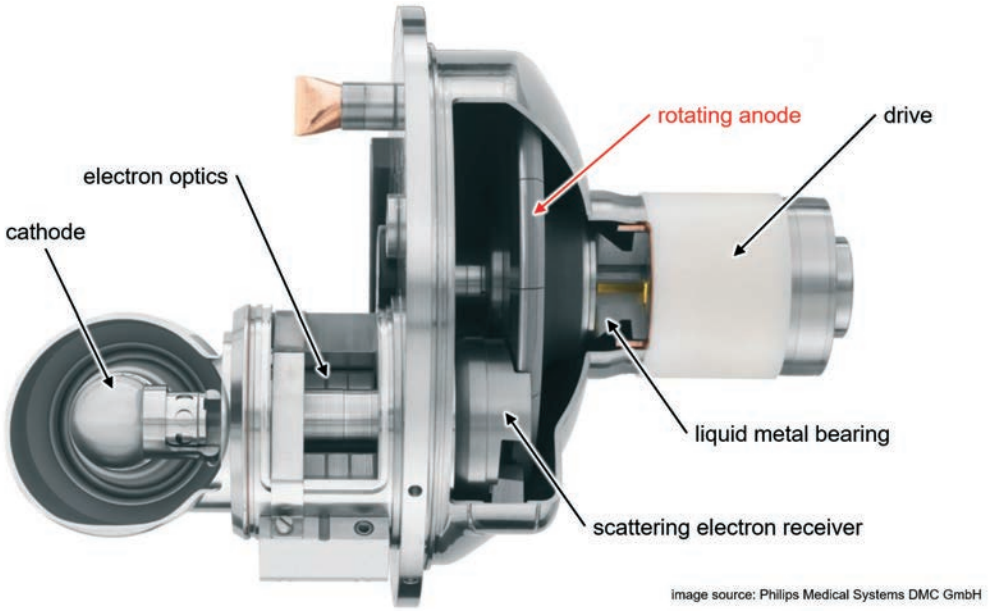
Dr.-Ing. Daniel Weck
Dr.-Ing. Thomas Behnisch

Funding

- Federal Ministry of Education and Research (BMBF)
- VDI Technologiezentrum GmbH

Project Partner

- Philips Medical Systems GmbH
- Hightex Verstärkungsstrukturen GmbH
- Strucnamics Engineering GmbH
- Helmut-Schmidt-Universität



Sectional model of an X-ray tube to illustrate the setup with metallic rotating anode

Supported by:
Federal Ministry of Education and Research
on the basis of a decision by the German Bundestag
VDI Technologiezentrum

PEP4.0

Development of a highly efficient linked product development process (PEP) for hybrid lightweight structures in the context of Industry 4.0

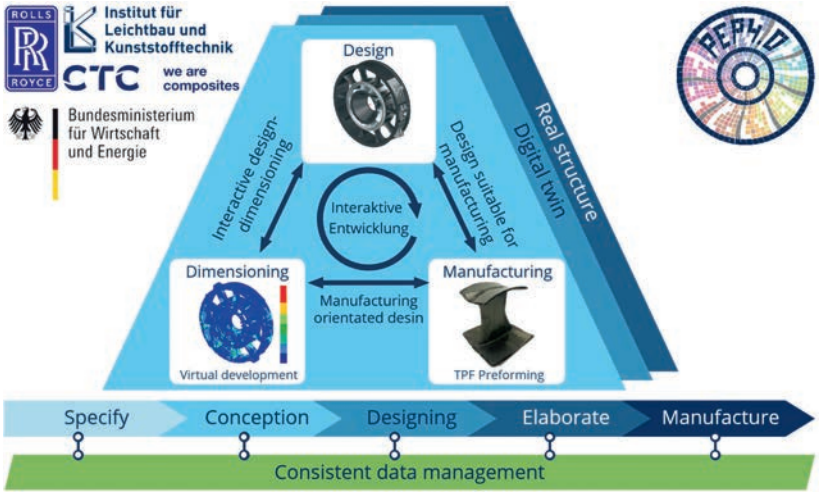


Fig. 1: Interactive development process with the individual disciplines of design, layout and manufacturing (top) along the phases from specification of requirements to manufacturing (bottom)

Period

01.07.2018 – 31.03.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Dr.-Ing. Sebastian Spitzer

Funding

- Federal Ministry for Economic Affairs and Energy (BMWi)
- German Aerospace Center (DLR)

Project Partner

- Rolls-Royce Deutschland Ltd & Co KG
- CTC GmbH

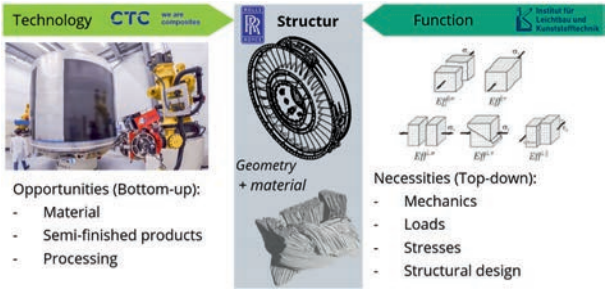


Fig. 2: Technological possibilities (left), functional necessities (right) and synthesis of technology and function in the structure (centre)

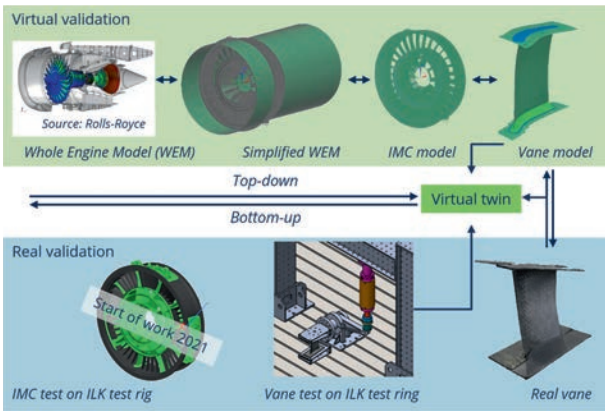


Fig. 3: Virtual (top) and real validation (bottom) from the overall engine model (WEM, left) to the individual components of a Vane (right) and linking of the individual elements via a digital twin (middle)

In the project "PEP4.0", the ILK is collaborating with Rolls-Royce Deutschland to research on efficient methods for developing an engine intermediate case (IMC) in metal-composite design. The basis for this is a digitally linked product development process, which combines the methods, models and data of the individual disciplines of design, dimensioning and manufacturing in a linked development structure from the specification of requirements up to the manufacturing (see Fig. 1).
Within the framework of the project, a function- and stress-oriented design takes place (top-down, ILK). The design determined in this way is aligned with the technological options available for aerospace applications (bottom-up). The synthesis of geometry and material results in the function- and production-oriented structure of a lightweight intermediate case (see Fig. 2). The technological work is carried out in close cooperation with CTC GmbH.
Within individual development phases, models are considered at different levels from the single component vane up to the overall engine model (WEM) in order to be able to assess the effect of a parameter change in the overall system. In parallel, the virtual results and models are verified and validated with real tests (see Fig. 3).
The project is funded under the fifth aviation research program (LuFo) of the German Federal Ministry for Economic Affairs and Energy BMWi (FKZ 20X1717B).

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

Supervised by:
DLR Projektträger

GePart

Development of efficient process technologies within the closed particle foam material cycle

The objective of the project is to improve the resource efficiency of particle foam expanded polypropylene (EPP). The main topic of the project is on the one hand to make the material cycle of the particle foams industrially possible by estabishing recycling processes, recycling technologies and strategies and on the other hand to significantly increase the energy efficiency of EPP processing by applying the novel radio frequency (RF) process technology. The core of the development of RF-technology is therefore the targeted further development of specific moulding technology to enable the efficient processing of polypropylene (PP) in series production.

In order to be able to close the material cycle, the recycling processes must be further developed in such a way that recycled particle foam waste material (end-of-life) is processed to a high-quality standard in order to feed it back into the processing chain of particle foams. Therefore it is necessary to clarify the degradation behaviour of the material in order to be able to define processes for treatment in a targeted manner. In addition, the use of RF-technology offers an outstanding potential to significantly increase the proportion of recycled material to 50–70 %.

These two main topics are accompanied by a comprehensive material analysis for the evaluation of the material properties along the entire cycle as well as the preparation of a life cycle assessment also considering several recycling cycles of the materials.

Period

01.12.2020–30.11.2023

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Dr.-Ing. Bernd Grüber

Funding

- Federal Ministry for Economic Affairs and Energy (BMWi)
- Project Management Jülich (PtJ)

Project Partner

- Ruch Novaplast GmbH
- Volkswagen AG
- Kurtz GmbH
- T. Michel Formenbau GmbH & Co. KG
- R. Plast GmbH
- Neue Materialien Bayreuth GmbH
- Kaneka Belgium NV (associated partner)

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

Supervised by:
Projektträger Jülich Forschungszentrum Jülich

ReCar

Development of a modular heating system made of recycled carbon fibre nonwovens for use in forming and preforming tools

Both the increasing use of carbon fibre reinforced polymers (CFRP) and progress in recycling of CFRP parts as well as preparation of production residues cause a high demand for applications of the obtained recycled carbon fibres (rCF) and semi-finished products produced therefrom (e. g. rCF nonwovens). Due to beneficial electrical properties, carbon fibres show great potential for use in heating elements, which offers new perspectives for application.
The aim of the project ReCar, which is funded by the BMBF within the Central Innovation Program for small and medium-sized enterprises (ZIM), is the development of a novel heating system made of rCF nonwovens. A comprehensive characterization of the electrical properties of rCF nonwovens is, among other things, required for the system's design. For this purpose, an experimental test stand was developed at the ILK, which enables the measurement of the electrical resistance of the rCF nonwovens as well as taking thermographic images during heating. The goal is an optimization of the temperature homogeneity and the heating time using design of experiments.
As the project continues, modularly configurable heating elements to heat forming and preforming tools will both be developed in cooperation with the project partners eco2heat GmbH and Plasta Kunststofftechnik Oederan GmbH. The influence of the integrated heating structures on the tools and processing will be investigated in additional processing studies.

Period

01.01.2020 – 30.06.2022

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

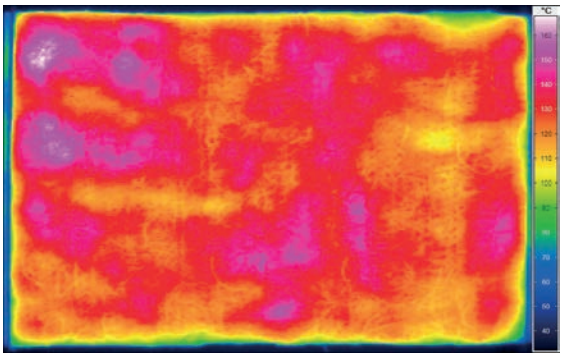
Ron Luft
Tom Dziewiencki

Funding

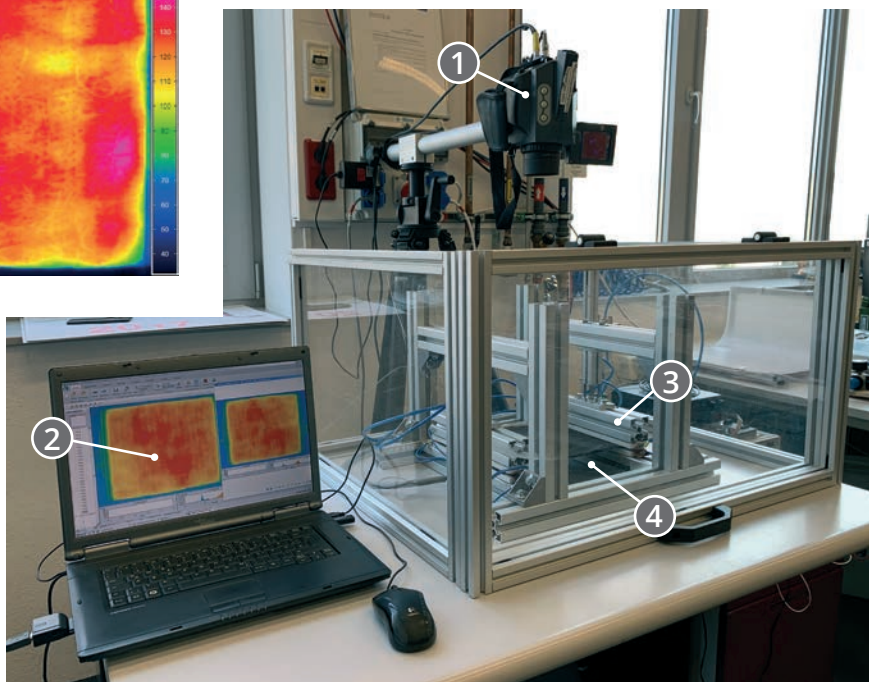
- Federal Ministry for Economic Affairs and Energy (BMWi)
- German Federation of Industrial Research Associations „Otto von Guericke" e. V. (AiF)

Project Partner

- eco2heat GmbH
- Plasta Kunststofftechnik Oederan GmbH



Thermographic image of a rCF nonwoven with a surface weight of 100 g/m²



1. *Thermographic camera*
2. *Camera control and thermal software*
3. *Terminal strip with contacting*
4. *rCF nonwoven*

Experimental test stand for electrical characterization and thermographic images of rCF nonwovens

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

Supervised by:
AiF

Multifunctional Interfaces FRP

Development of multifunctional interfaces for joining FRP with metals using established joining technologies

Multi-material design with fibre reinforced plastic (FRP) and metals offers a high potential for resource- and cost-efficient lightweight constructions. However, the availability of suitable joining technologies often obstructs the use of FRP in series production. In addition, despite the increasing diversity of materials, industry demands to limit the number of different joining methods.

Together with the Laboratory for Materials and Joining Technology (LWF) at the University of Paderborn, ILK scientists are developing a new pre-competitive technology for FRP/metal joints based on established spot joining processes such as resistance spot welding or clinching. For this purpose, a metallic insert is embedded in a thermoplastic FRP structure during part manufacturing as a multifunctional interface. The technology is based on the concept of moulding holes by a pin and simultaneously placing the metallic insert in the moulded hole without fibre damage. A counter punch located on the die side provides a form fit between the multifunctional interface and and the FRP. Subsequently, the FRP component can be joined to metal structures using established spot joining methods. With this novel joining system, FRP structures are intended to be integrated economically and efficiently into modern multi-material designs by the integration into already available assembly process chains for classic metal constructions.

Period

01.10.2019 – 31.03.2022

Project Director

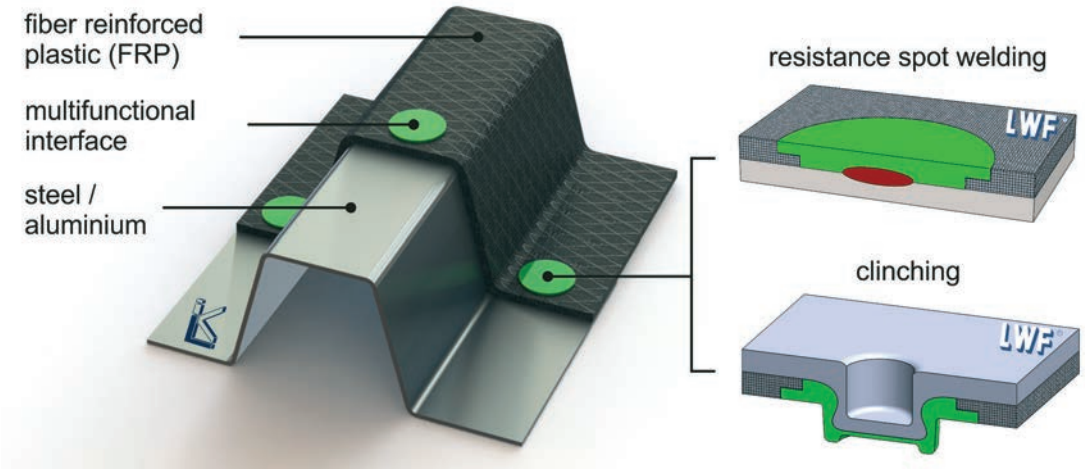
Prof. Dr.-Ing. habil. Maik Gude

Contact Person

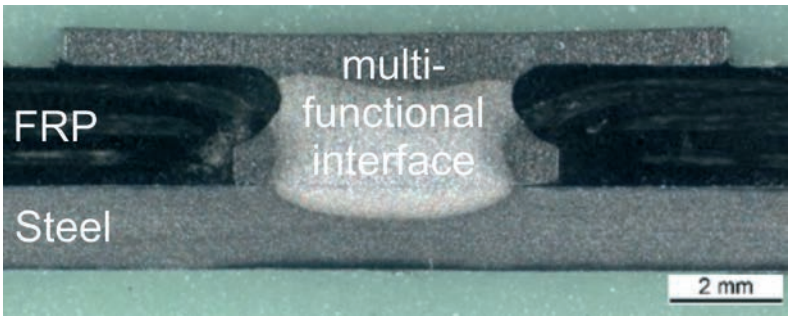
Juliane Troschitz
Dr.-Ing. Robert Kupfer

Funding

- Federal Ministry for Economic Affairs and Energy (BMWi)
- German Federation of Industrial Research Associations „Otto von Guericke“ e. V. (AiF)



Multifunctional interfaces for joining FRP and metals using established spot joining technologies



Micrograph of a welded joint with multifunctional interface

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

Supervised by:
AiF

AutoDrive

Advancing fail-aware, fail-safe and fail-operational electronic components, systems and architectures for highly and fully automated driving to make future mobility safer, more efficient, affordable and end-user acceptable

The AutoDrive project is a European lighthouse project funded by the Ecsel Joint Undertaking. The European research project, with more than 60 international partners from industry and research, is setting the stage for safer and more efficient highly or fully automated driving through both technological advancements and standardization efforts. The AutoDrive project increases the current level of safety and reliability by significantly advancing the fail-safety of vehicle technologies in the hardware and software domain. As a result, vehicle systems can continue to be used or transitioned to a safe operating state even in the event of a failure. AutoDrive thus enables safer, more efficient and more affordable mobility and thus increases acceptance for the end user.

To this end, ILK researchers are developing an efficient and highly integrated inductive charging system with 10 kW charging power for electric vehicles with 400 V or 800 V on-board voltage. The main focus of the research work is the further development of modeling methods in order to be able to optimally integrate inductive charging systems into installation spaces with high magnetic, thermal and mechanical requirements. The demonstrator developed as part of the project work achieves an average transmission efficiency of 90.2 % at 10 kW transmitted power and 92 % at the optimum. With a thickness of only 20 mm and a total weight of less than 6 kg, the on-board charging module thus offers good conditions for integration even in tight installation spaces.

Period

01.06.2017 – 31.09.2020

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

Dr.-Ing. Anja Winkler
Martin Helwig

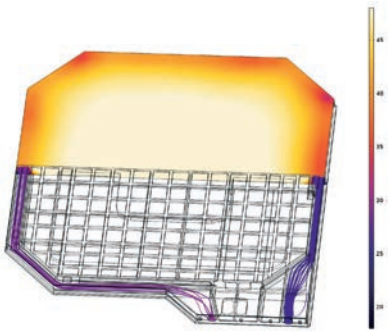
Funding

- European Union
  (7th Research Framework Programme)
- Federal Ministry of Education
  and Research (BMBF)
- Freestate of Saxony
- VDI/VDE
  Innovation + Technology GmbH

Project Partner

- Infineon Technologies AG
- Daimler AG

Laboratory demonstrator of the inductive charging system on vehicle side



Numerical simulation model for electromagnetic thermal system design

Measurement of the electromagnetic field of inductive charging systems on the HiL test bench of the ILK

European Union

ECSEL Joint Undertaking

Supported by:

Federal Ministry of Education and Research

on the basis of a decision by the German Bundestag

This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.

This project has received funding from the Electronic Component Systems for European Leadership Joint Undertaking under grant agreement No 737469. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Germany, Austria, Spain, Italy, Latvia, Belgium, Netherlands, Sweden, Finland, Lithuania, Czech Republic, Romania, Norway

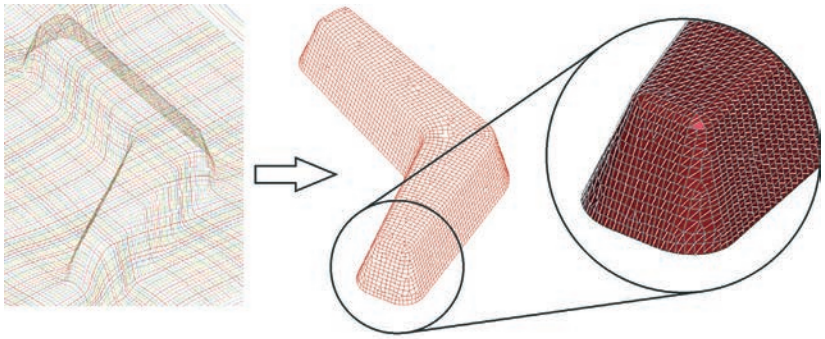
Supervised by:

VDI|VDE|IT

AMARETO

Saxon alliance for material- and resource-efficient technologies

Communication tool "Webpresenter" to disseminate the cooperation of the science locations and the joint scientific results



Coupling of meso-scale models for textile forming with macro-scale models for structural analysis

Period

01.01.2017 – 28.02.2021

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Dr.-Ing. Daniel Weck
Dr.-Ing. Bernd Grüber

Funding

- Free State of Saxony
- European Regional Development Fund (ERDF)
- Sächsische Aufbaubank (SAB)

Project Partner

- TU Bergakademie Freiberg
- TU Chemnitz
- Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik

In the Saxon collaborative project AMARETO, the cooperation between TU Chemnitz, TU Dresden and TU Bergakademie Freiberg as well as Fraunhofer IWU was established. The aim of the cooperation is to bundle the key competences of the sites and thus implement holistic solutions along the value chain. In three work complexes, methods for efficient material development (Smart Material), optimised component design (Smart Design) and resource-efficient production (Smart Production) were developed.

In the Smart Design complex, for which the TU Dresden was responsible, interactive development processes for high-performance components in multi-material design were examined. The focus lay on simulation methods for coupled process-structure analysis in order to be able to take into account not only functional requirements but also manufacturing influences in the development process and thus generate a deeper understanding of the design of lightweight structures made of metal and fibre composites.

The collaborative project generated a multitude of publications and theses, and was accompanied by several transfer events with SMEs. The results are presented in the communication toll "AMARETO-Webpresenter". The established interconnected structures form the basis for future cooperation of the three sites and are utilized to provide scientific support especially to the saxon economy.

European Union
Europe funds Saxony. EFRE European Regional Development Fund
This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.
Supervised by: SAB

3D³

Additive manufacturing of continuous fibre-reinforced composites with tailor-made properties using UV-curing thermoset polymers

Established manufacturing technologies have only limited potential for economic production of customized lightweight structures with tailor-made properties. In this context, additive manufacturing technologies offer entirely new horizons, but are by now only available for thermoplastic matrix systems. Within the framework of the Fraunhofer centre "Smart Production and Materials", subproject 3D³, scientists at the TU Dresden Institute of Lightweight Engineering and Polymer Technology (ILK) develop an entirely new manufacturing process based on UV light-curing matrix systems for the production of continuous fibre-reinforced thermoset 3D printing structures.

Core element of the newly developed automated manufacturing cell is a highly integrative mixing head that addresses the main research challenge of enabling optimal fibre impregnation with the liquid resin and fast curing for form stability within few seconds after deposition on the robot-guided printing bed. Based on extensive UV-rheological measurements accompanied by processing studies a fundamental process understanding has been elaborated. The novel manufacturing process is predestined for manufacturing small batches of individualized composites structures and, as a supplement to established processes, enables increased flexibility in the serial production of lightweight components.

Period

01.07.2019 – 31.12.2020

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Sirko Geller
Eckart Kunze

Funding

- Free State of Saxony
- European Regional Development Fund (ERDF)
- Sächsische Aufbaubank (SAB)

Automated manufacturing cell for 3D-printing of thermoset continuous fibre reinforced composite parts

Print head for 3D printing of continuous fibre-reinforced polymers

European Union
Europe funds Saxony. EFRE European Regional Development Fund
This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.
Supervised by: SAB

DCFR with AMTwin and ePredict

Analysis of interdependencies between micro structure and system reliability

The Dresden Center for Fatigue and Reliability (DCFR) is a network of research and industrial partners with the aim of linking the distributed interdisciplinary competences in the fields of materials, structural mechanics and electronic systems to a holistic approach about reliability of modern materials and systems. This cooperation is being successfully tested in the AMTwin and ePredict projects, which are funded from taxpayers' money on the basis of the budget passed by the members of the Saxon state parliament and from money from the European Regional Development Fund (ERDF). At the ILK, the focus in each case is on elucidating the microstructure of the materials and describing structure-property relationships. The range of materials investigated is broad – from short-fibre-reinforced thermoplastics to laser-sintered titanium. The current limits of the methods used for structural analysis, such as microscopy and computed tomography, are significantly extended and qualified by synergetic linking via innovative methods of image processing and evaluation. The insights into microstructure thus gained form the basis for the development of cross-scale material and structural models, which, when linked to data from the laboratory and real-world applications, enable the elucidation of process-structure-property relationships.

Period

01.08.2019 – 30.06.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

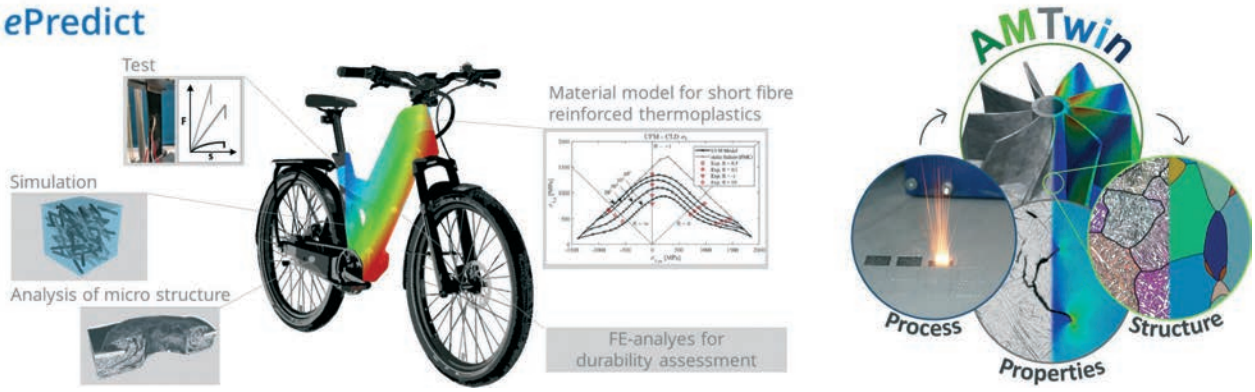
Dr.-Ing. Ilja Koch
Gordon Just
Karsten Tittmann
Paul Schulz

Funding

- Free State of Saxony
- European Regional Development Fund (ERDF)
- Sächsische Aufbaubank (SAB)

Project Partner

- TUD-IFKM
- IKTS
- IWS
- IWU
- TUD-IFWW
- TUD-LWM



Projects ePredict and AMTwin as elements of DCFR
"Predictive Maintenance for e-Mobility" – work at ILK (left) and "Data driven Process, Material and Structure Analysis for Additive Manufacturing" (right)

European Union
Europe funds Saxony. EFRE European Regional Development Fund
This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.
Supervised by: SAB

RAVI

New generation of efficiency-enhanced, emission-free vibrating tampers

Currently used combustion engines for vibrating tampers leave only little room for reducing emissions and improving handling. The ILK, together with the project partners RAVI Bau- und Mietgeräte GmbH and EMEC-Prototyping GmbH, is meeting the increased requirements for emission-free operation, handling and occupational safety by developing an electric, battery-powered drive system for a new vibrating tamper. The work is taking place within a project funded by the SAB and, in addition to the development of the electric drive system, also includes scientific investigations to reduce the vibration load on the operator by means of adapted mechanisms and materials. For example, the demonstrator developed at the end of the project uses compliant structures made of glass-fibre-reinforced plastic, which dampens the vibrations transmitted to the operator through their material properties. Furthermore, novel compliant mechanisms for power transmission in connection with linear drives were investigated. This design innovation has a high potential for reducing the number of components and the vibration load on the operator, which is of particular interest in the construction machinery environment.

Period

01.07.2018 – 30.04.2021

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

Dr.-Ing. Martin Dannemann
Philip Steinbild

Funding

- Free State of Saxony
- European Regional Development Fund (ERDF)
- Sächsische Aufbaubank (SAB)

Project Partner

- RAVI Bau- und Mietgeräte GmbH
- EMEC-Prototyping GmbH

Electrically driven vibrating tamper (left) and demonstrator for a tamper utilizing a deltoid mechanism with compliant joints (right)

European Union
Europe funds Saxony.
EFRE
European Regional Development Fund
This measure is co-financed with tax funds based on the budget approved by the Saxon state parliament.
Supervised by:
SAB

DigiKunst

Digital-supported learning tools in the education of process mechanics for plastics and rubber technology

In the education of process mechanics for plastics and rubber technology, imparting a technical understanding of manufacturing processes and building up skills in the use of machines and systems play an important role. However, the processes are complex and despite specialisation usually only exemplary processes can be taught and selected production scenarios can be trained. In addition, the physical processes inside the machines and tools always remain invisible even during practical work on the equipment. Therefore, the technically complex interrelationships currently have to be taught in an abstract way and sometimes at great expense of time.

In the DigiKunst project, a digitally supported learning concept is developed, implemented and tested in training and further education at the example of injection moulding technology. A real-time animated 3D model of an injection moulding machine is produced and implemented in a learning app. On the one hand, the learning concept will convey the invisible technical processes of plastics technologies directly on the machine, and on the other hand, it will enable people to experience and understand them outside the technical centre. The teaching and learning concept focusses on essential elements of the injection moulding machine and the moulds as well as on process control.

Period

01.06.2019 – 31.05.2022

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

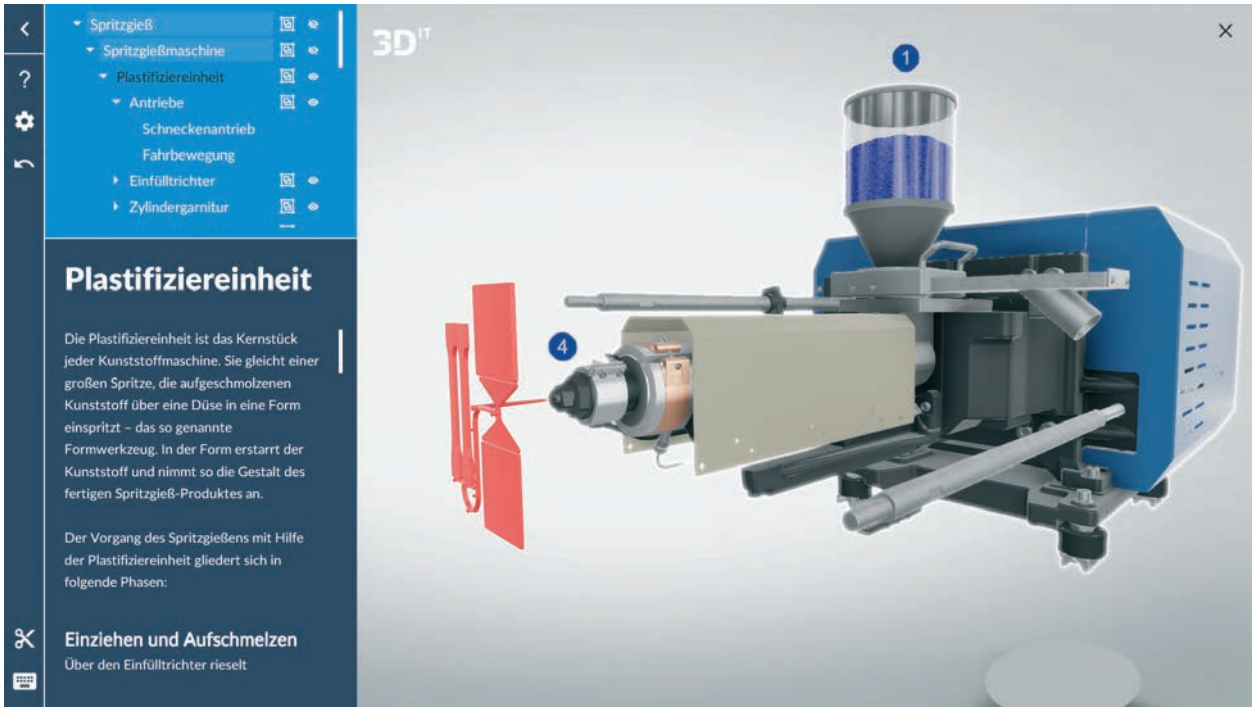
Dr.-Ing. Robert Kupfer
Alexander Liebsch

Funding

- European Social Fund (ESF)
- Sächsische Aufbaubank (SAB)

Project Partner

- 3D Interaction Technologies
- Bildungswerk der Sächsischen Wirtschaft
- Fahrzeugelektrik Pirna



Current development status of the learning software with digital model of the plasticising unit

Supervised by:

Europäische Union
Europa fördert Sachsen. ESF Europäischer Sozialfonds
SAB

K-Crash

Crash Simulation Technology for Composite-based Novel Lightweight Structures

FRP crash absorber sub-structure

Period

01.01.2018 – 30.06.2021

Project Director

Prof. Dr.-Ing. Niels Modler

Contact Person

Holger Böhm
Jonas Richter
Dr.-Ing. Andreas Hornig

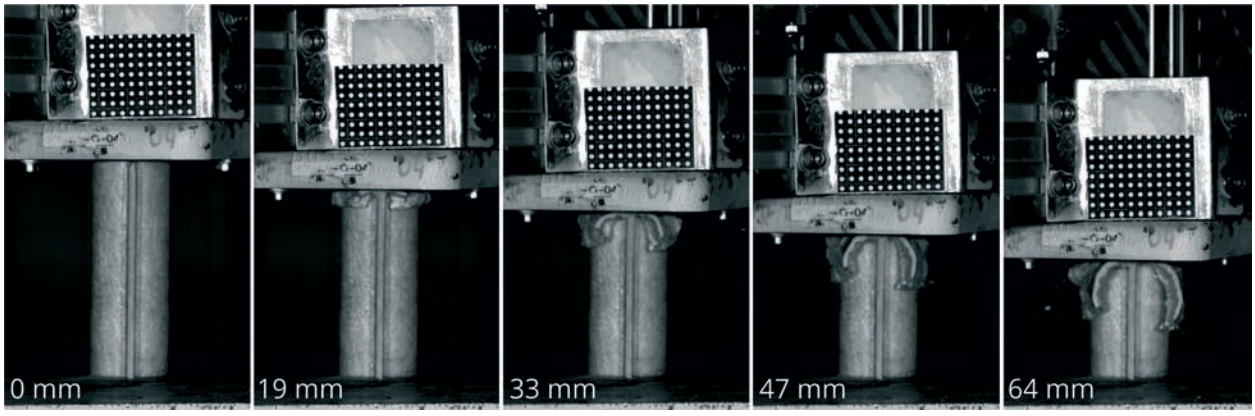
Funding

Korea Institute of Materials Science (KIMS)

Project Partner

Korea Institute of Materials Science (KIMS)

For an efficient engineering procedure, adapted numerical methods in combination with a sufficient data base are indispensable and therefore a key technology. To establish composite technologies for technical products like future lightweight car body structures, crash and impact events have to be considered during the engineering process. The ILK is one of the leading research institutes in the field of the development, adaption and application of methods for the modelling, simulation and testing of composite based lightweight structures under crash and impact load. To strengthening the strategic partnership between the Korea Institute of Materials Science (KIMS) and the ILK, the experimental and numerical investigation of the fundamental deformation and failure phenomena for a novel thermoplastic composite materials are in focus of the research. In this context, high-fidelity modeling techniques are to be developed which enable a robust simulation of the crash performance of composite structures. This should make it possible in the future to minimize the currently large experimental effort for the investigation of crash-loaded structures and to perform variant studies by means of virtual experiments.

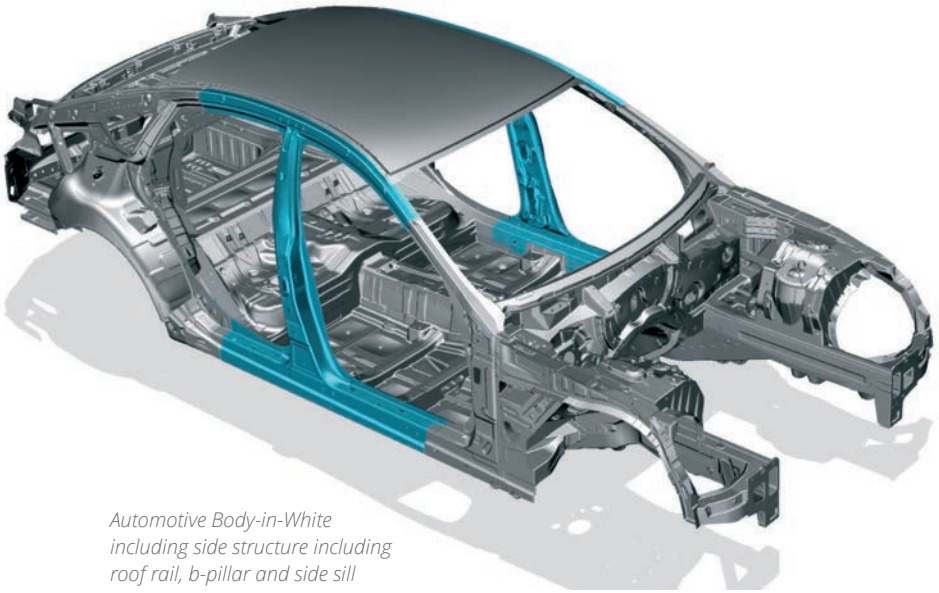


High speed camera recordings during drop-tower test of crash absorber sub-structure with drop height: 3.30 m, drop mass: 92.2 kg and crash absorber length: 140 mm

KIMS Korea Institute of Materials Science

MMSS

Development of mass production total engineering technologies for metal-composites hybrid process (joining & forming) and more 25 % lightweight side crash car body structure components



Automotive Body-in-White including side structure including roof rail, b-pillar and side sill

Period

01.01.2018 – 31.03.2021

Project Director

Prof. Dr. rer. nat. Hubert Jäger

Contact Person

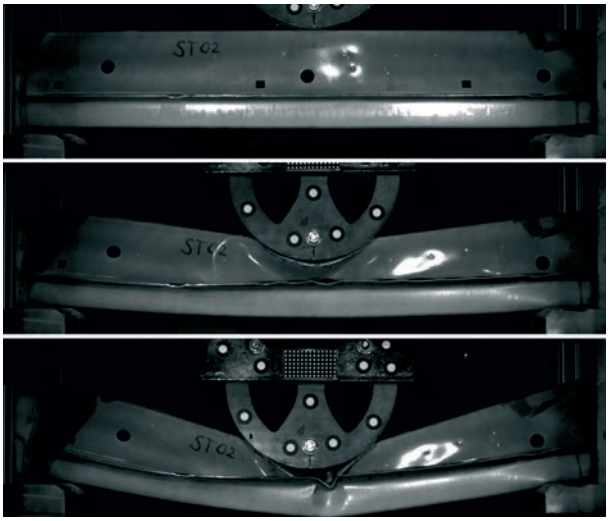
Dr.-Ing. Bernd Grüber
Holger Böhm
Jonas Richter

Funding

- Korean Evaluation Institute of Industrial Technology (KEIT)
- Korea Institute of Materials Science (KIMS)

Project Partner

- Korea Institute of Materials Science (KIMS)
- Sungwoo Hitech
- Dongsung Chemicals
- Hankuk Carbon Co. LTD.
- Pusan National University
- Andong National University



Drop tower crash test of reference steel side sill structure

Crash simulation model of complete Body-in-White

The Korea Evaluation Institute of Industrial Technology (KEIT) has launched a joint research project with Korean companies and participation of scientists from the Institute of Lightweight Engineering and Polymer Technology of the TU Dresden, in which a new lightweight vehicle side structure and associated highly efficient production processes are to be developed. As part of this project, the ILK focuses on simulation methods and design strategies for the design of such a side structure in the event of side-crash. The use of high-performance computing resources at ZIH Dresden makes it possible to carry out realistic and computationally intensive crash simulations at component and vehicle level to efficiently assist the design and dimensioning process. The side structure itself is designed in hybrid multi-material design and consists of B-pillar, roof-rail and side-sill. In a side impact, this structural part takes over the main part of the load and protects the passengers from serious injuries. The aim of the project is to build this structure in hybrid multi-material lightweight construction, which is at least 25 percent lighter than a conventional module with at least the same performance.

Keit
Korea Evaluation Institute of Industrial Technology

Supervised by:
KIMS

Do-EfS

Digitally Optimised Engineering for Services; HAP3: Engine Wear and Damage Modelling

The aim of the joint project is to develop an overall wear model of current engine generations to predict the influence of wear on the overall efficiency of the engine. To this end, wear-intensive individual components and subsystems of aircraft engines are being investigated in realistic thermomechanical load tests using specially developed test methods and test stands. Among other things, methods are used to investigate the rubbing behavior, enabling determination of the forces and deformations occurring, the temperatures at the blade tip and the liner material, and the induced blade vibrations (Fig. 1). Furthermore, the wear and damage behaviour is analyzed both on individual casing plain bearings (Fig. 2) and subcomponents of the overall VSV system (Fig. 3). The wear and damage behaviour is determined phenomenologically and compared with real in-service data. The results obtained make it possible to reduce the maintenance effort and costs through customisable service intervals and contents. This can significantly improve the energy efficiency and environmental friendliness of current and future engine generations.

Period

01.08.2018 – 31.12.2021

Project Director

Prof. Dr.-Ing. habil. Maik Gude

Contact Person

Dr.-Ing. Christoph Ebert
Richard Protz

Funding

University Technology Centre
Rolls Royce plc. (RRD)

Project Partner

University Technology Centre
Rolls Royce plc. (RRD)

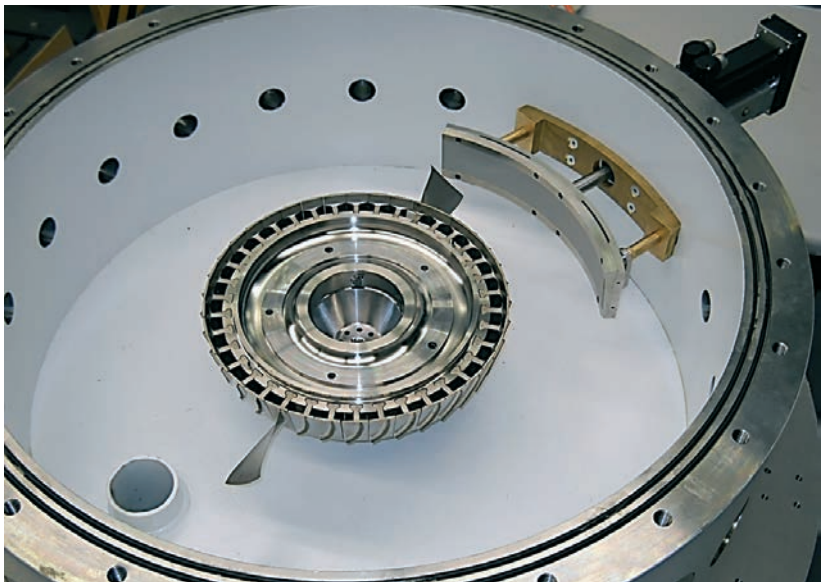


Fig. 1: Test chamber of the blade strip test rig

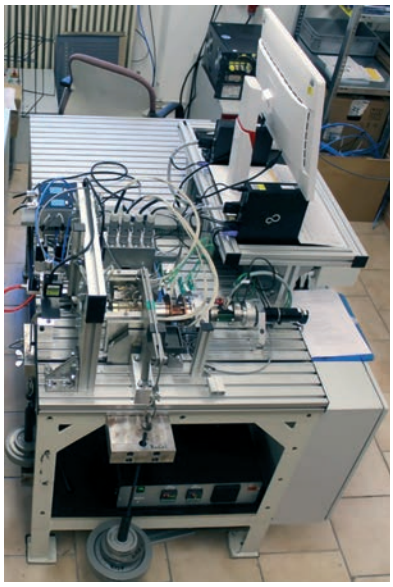


Fig. 2: VSV-Single plain bearing test rig

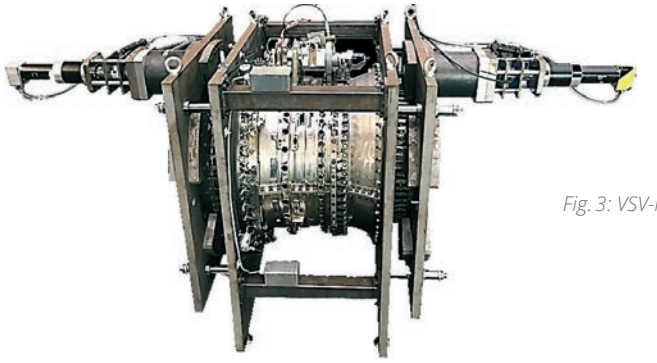


Fig. 3: VSV-multi stage test rig

Rolls-Royce

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IVeT

Unified Architecture for interactive digital twins

Every year, zettabytes of data are generated in research and industrial applications for the control, condition monitoring and optimization of plants and structures. Frequently, there is no direct feedback of the information gained into development. In contrast, the data is available for a very short time, but this information is only incorporated into new development cycles, in multi-stage follow-up steps.

Digital twins represent a significant innovation to accelerate the extraction and flow of information such as process parameters and to enable them in real time applications. These are virtual images of physical structures and relationships and their targeted structuring and linking of diverse data from a wide range of phases in the product life cycle.

The intrinsic research project IVeT explored how novel tools can be used to efficiently develop Digital Twins and integrate them into the product development cycle. A rotor test bed was set up for this purpose for application in multi-material design. The data obtained was used to determine the structural dynamic behavior of FRP rotor under ice accretion. Wind turbines are one application example. The identification of necessary interfaces and software technologies for universal data transport was a central goal in the construction and developement of the test bed.

Period

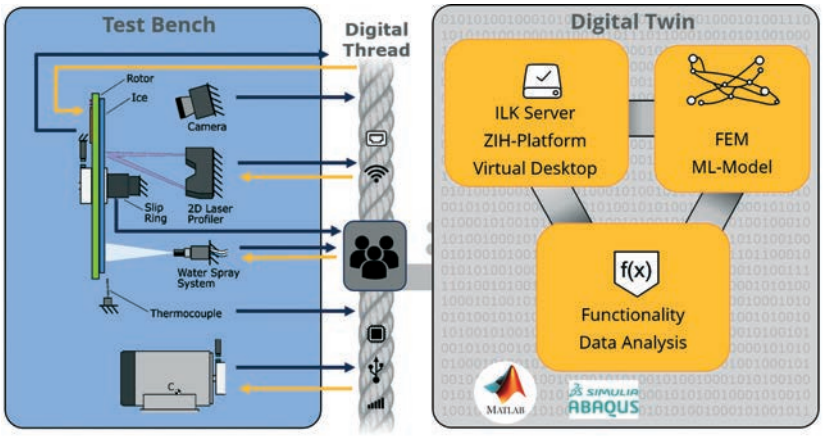
01.08.2019 – 01.10.2020

Project Director

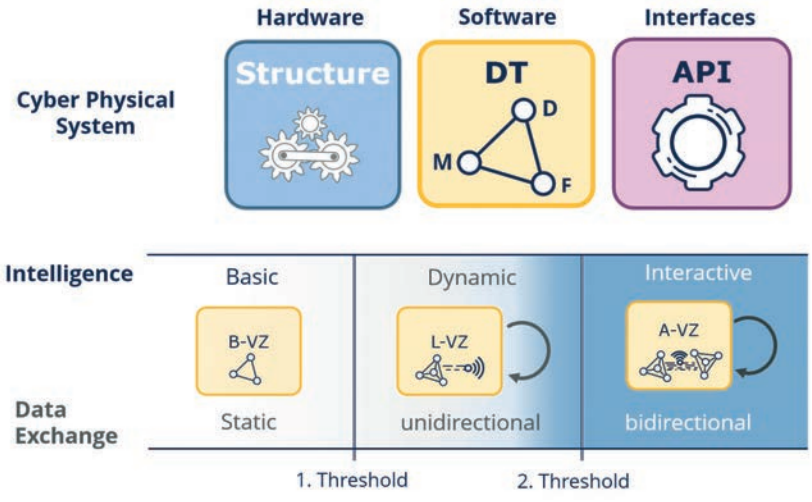
Dr.-Ing. Angelos Filippatos

Contact Person

Dr.-Ing. Angelos Filippatos
Minh Nguyen



IVeT architecture shown on the example of an rotor test bench connected to its digital twin via the digital thread



The three main development stages of a digital twin based on their data exchange capabilities

SensKI

Novel sensor technologies with AI integrated on physical and information level

Novel sensor technologies play a crucial role in the increasing digitalization of various economic sectors. The focus of SensKI is therefore on novel sensors and sensor-related information analysis using artificial intelligence (AI) algorithms. The aim is to develop a completely new concept in measurement technology, in which technical equivalents for the biological senses and perception are developed and combined.

The focused sensor technology is based on the analysis of propagation phenomena of high-frequency electromagnetic waves. A readout device conceived in the project and implemented in cooperation with an industrial partner allows the connection of specially developed sensors of different physical quantities. The key advantage of the followed measurement principle is a spatial resolution of all sensors based on it. In the project, two linear sensors: a strain sensor and a resin infiltration sensor, as well as a two-dimensional touch sensor were investigated.

The raw sensor data is analyzed using AI methods that enable different sensor outputs. In addition to a direct, spatially resolved profile of the physical quantity, abstracted forms of information such as terms, types, instances can also be output. The approach potentially enables a new quality of many engineering applications, such as industrial process control and regulation, human-machine interaction, and condition-based maintenance of critical machinery, equipment, and infrastructure objects.

Period

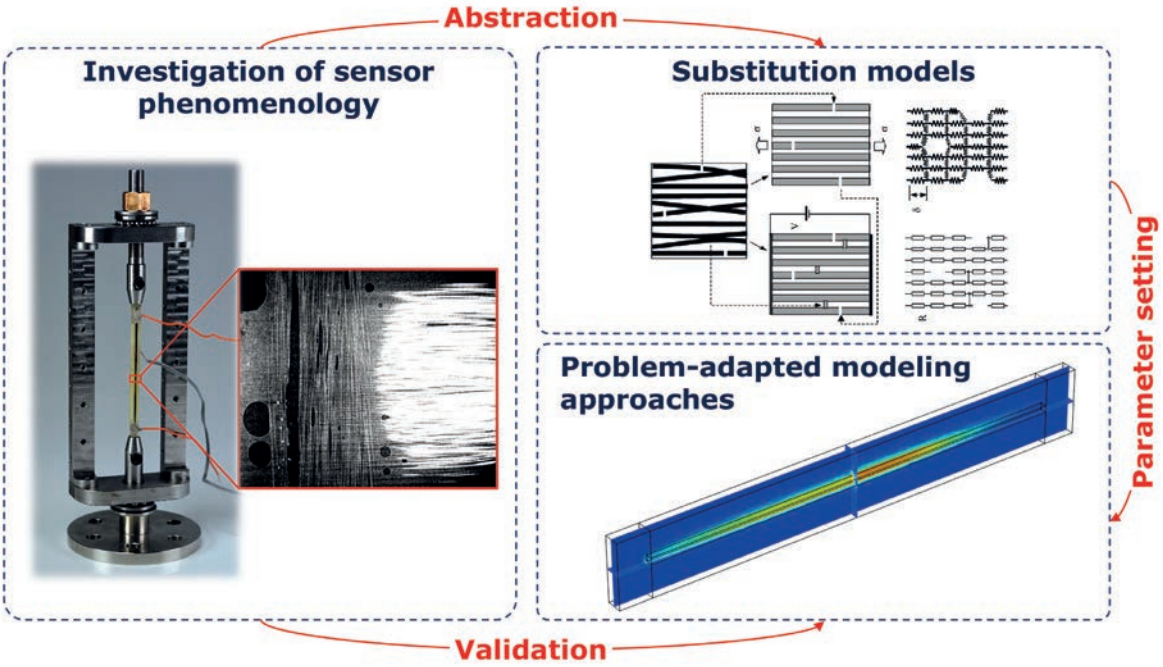
01.08.2019 – 01.10.2020

Project Director

Dr.-Ing. Pawel Kostka

Contact Person

Dr.-Ing. Pawel Kostka
Dr.-Ing. Martin Dannemann



Principle procedure using the example of a new type of strain sensor

Project Overview (Selection)

1000KM+	Scalable European Powertrain Technology Platform for Cost-Efficient Electric Vehicles to Connect Europe
3D³	Leistungszentrum SMART PRODUCTION AND MATERIALS TP: Additive Fertigung von faserverstärkten 3D-Druck-Strukturen mit maßgeschneiderten Eigenschaften auf Basis reaktiver Polymersysteme
ABSOLUT	Automatischer Busshuttle selbstorganisierend zwischen Leipzig und dem BMW-Terminal
ADAPT	Selbstadaptierendes Zuschnittsystem und prozessbegleitende Qualitätssicherung im CFK-Verarbeitungsprozess
ADHYBAU (ex. BASELA)	Entwicklung additiver Verfahren und Faserverbund-Metall Hybridbauweisen für den Einsatz in tiefkalter Umgebung (AdHyBau) TP: Neuartige Bauweisen für Strukturen in elektrischen Antrieben mit kryogener Kühlung
AI4DI	Artificial Intelligence for Digitalizing Industry
AMARETO	Sächsische Allianz für Material- und Ressourceneffiziente Technologien
AMSIM	Entwicklung einer sequentiellen Simulationsmethodik zur Analyse und Optimierung der Gestaltung additive gefertigter Bauteile unter Berücksichtigung prozess- und strukturbedingter Anisotropien im Strangablegeverfahren
AMTWIN	Datengetriebene Prozess-, Werkstoff- und Strukturanalyse für die Additive Fertigung
ARCHITECT	Trustable architectures with acceptable residual risk for the electric, connected and automated cars
AUTODRIVE	Energieversorgung, Kommunikation und Verkehrsverhalten von hoch- und vollautomatisierten Fahrzeugen
BRYSON	BauRaumeffiziente HYdrogenSpeicher Optimierter Nutzbarkeit TP: Prozessentwicklung zur Fertigung thermoplastischer Kettentanksysteme
C3-V2.5A	Beanspruchungsgerechte Carbonbewehrungsstäbe für einen wirtschaftlichen Einsatz im Bauwesen TP: Entwicklung angepasster Bewehrungsstabprofilierungen und Fertigungskonzepte
C3-V4.16	TP: Grundlagenuntersuchungen zur Entwicklung einer neuartigen Prüfmethode für Carbonbewehrungsstäbe mit variablen Oberflächentopologien
CECO	Entwicklung eines Herstellungsprozesses für neuartige cellulosebasierte Composite zur Spritzgießverarbeitung
COMPOLL	Combating environmental pollution through internationalisation of education in Germany and India
DAHLIA	Digitale Technologien für hybride Leichtbaustrukturen TP: Fusion der Werkstoff- und Prozessmodelle zu einem digitalen Zwilling

Director	Expert Unit	Start	End	Funding	Project Executing
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	01/2019	06/2022	EU	
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	07/2019	12/2020	SAB	SMWK
Prof. Dr. rer. nat. Hubert Jäger	Leichtbauweisen	01/2019	12/2021	BMWi	DLR
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	11/2018	04/2021	BMBF	PTKA-PFT
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	05/2020	04/2023	BMWi	DLR
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	05/2019	05/2022	EU / BMBF	VDI/VDE
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	01/2017	02/2021	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	06/2019	11/2021	AiF	FSKZ
Prof. Dr.-Ing. habil. Maik Gude	Prüfmethoden und Materialmodelle	12/2019	06/2022	SAB	
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	07/2020	06/2023	EU / BMBF	VDI/VDE
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	05/2017	10/2020	EU / BMBF	VDI/VDE
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	12/2019	05/2023	BMWi	PTJ
Prof. Dr. rer. nat. Hubert Jäger	Materialmodelle	01/2019	02/2021	BMBF	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Materialmodelle	09/2018	03/2021	BMBF	PTJ
Prof. Dr. rer. nat. Hubert Jäger	Verbindungstechniken	08/2019	01/2022	AiF	DECHEMA
Prof. Dr.-Ing. habil. Maik Gude	Internationales	07/2020	06/2024	DAAD	
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren / Funktionsintegration	02/2020	03/2022	SAB	

DEU-CHN-WS	Deutsch-Chinesischer Workshop TU Dresden-Tongji Universität
DIGI-KUNST	Digitalgestützte Lernwerkzeuge in der Ausbildung von Verfahrensmechaniker/-innen für Kunststoff- und Kautschuktechnik zur Berufsnachwuchssicherung (Digi-Kunst)
DIWA	Durchgängige Analyse und Bewertung fertigungsbedingter Faserfehlorientierungen in dickwandigen Faser-Kunststoff-Verbundstrukturen TP: Analyse des Einflusses fertigungsbedingter Faserfehlorientierungen auf das Werkstoffverhalten von dickwandigen Faser-Kunststoff-Verbunden
ENZYME	Enzymbasierter Kreislaufprozess für die nachhaltige Produktion und Verwertung von Naturfaser-Biocomposit-Werkstoffen TP: Antragstellung Phase 1 / Vorbereitung von Netzwerkaktivitäten: Enzymes for more environment-friendly consumer products / FNR-16-2020
EPREDICT	Predictive Maintenance für die e-Mobilität TP: Zuverlässigkeit von Polymerstrukturen bei thermome-chanischer Belastung in elektrischen Antriebssystemen
EVHY (HYBRID-STRUKTUREN)	Eigenschaften der Verbindungszone in textilverstärkten Thermoplast-Hybridstrukturen
FASSADE	Entwicklung eines reproduzierbaren Herstellungsverfahrens für variabel gekrümmte Fassadenelemente aus Metall-Kunststoff-Verbundblechen TP: Entwicklung einer FE-Simulation zur effektiven Entwicklung des Herstellungsverfahrens
FAVORIT	Faserverbundbasierte Ventilator-Lüfterräder für rationelle industrielle Thermoprozesse TP 5: Auslegung und Prüfung von beschaufelten faserkeramikbasierten Lüfterrädern (Rotorauslegung und Komponententest)
FELISA	Automatisierte Fertigung von Faser-Thermoplast-Verbund-Profilen für offene und geschlossene Luftfahrtstrukturen in Serienanwendung TP: Tape-Braid-Patch Preforming für komplex geformte Faser-Thermoplast-Verbund-Profile
FLEUR	Aktive Flächen mit Reaktionsstrukturen für urbane Räume TP: Entwicklung von Modellen zur Auslegung hybrider aktiver Tragwerksstrukturen mit Funktions-integration
FLIER	Flexible Wandstrukturen für akustische LInER
FOREL2	Verbundprojekt: Forschungs- und Technologiezentrum für ressourceneffiziente Leichtbau-strukturen der Elektromobilität 2 TP: Übergreifende Strategieentwicklung zum Einsatz vernetzter Prozessketten in der Fertigung funktionsintegrativer Leichtbaustrukturen
FOSTESA	Entwicklung eines an den individuellen Pferderücken angepassten form- und steifigkeits-angepassten Sattelbaums TP: Auslegung, Dimensionierung und Test einer form- und steifigkeitsangepassten Sattelbaum-struktur und Erforschung geeigneter Kunststoffe zur Entwicklung eines Herstellungsprozesses

Director	Expert Unit	Start	End	Funding	Project Executing
Prof. Dr.-Ing. Niels Modler	Internationales	11/2020	11/2020	Chinesisch-Deutsches Zentrum für Wissenschafts-förderung	
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	06/2019	05/2022	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Prüfmethoden und Materialmodelle	04/2020	03/2023	DFG	
Prof. Dr. rer. nat. Hubert Jäger	Sonderwerkstoffe- und verfahren	10/2019	01/2020	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Materialmodelle	08/2019	06/2022	SAB	
Prof. Dr. rer. nat. Hubert Jäger	Verbindungstechniken	06/2018	02/2021	AiF	FSKZ
Prof. Dr.-Ing. Niels Modler	Leichtbauweisen	12/2018	05/2021	AiF	AiF
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	09/2016	05/2020	BMWi	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	04/2019	09/2022	BMWi	DLR
Prof. Dr.-Ing. Niels Modler	Materialmodelle	04/2019	03/2022	SAB	
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	06/2020	08/2023	BMWi	DLR
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	12/2016	05/2020	BMBF	PTKA-PFT
Prof. Dr.-Ing. Niels Modler	Leichtbauweisen	07/2018	03/2021	AiF	AiF

FURNIER	Entwicklung und technologische Umsetzung tragender Profilstrukturen auf Basis von Holzfurnieren für ein ultraleichtes Stativ für Fotoanwendungen TP: Kennwertbestimmung und Modellierung des Werkstoff- und Strukturverhaltens
FUSSHEBER	Entwicklung einer Fußheberorthese mit kinematischen, aktorischen Funktionen TP: Entwicklung eines Verbundwerkstoffes und korrespondierender Kinematik für aktive Fußheberorthesen
GEPART	Entwicklung effizienter Verfahrenstechnologien innerhalb des geschlossenen Partikelschaum Werkstoffkreislaufs TP: Virtuelle und experimentelle Werkstoffcharakterisierung für rEPP und EPP- Partikelschaum
GERUSAM	Additive Fertigungstechnologien für funktionalisierte Leichtbaustrukturen
GESCHA II	Erarbeitung der Gesetzmäßigkeiten der Schaumstrukturbildung im Gefrierschäumprozess biokompatibler Keramikschäume
GRK-IFEV	GRADUIERTENKOLLEG 2430 Interaktive Faser-Elastomer-Verbunde
HYBCRASH	Seriennahe Technologien für hochbelastete hybride Multilayer-Crashstrukturen TP: Herstellung hybrider Verbunde mittels Pressverfahren
HYBSCH	Teilflexible Wabenkernstrukturen für effiziente Schalldämpfer TP: Bauweisenentwicklung und Technologiesynthese zur Fertigung zellularer Kunststoff-hybridstrukturen für den Einsatz in Schalldämpfern
HYFOTOOL	Hybrid Forming Tool – Entwicklung eines ultraleichten, leistungsfähigen Stahl/Kunststoff-Hybridwerkzeugs zum Tiefziehen von Blechen inklusive einer erstmaligen Integration von RVDT-Sensorik zur Erfassung der Werkzeugbeanspruchungen TP: Untersuchung der Materialeigenschaften und Entwicklung der Verstärkungsstrukturen für das HyFo-Tool auf Basis von FE-Simulationen
HYPRO	Ganzheitliche Umsetzung hybrider Bauweisen in die Serienproduktion
HYSTERESIS	Zyklisch-dynamische Eigenschaften von Partikelschäumen
I-DETEKT	Intelligentes Batterieschutzsystem für Elektrofahrzeuge zur Detektion von unerwünschten mechanischen Beschädigungen TP: Entwicklung e-Preform
ILKINAUS	Development of tailored carbon fibres for multifunctional composites
IMEM	Entwicklung einer innovativen Membranpresse zur effizienteren Fertigung von Faserverbund-bauteilen aus thermoplastischen Halbzeugen in kleinen und mittleren Seriengrößen TP: Entwicklung einer optimierten Prozessführung sowie eines Temperaturmanagements zur effizienten Fertigung von Faserverbundbauteilen in der neuartigen Membranpresse
INDIRA	Integration maßgeschneiderter Lasteinleitungselemente in einen KMU-gerechten einstufigen Fertigungsprozess für komplex geformte Sandwichverbundstrukturen TP: Entwicklung und Implementierung werkstoff- und funktionsgerechter Insertelemente für hochbeanspruchte Sandwichverbundstrukturen

Director	Expert Unit	Start	End	Funding	Project Executing
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	10/2019	09/2021	BMEL	FNR e. V.
Prof. Dr.-Ing. Niels Modler	Leichtbauweisen	12/2018	05/2021	AiF	AiF
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	12/2020	11/2023	BMWi	PTJ
Prof. Dr.-Ing. Niels Modler	Funktionsintegration / Sonderwerkstoffe- und verfahren	05/2020	04/2021	BMBF	DLR
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	01/2020	06/2022	DFG	
Prof. Dr.-Ing. Niels Modler	Numerische Verfahren	11/2018	01/2023	DFG	
Prof. Dr. rer. nat. Hubert Jäger	Numerische Verfahren	07/2016	12/2020	SAB	
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	04/2020	03/2023	DFG	
Prof. Dr.-Ing. Niels Modler	Prüfmethoden und Materialmodelle	04/2019	09/2021	AiF	AiF
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	05/2020	10/2022	BMBF	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	12/2020	11/2023	DFG	
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	12/2020	11/2023	BMWi	PTJ
Dr.-Ing. Robert Böhm	Materialmodelle	01/2020	12/2021	DAAD	
Prof. Dr.-Ing. Niels Modler	Thermoplastverfahren	01/2020	06/2022	AiF	AiF
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	11/2019	10/2021	AiF	AiF

INPRO	Integrale Leichtbau-Profilsysteme aus Faser-Thermoplast-Verbund funktionalisiert im Spritzform-Prozess TP: Konzeption, Design und prozesstechnologische Beschreibung funktionalisierter Faser-Thermoplast-Verbund Hohlprofile
INSERT	Simulationsgestütze Entwicklung von belastungs-, werkstoff- und prozessgerechten Lasteinleitungselementen für thermoplastische Faserverbundwerkstoffe
K-CRASH	KIMS Academic Laboratory: Technology transfer for crash and impact modelling, simulation and testing for composite based lightweight structures
KOBRA	Kompakte Faserkeramik basierte Röntgenröhre für mobile Computertomographen TP: Strukturmechanische Auslegung und experimentelle Erprobung einer Rotationseinheit aus Faserverbundkeramik für kompakte Röntgenröhren
KOKOMAG	Entwicklung und Bewertung eines korrosionsgeschützten, nichtbrennbaren kohlenstofffaser-verstärkten Magnesium-Werkstoffs für die Anwendung in der Luftfahrt
LEVADI	Lebensdaueranalyse für Klebverbindungen in großen FKV-Strukturen mit variierenden Kleb-schichtdicken
LIGHTSAX	Potentiale des Leichtbaus in Wissenschaft und Wirtschaft in Sachsen
LIWEKO	Gewichtsreduzierte Leichtbau-Spannmittel, -Werkzeuge und -Komponenten für rationelle hochdynamische Zerspanungsprozesse TP: Entwicklung hybrider Bauweisen sowie Auslegung und Prüfung gewichtsreduzierter Rotoren für hochdynamische Schleifbearbeitungsprozesse
MALAGA	Maßgeschneiderte Metall-Polymer-Metall-Schichtverbunde für verbesserte Energie-absorptionscharakteristika von Crash-Strukturen
MEGRAV	Methodische Entwicklung von Metall-Graphit-Verbundwerkstoffen für Gleitlageranwendungen im Hochtemperaturbereich
METEOR	Methoden und Technologien zur Validierung und Optimierung der Ressourceneffizienz von Prozessnetzwerken bei der Herstellung hybrider Leichtbaustrukturen TP: Aufbau Prozessnetzwerk und der virtuellen Prozesskette
MINDENDO2	Entwicklung von Miniaturstrukturen aus Faserkunststoffverbundwerkstoffen für die ultraschall-basierte Dekontamination von non-shedding surfaces im menschlichen Organismus
MLDDS	Untersuchung des Schädigungsverhaltens von schnell-drehenden Faserverbundrotoren durch in-situ Messtechnik
MM3D	Generative Fertigung von Multi-Material-Leichtbaustrukturen
MMSS (SCKOR)	Development of Mass Production Total Engineering Technologies for Metal-Composites Hybrid Process (Joining & Forming) & Over 25 % Lightweight Side Crash Carbody Structure Components
MUFUS	Entwicklung multifunktionaler Schnittstellen zum Verbinden von FKV mit Metallen unter Nutzung etablierter Fügeverfahren
ORGON	Organoblechstrukturen mit funktionalen Oberflächen

Director	Expert Unit	Start	End	Funding	Project Executing
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	08/2020	07/2023	BMWi	DLR
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	07/2019	09/2021	DFG	
Prof. Dr.-Ing. Niels Modler	Numerische Verfahren	05/2018	06/2021	KIMS	KIMS
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	10/2019	09/2022	BMBF	VDI
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	08/2020	07/2023	BMWi	DLR
Prof. Dr.-Ing. habil. Maik Gude	Prüfmethoden und Materialmodelle	04/2020	03/2023	AiF	DVS
Prof. Dr. rer. nat. Hubert Jäger	Thermoplastverfahren	09/2019	10/2020	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	10/2019	09/2022	BMWi	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	10/2018	12/2020	DFG	
Prof. Dr. rer. nat. Hubert Jäger	Verbindungstechniken	09/2018	12/2020	AiF	FKM e. V.
Prof. Dr.-Ing. habil. Maik Gude	Sonderwerkstoffe- und verfahren	12/2020	11/2023	BMWi	PTJ
Dr.-Ing. Martin Dannemann	Funktionsintegration	05/2018	02/2022	DFG	
Prof. Dr.-Ing. habil. Maik Gude	Funktionsintegration	06/2017	07/2021	DFG	
Prof. Dr.-Ing. Niels Modler	Thermoplastverfahren	06/2017	08/2020	SAB	
Prof. Dr. rer. nat. Hubert Jäger	Numerische Verfahren	07/2017	03/2021	KEIT	KIMS
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	10/2019	03/2022	AiF	EFB
Prof. Dr.-Ing. Niels Modler	Thermoplastverfahren	02/2020	07/2022	AiF	FVLK

PEM	Polymerelektrolytmembran (PEM) für Vanadium-Redox-Flow-Batterien
PEP4.0	Digital synchronisierte Entwicklungsarchitektur für den Produktentstehungsprozess 4.0
PLRV	Entwicklung einer großräumigen Leichtbau-Transportbox TP: Entwicklung des Prüfstandes und der Prüfmethoden zur experimentellen Charakterisierung der Leichtbau-Transportbox
PROPLUG	Entwicklung eines strukturintegrierten Steckverbindungssystems für die Elektrifizierung von funktionalisierten Faserverbundbauteilen TP: Integrationskonzepte und -technologien und mechanische Charakterisierung
PULTIX	Neuartiger Pultrusionsprozess zur kontinuierlichen Herstellung duroplastischer Bewehrungsstäbe mit Helix-Profilierung
RAVI	Neue Generation wirkungsgradgesteigerter, emissionsfreier Vibrationsstampfer TP: Wirksystem und Einflussgrößen – Ermittlung und funktionale Ausnutzung
RECAR	Entwicklung eines modularen Heizsystems aus rezyklierten Carbonfaservliesen für den Einsatz in Umform- und Preformingwerkzeugen TP: Charakterisierung der Eigenschaften von Heizvliesen aus rezyklierten Carbonfasern sowie Erforschung der Applikationsmöglichkeiten im Preformingprozess textiler Halbzeuge
ROBIN	Robotergestützte mobile Injektionseinheit zur prozessintegrierten Fertigung hybrider Bauteilstrukturen (Robotised Injection Moulding)
ROBUST	Effiziente und robuste Entwicklungs-, Validierungs- und Produktionsprozesse hybrider Metall-Faserverbund-Bauweisen für verkehrs- und energietechnische Systeme im Kontext der Industrie 4.0
SCADS2	Competence Center for Scalable Data Services and Solutions Dresden/Leipzig – Phase 2
SMARTMEMBRANE-C	Smart membrane pressing technology for manufacturing of high performance composite components TP: Entwicklung einer intelligenten Membrane zur presstechnologischen Herstellung von Hochleistungsverbundwerkstoffen mit hoher geometrischer Variabilität
SNAPCURE 4.0	Innovative Prozessketten mit schnell aushärtenden Polymersystemen (Snap-Cure-Polymers 4.0) TP: Entwicklung und Validierung kombinierter informations- und beschreibungsbasierter Struktur- und Prozesskettenmodelle
SPP 1640 III	Fügen durch plastische Deformation Phase III: TP: Simulationsgestützte Entwicklung und Qualifizierung eines neuartigen Thermoclinch-Fügeverfahrens für Mischbauweisen mit textilverstärkten Thermoplastverbunden
SPP 1712 II	Intrinsische Hybridverbunde für Leichtbaustrukturen TP: Erarbeitung der theoretischen und technologischen Grundlagen für intrinsische Thermoplastverbund-Metall-Hohlstrukturen mit beanspruchungsgerecht ausgeführtem skalenübergreifendem Formschluss
SPP 1897 – II. Phase	Complex-Shaped Lightweight Structures with Adaptive Dynamic Behaviour through Evanescent Morphing

Director	Expert Unit	Start	End	Funding	Project Executing
Dr. rer. nat. Uwe Gohs	Sonderwerkstoffe- und verfahren	06/2019	05/2022	DFG	
Prof. Dr.-Ing. habil. Maik Gude	Leichtbauweisen	07/2018	03/2022	BMWi	DLR
Prof. Dr.-Ing. habil. Maik Gude	Prüfmethoden und Materialmodelle	08/2020	07/2022	AiF	AiF
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	12/2020	11/2023	BMBF	VDI/VDE
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	10/2019	09/2021	AiF	Carbon Composites
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	07/2018	04/2021	SAB	
Prof. Dr.-Ing. Niels Modler	Duroplastverfahren und Preforming	01/2020	06/2022	AiF	AiF
Dr.-Ing. Michael Krahl	Thermoplastverfahren	03/2020	08/2021	BMWi	PTJ
Prof. Dr. rer. nat. Hubert Jäger	Thermoplastverfahren	02/2019	07/2021	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	10/2018	09/2021	BMBF	DLR
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	01/2020	12/2021	AiF	FILK
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	11/2018	08/2021	SAB	
Prof. Dr.-Ing. habil. Maik Gude	Verbindungstechniken	07/2017	04/2020	DFG	
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	06/2017	09/2020	DFG	
Dr.-Ing. Pawel Kostka	Funktionsintegration	10/2019	09/2022	DFG	

STYQZAHL	Strukturelle Metall-Kunststoff-Hybridbauweise am Beispiel eines Stoßfänger-Querträgers der elektrifizierten, automobilen Großserie – Darstellung eines wirtschaftlichen Herstellungsprozesses durch Integration einer On-Line-Qualitätssicherung und Optimierung der Materialausnutzung
SUMMER SCHOOL	Sommerschule „Intelligente Leichtbausysteme“
SWING	Analyse und Simulation des fertigungsabhängigen Schwindungsverhaltens glasfaserverstärkter Epoxidharze zur verbesserten Vorhersage von Oberflächenwelligkeiten und Verzug
TAPE-PROTHESE	Entwicklung einer Technologie zur Fertigung von Schäften für Unterschenkelprothesen auf der Basis vorkonfektionierter Rohlinge aus Tape-Geflecht für eine schnelle, individuelle Anpassung an den Patienten TP: Entwicklung einer Verfahrenstechnologie zur Fertigung von Prothesenschäften mittels OrganoTubes
TAPETEC	Advanced Tape Technology
TERESA	Thermoplastisches Endkontur-Sandwich für innovative Luftfahrtanwendungen Teilvorhaben: Entwicklung von funktionalisierten thermoplastbasierten Sandwichstrukturen für Luftfahrtanwendung
T-EXOSUIT	Textilbasiertes Exoskelett mit individuell einstellbarem graduellen Bewegungswiderstand und User-Interface zur präventiven und rehabilitativen Unterstützung des Bewegungsapparats TP: Konstruktion eines textilbasierten Exoskeletts mit integrierter Sensorik und User-Interface
THOPOL	Thermisch hochbelastbare Polymersysteme für Leichtbau Antriebe TP: Effiziente Verarbeitungstechnologien und robuste Auslegungsmethoden für rotierende Leichtbaustrukturen
TRANSTECH	Verkehrsübergreifende, synergetische Technologien für regionale emissionsfreie Mobilität
TRR 285 – A03	Berechnung und Bewertung prozessinduzierter Werkstoffstrukturphänomene in FKV-Metall-Verbindungen
TRR 285 – C04	Lokale und integrale in situ Analyse prozess- und betriebsbedingter Schädigungseffekte von Fügeverbindungen
VEDUFO	Entwicklung eines neuen Herstellungsprozesses für faserverstärkte Kunststoffe mittels beheizbarer Vakuummembran und 3 Monate bei 25 °C lagerstabilen, unter 120 °C aushärtbaren Epoxidharzfolien TP: Entwicklung des Verfahrenskonzepts und Prozessparameterbestimmung eines neuen RFI-Prozesses mit beheizbarer Vakuummembran
VITSCHA	Neuartiges transparentes Vitrinenscharnier TP: Entwicklung der Simulation sowie der Klebetechnologie für ein transparentes Scharnier
XEROPUL	Entwicklung einer Technologie zum selektiven Auftrag von Pulverbindersystemen mittels Xerografie TP: Voruntersuchungen und Prozessstudien zur Pulverbinderapplikation mittels Xerographie

Director	Expert Unit	Start	End	Funding	Project Executing
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	05/2020	10/2022	BMBF	PTJ
Prof. Dr.-Ing. habil. Maik Gude		03/2020	12/2022	TUD, Bereich ING	
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	02/2019	01/2022	DFG	
Prof. Dr.-Ing. Niels Modler	Thermoplastverfahren	05/2019	04/2021	AiF	AiF
Dr.-Ing. Christian Garthaus	Thermoplastverfahren	11/2017	07/2020	BMWi	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Thermoplastverfahren	05/2019	04/2022	BMWi	DLR
Prof. Dr.-Ing. Niels Modler	Funktionsintegration	08/2018	10/2020	BMBF	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	02/2019	01/2022	BMBF	PTJ
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	02/2019	04/2020	BMBF	DLR
Prof. Dr.-Ing. habil. Maik Gude	Numerische Verfahren	07/2019	06/2023	DFG	
Dr.-Ing. Robert Kupfer	Verbindungstechniken	07/2019	06/2023	DFG	
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	11/2019	04/2022	AiF	AiF
Prof. Dr.-Ing. Niels Modler	Leichtbauweisen	12/2019	11/2021	AiF	AiF
Prof. Dr.-Ing. habil. Maik Gude	Duroplastverfahren und Preforming	03/2019	08/2021	AiF	AiF

Contact person international cooperation

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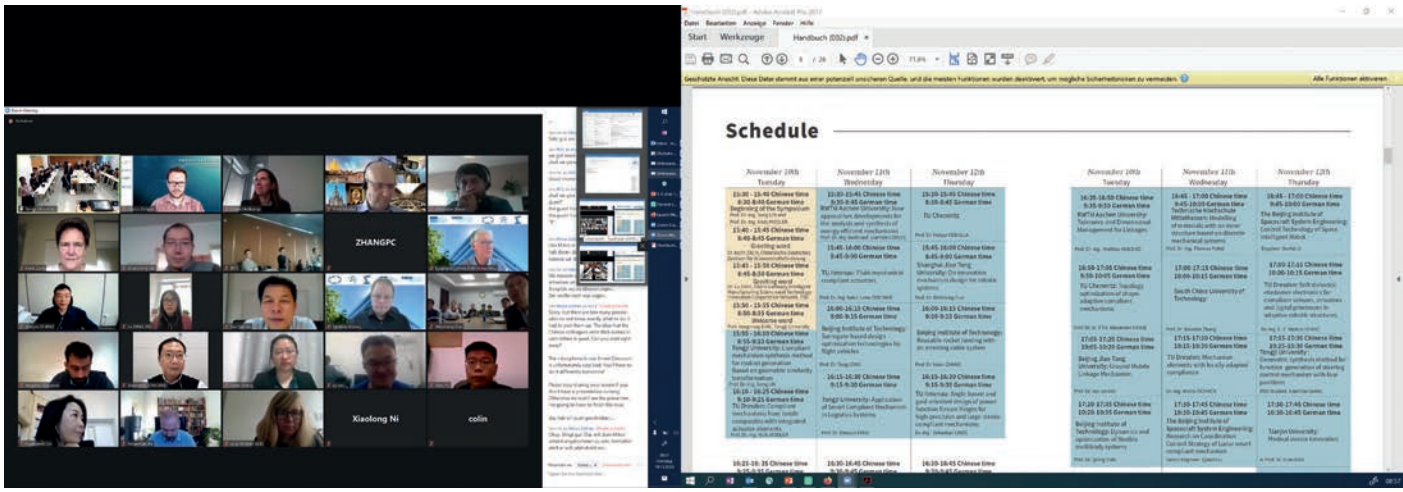
Internationalisation

The lively international activities of 2019 were carried over into the new year, so that a wide range of new projects could be initiated and launched in the first three months of 2020. As the pandemic progressed, many of these activities had to be postponed or moved to the digital space, but this only slightly limited the intensity of the international activities. Rather, it offered the opportunity to test and introduce new tools and methods of digital cooperation, so that it can be assumed that the use of hybrid formats will enrich and intensify international cooperation in the long term.

Ethiopia	Addis Ababa Science and Technology University
Australia	Deakin University, Melbourne
China	Tongji University, Shanghai Beijing National Innovation Institute of Lightweight, Peking Chinese Academy of Science, Ningbo Institute of Materials Technology
Greece	National Technical University of Athens University of Patras
Great Britain	University of Bristol Imperial College, London University of Oxford
India	Indian Institute of Technology, Neu Delhi
Italy	Università di Bologna
Latvia	Technical University, Riga
Netherlands	Technical University Delft
Poland	Politechnika Warszawska, Warschau Politechnika Wrocławska, Breslau Politechnika Poznanska, Posen Akademia Górniczo-Hutnicza, Krakau Politechnika Śląska, Gleiwitz
Romania	Politehnica University of Timisoara
Singapore	Nanyang Technological University
South Korea	Korea Institute of Science and Technology Jeonbuk Branch Korea Institute of Carbon Convergence Technology, Jeonju Korea Institute of Materials Science, Changwon
Ukraine	National Aviation University, Kiew

Sino-German Symposium on Compliant Mechanisms

One of the highlights of 2020 was the Sino-German Symposium on Compliant Mechanisms, which was organised by ILK from 10 – 12 November together with the Chinesisch-Deutschen Hochschulkolleg (CDHK) of Tongji University Shanghai with the participation of numerous German and Chinese university partners. The symposium was funded by the German-Chinese Centre for the Promotion of Science (CDZ), which is a joint venture of the German Research Foundation (DFG) and the National Natural Science Foundation of China (NSFC) that focuses, among other things, on scientific cooperation in the engineering sciences. The original plan to hold the symposium in May 2020 at Tongji University was thwarted by the Corona pandemic, so the project leaders Prof. Niels Modler and Prof. Song Lin decided to move the symposium to November and to organise it digitally. In the virtual event, which was held across time zones, the participants had the opportunity to present their current research and discuss it with renowned experts from Germany and China. The participants included representatives from TU Dresden, TU Chemnitz, RWTH Aachen, TU Ilmenau and Hochschule Mittelhessen on the German side and from numerous research institutions on the Chinese side, including Tongji University, Tianjin University, Jiao Tong University and the Beijing Institute of Technology. Afterwards, the event was considered a complete success by all participants and the experience gained from it will be used to shape future cooperation activities.



DAAD Deutscher Akademischer Austauschdienst
German Academic Exchange Service

Together with IIT Delhi against environmental pollution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Within the framework of the joint call for proposals "Indo-German Partnerships in Higher Education (IGP)" of the German Academic Exchange Service (DAAD) and the Indian University Grants Commission (UGC), the project "Combating Environmental Pollution through Internationalisation of Education (COMPOLL)" was launched, which the ILK is implementing together with the Institute of Technology Delhi (IIT Delhi). The IIT Delhi and the TU Dresden have been working together for many years in various scientific disciplines such as mechanical engineering, rotordynamics, tribology or computer science in order to ensure resource efficiency of products, processes, sustainable systems and materials. A strategic cooperation to combat pollution and reduce the human footprint requires overarching cooperation between main environment-focussed players on the Indian and German sides. The

present project aims at bundling the existing contacts and activities and putting them at the service of increasing pollution awareness by means of waste reduction and recycling, utilisation of biologically based materials as well as return to design solutions allowing repair and overhaul.The aim of the project is to help intensify cooperation between the two universities over the next four years by intensifying partnership at the institutional level and developing and implementing innovative teaching and research profiles. In addition to curricular design, the planned activities include the implementation of summer schools, workshops and conferences, and several study and research visits to the respective partner are also planned. The project is based on the long-standing history of cooperation between the ILK and the IIT Delhi. An overarching goal of the DAAD and the UGC is to network all project partners funded under the IGP on both the Indian and German sides in order to facilitate an exchange of experiences and to exploit possible synergies.

Model project: Focus on the academic success of international students at the ILK

As part of the DAAD funding initiative "STIBET II – Modellprojekte zur Verbesserung der Willkommenskultur", the ILK was positively evaluated in autumn 2020 for the project "Erfolgreich – Digital – Integriert: Studium an der TU Dresden (EDI:TUD)", which starts in January 2021. This was the first time that the Technische Universität Dresden succeeded in participating in the STIBET programme, which has been running since 2006. Due to its particularly high proportion of international students, the ILK is acting as a model location. In the course of the project, approaches are being developed which have a model character and which can also be transferred to the entire TUD and further on to other universities.

In concrete terms, the EDI:TUD project aims to provide international students with close support directly in their immediate everyday study environment throughout their entire path to graduation, in order to avoid students dropping out, to shorten the overall duration of their studies, to improve their study results and to facilitate their integration into the TU Dresden. It relies heavily on the close networking of German and international students. In addition, international students are to be recruited as junior academics for later doctoral projects while they are still studying by involving them in a tutor activity at an early stage. The project is closely accompanied by the Centre for Quality Analysis (ZQA).

Expansion of the Erasmus+ network

Due to travel and mobility restrictions, several mobilities planned through Erasmus+ (KA 103 and KA 107) could not be carried out. Thus, visiting scholar stays to and from South Korea and China were postponed to the next year. Nevertheless, the ILK took advantage of the pandemic-related break to establish and expand the Erasmus+ network: The ILK renewed Erasmus agreements with numerous partners that have been in place for many years, so that students, researchers and administrative staff can continue to benefit from the ILK's strong network in the future and incorporate stays abroad for study, research or further education purposes into their CVs. At the same time, the ILK expanded its Erasmus network to include new international partners, such as the University of Patras. Particularly noteworthy is a new cooperation agreement concluded in September 2020 with the Addis Ababa University of Science and Technology in Ethiopia, which is the result of a networking visit conducted in the summer of 2019.

Digital Education at ILK

Conversion of teaching

Due to the Corona pandemic, the ILK was also forced to move its entire (face-to-face) teaching programme with more than 15 courses into the digital space shortly before the start of the summer semester.

In addition to the need to make use of digital lecture/seminar rooms, which were only available in larger numbers and capacities in the course of the first weeks of the semester, the teaching material was also to be offered in asynchronous video formats. This gave students the opportunity to avoid busy time slots with high network and server utilisation and to download or stream teaching material for self-study according to individual scheduling. For the majority of the lecturers, using the MAGMA-Platform was new and unfamiliar; nevertheless, they were able to switch over quickly.

It was also necessary to fundamentally adapt communication with the students. Whereas before "digitisation" all agreements and announcements on teaching material, changes of dates, SHK applications, etc. were mainly made verbally during the lectures, afterwards only the digital way was available. Obviously, the Faculty of Mechanical Engineering decided to use the online platform for academic teaching and learning – OPAL. With the provision of the virtual addresses and the announcement that all communication about the courses would take place solely via the OPAL courses, the way in which teaching material and longer-term information was made permanently available could be standardised at the faculty and thus also at the ILK. With OPAL, a central, albeit only virtual, point of contact has been established through which important news can be quickly and widely distributed to students and teachers.

Teaching concept

In contrast to lectures, which could be transferred to the digital space after a familiarisation phase but with increased effort, the preparation, implementation and follow-up of digital exercises and practical courses required entirely new didactic-methodical learning-teaching concepts. The experience gained in the process was mostly used on a

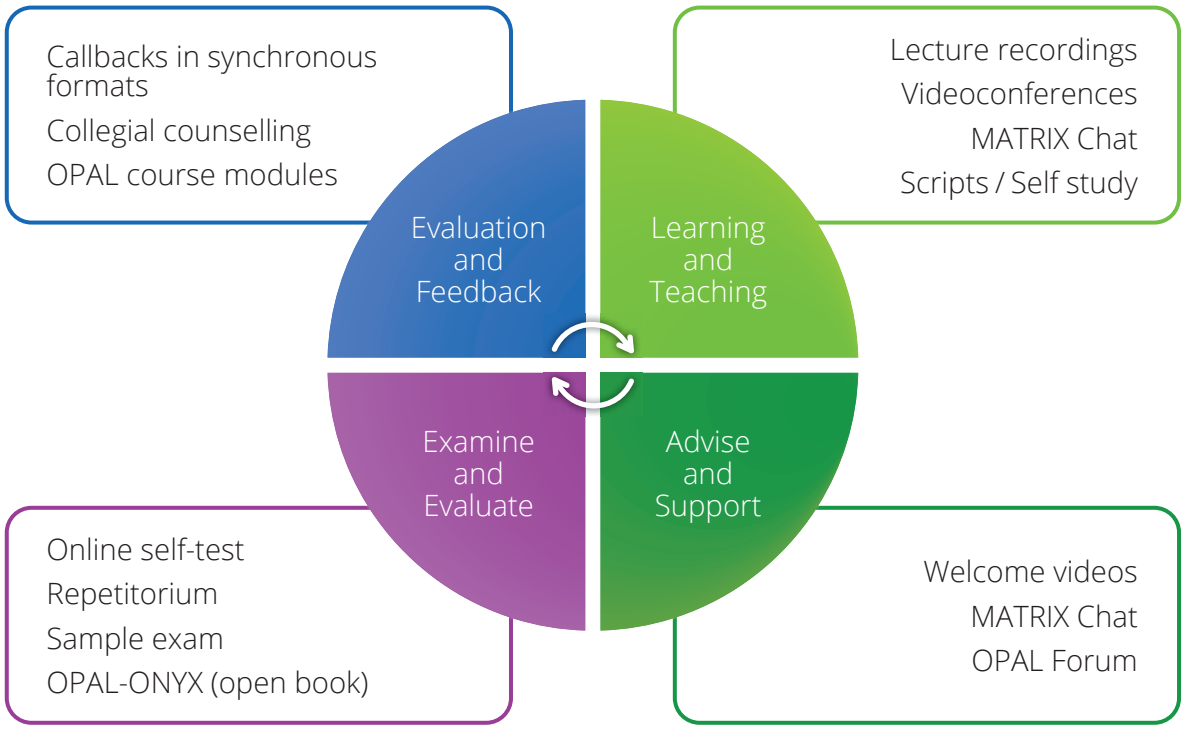

Fig. 1: Dimensions of the digital teaching-learning formats tested at the ILK with exemplary fields of application

weekly basis to iteratively improve the teaching-learning concepts. Four aspects of digital teaching were focused on in particular (Fig. 1).

At the beginning of the semester, activities were concentrated in the area of **teaching and learning**. Here, the activities focused on the digitisation of lecture, exercise and practical course materials as well as the establishment of digital communication channels. **Exchange** between students and between students and teachers is essential for successful teaching, and various channels were used for this purpose.

The conversion of **examinations** to digital examinations was supported by self-tests during the semester and a mock examination, so that content-related and technical challenges for students and teachers alike could be addressed.

An important building block for the continuous improvement of teaching, whether digital or analogue, is constructive **feedback** from students. This was obtained whenever possible through direct teacher-learner discussions, and for selected courses also through digital evaluation questionnaires on the learning platform.

Lectures

Many lecturers used the recording function of PowerPoint for their lectures, so that they could underlay the lecture notes with an audio track and also make them available as a video in the form of a simple PDF document for further reading. Alternatively, screencast programmes were used, with which actions in programme windows or on the complete desktop and also audio tracks can be recorded. Occasionally, people also experimented with interactive PowerPoint formats, in which different areas of the slides are only discussed successively after pressing a button and thus individual explanations could also be repeated. There was generally positive feedback for this.

In order to encourage the students to communicate more actively, supplementary consultations were increasingly offered in the course of the semester in addition to lecture videos, in which questions could be asked about the material from the previous weeks. In general, self-tests met with great response among the students. In addition, lecturers gain an impression of learning progress.

With the enforced omission of classroom teaching, it was also possible to test the departure from frontal teaching and to encourage students more strongly to study on their own. Instead of setting up exercises as lecture events as usual, the principle of the **flipped class room** was used. Assignments are made available with one to two weeks notice and the exercises are designed purely as question time/consultation. In addition, communication channels for comprehension questions were available at all times via chat rooms and e-mail, which could also be used for professional exchange between the students. Afterwards, sample solutions to the exercises were provided to help students who were unable to participate in the consultations or were disadvantaged due to language barriers.

Examinations

For the majority of the courses, digital examinations were carried out on newly installed instances of the central learning platform. Due to the new framework conditions, the questions had to be conceptually redesigned. Restricting the use of aids was virtually impossible. The examination questions were designed in such a way that in principle all aids – as **open books** – are available. This is also where the potential of digital examinations lies: instead of focusing on transfer knowledge – as is usual in face-to-face examinations – the examination must be more competence-oriented. As expected, the preparation effort is immense due to the changeover, but in addition to the typical multiple-choice questions, there are also task formats available with which solutions to mathematical problems can be tested and even consequential errors can be taken into account.

Summary

Faculty-wide surveys among the students showed that the digital course offerings were well received, and digital examinations are also perceived as an advantage. The lecturers have additional elements at their disposal – even if they were initially surprised and forced to do so – for a varied design of teaching, which can and will certainly also be used after returning to the classroom.

Theses

Name	Type	Theme
Bätzel, Tim	DT	Experimental and numerical investigation of the deformation and failure behaviour of ballistic gelatine under impact loads
Ballasus, Attila	DT	Development of a novel, sustainable composite material containing agriculturally produced long fibres
Beckert, Thomas	DT	Development and valiDTtion of pultrusion techniques for different resin systems for production of thermoset carbon fibre reinforced rebars for embedding in light metal melts
Bieder, Julia	BT	Characterization of the mechanical properties of a composite metal adhesive bond under consideration of different load speeds
Boyksen, Jan	DT	Consideration of manufacturing aspects in the optimization process of endless fibre reinforced 3D-printed structures
Braeuer, Rebecca	DT	Investigation of the assembly process of a battery cell stack into a one-piece battery case
Danz, Florian	DT	Development of an infusion-based manufacturing process for the production of high-performance components for the medical sector with snap-cure resin systems
Döllinger, Fabian	DT	Development and analysis of an additive manufactured structural component to evaluate the design method “generative design”
Fasselt, Janek	DT	Investigation of the cennection auqlitiy in addtive manufacturing of tool components by menas of laser metal deposition
Faust, Johann	DT	Weight-optimized design of a ceiling panel for aviation with due regard to constructive systematics
Geier, Lukas	DT	Development of an additive forming tool for the processing of thermoplastic semi-finished products
Gohdes, Marvin	DT	Development and prototype implementation of a lightweight ski jump binding
Großer, Karline	DT	Experimental studies on influencing the structure-borne sound propagation by modification of the fibre-matrix adhesion
Grzybek, Martin	DT	Pultrution of thermoplastic composites
Gündogdu, Berk	DT	Development of a surface geometry for carbon composite rebars and characterization of the correspondigng interaction with the concrete material
Guo, Ruiqi	DT	Interlinked process and structural analysis of a composite component
Guzun, Lilian	DT	Development and analysis of an additive and subtractive processing center
Haaf, Pascal	DT	Application of recycling materials at the example of a buckle
Han, Jin	DT	Development and evaluation of a procedure for the use of a “Virtua/ Fügemeisterbock” in the pre-series start-up

Name	Type	Theme
Hildebrand, Christoph	DT	Design and examination of a high-performance pul! and push loop in hybrid construction
Hoffeins, Paul	DT	Parameter based optimization of the rotor layout of a permanent magnet synchronous machine
Hönel, David	BT	Design of a door kinematics system for vehicles of urban mobility in public transport
Jia, Shuo	DT	Roll bending of aluminum sheets with variable radii of curvature
Kaczmarek, Moritz	DT	NDT on FKV large components by means of thermography
Kaden, Christoph	DT	Selective powder binder application by means of xerography for the preforming process
Kaube, Nils	DT	Numerical-constructive design of energy-efficient isolation systems for liquid composite molding tools
Kowalik, Selina-Christin	BT	Investigation of the process parameters in the direct consolidation process of tape braided preforms with regard to the quality of the components to be achieved
Li, Ziyuan	DT	Fundamental studies an the modification of cross-linking properties of thermoset matrix systems for additive manufacturing processes
Lindenau, Johannes	DT	Development of a vario thermal tooling system to produce hollow thermo-plastic composite profiles
Ma, Junnan	DT	Thermal simulation of cooling systems for suitability testing of cooling sy-tems for thermoplastic electric motor housings
Miene, Sascha	DT	Potential analysis of fibre reinforced thermoplastic hollow structures with an additively manufactured load introduction element
Mindner, Felix	DT	Injection moulding suitable design of electric motor housings
Müller, André	DT	Development of an additive producible lightweight component for machine tools
Müller, Philipp	DT	Investigations on the build-up of a function-integrative bionic system using the example of a water strider
Muschalski, Lars	DT	Estimation of the potential of fibre-reinforced materials to improve the buckling load/weight ratio of compression loaded bar structures
Nieke, Patricia	DT	Development of a sensor-assisted support structure für a mobile CT system
Niu, Qian	DT	Experimental investigation and simulation analysis of the damage behaviour of glass fibre reinforced epoxy rotors
Ortiz De Zárate TejaDT, Aizea	BT	Development of a fibre composite foot lifting orthosis in lightweight construction
Peller, Hannes Franz Maria	DT	Development of a process for the production of CFRP thin-film laminates for structure-loadable electrodes

Name	Type	Theme
Peters, Romy	DT	Investigation of the stretching influence of different stabilisation processes on the electrical conductivity of hexabenzocoronene/PAN-based carbon fibres
Ramisch, Philipp	DT	Development of a continiously digitalized manufacturing process for a high loadable engine composite strut
Rennert, Johannes	BT	Extension and analysis of a software tool for hte parameterised generation of representative volume elements of unidirectional fibre-reinforced composites
Ryssel, Hannes	DT	In-situ CT-Analysis of mechanical joints
Scharbow, Scally Joyce	DT	Evaluation of the application-specific lightweight potential of continuous-fibre wire-reinforced thermoplastics in automotive engineering
Schlegel, David	DT	Pre-developnent fo design space adapted hydrogen pressure vessels for aircrafts
Schlunze, Kevin	DT	Lightweight design of hardwood components for industrial production of sustainable functional furniture
Schmeyers, Marcel	DT	Development of a technology to reduce material-specific preform thickening
Schmidt, Felix	DT	Numerical analysis of the delamination behaviour of fabric-reinforced composites
Schmidt, Florian	DT	Design and manufacture of a car rim with long-fibre reinforced car rim spoke star close to serial production of carbon fibre reinforced car rims
Schöpfel, Thomas	BT	Performance analysis and optimization of CFRP bicycle rims with regard to their spoke anchoring
Seidel, Robert	DT	Single roving placement based on chemical fixation for the tailored fibre placement processing
Stork, Alexander	DT	Development of a material model for the light-optical description of CFRP structures as a function of temperature and time
Sychowski, Marius Jan von	BT	Investigation of the application potential of a collaborative robotic system for additive manufacturing using Fused Layer Modeling (FLM)
Tan, Liming	DT	Numerical modelling of the structural behaviour of a hat profile in hybrid design under high dynamically bending loading
Tang, Boxin	DT	Natural fibre-based materials in mechanical engineering – requirements for mechanical characteristics and their determination
Ueberschär, Felix	DT	Design and dimensioning of a lightweight assembly carrier cockpit made of a fibre reinforced composite
Voigt, Norman	DT	Development of a passive support structure for function-integrative orthoses
Wang, Wenjie	DT	Design and optimization of an automobile component in hybrid design under crash load condition
Weigel, Franz	DT	Process investigations for the thermoplastic pultrusion of differently profiled semi-finished bar products

Name	Type	Theme
Wiebicke, Felix	DT	Numerical analysis on the inter fibre failure of real mircostructures in unidirectional fibre-reinforced polymers
Wießner, Maximilian	DT	Development of a sensor-equipped mould for the processing of polymer foams based on vegetable oils
Wurster, Leo	DT	Technological validation of the product development of hybrid frame structures for two-wheel motor vehicles
Xu, Yun	DT	Investigations into the influence of electric or magnetic fields on the orientation of fibres in polymeric matrices
Yang, Jiaqi	DT	Investigation of machine learning for the analysis of complex process chains in fibre composite manufacturing
Zhang, Hailun	DT	Numerical Simulation of pin-reinforced composites
Zhang, Xianglu	DT	Analysis of an aviation series production process using process data and numerical simulations
Ziervogel, Fabian	DT	Development of a semi-automated cutting and contracting of hybrid filaments for the FDM process

juniorIng.

Association for Engineering and Natural Sciences Junior Education Saxony

The non-profit "Verein für Ingenieur- und naturwissenschaftliche Juniorenbildung Sachsen (e. V.)" (Association for Engineering and Natural Science Junior Education Saxony), short: juniorIng. Sachsen e. V., was founded in 2009. With this association, we want to arouse technical interest among children and young people at an early stage and to inspire them with a lasting enthusiasm for technology. To this end, we work closely with sponsors of scientific and cultural events in Saxony. We organize information events on materials and lightweight topics for daycare centres, schools, vocational schools and society. In addition, we support educational staff in the age-appropriate teaching of engineering and natural science issues, e.g. with project days or the supervision of school work. To this end, we develop and lend visual aids, such as demonstration boxes, and conduct experiments suitable for children.

Contact Person

Prof. Dr.-Ing. habil. Maik Gude
Dr.-Ing. Anja Winkler
Dr.-Ing. Martin Dannemann

Academic Club Lightweight Engineering at the TU Dresden e. V.

The “Akademischer Club Leichtbau an der TU Dresden e. V.” (ACL) is an association of alumni, scientists and sponsors of the Institute of Lightweight Engineering and Polymer Technology at the Technische Universität Dresden. Highly complex lightweight system developments also require a sustainable network of science and industry. Against this background, the ACL sees itself since its foundation in the year 2003 as a discussion platform for the exchange of experience and knowledge transfer from young graduates through proven experts. The aims of the association are the non-material and material support of teaching and research in the field of lightweight engineering and related areas, as well as the support of a cooperation network of alumni of the course in lightweighting at the Technische Universität Dresden. This is achieved both by publishing research results at lectures and discussion conferences for the scientific exchange of ideas between university and practice, and by establishing and maintaining personal contacts between students, graduates, employees and sponsors of the ILK.

The core of the activities is the regular ACL Round Table. It is the discussion platform for the exchange of knowledge and technology between industry and research. In addition to talks by regional layers in the field of lightweighting or ILK staff, it also serves as a stage for the presentation of the finalists of the annual ACL Young Talent Award, which is presented at the International Dresden Lightweight Engineering Symposium. Students and graduates of the Technische Universität Dresden can apply for the prize with outstanding completed papers or diploma theses in the field of lightweight engineering.

The ACL normally also contributes by supporting various network events held annually at the ILK, such as the alumni meeting or the student meeting evening. Students and staff meet here in the relaxed atmosphere of the ILK’s test hall. In this way, the “junior lightweight engineers” can exchange experiences beyond the boundaries of their year and get to know the ILK staff and professors personally outside the official framework. In addition, the ACL provides financial support for the annual excursions to lightweight manufacturing partners in industry and research. In 2020, however, all such activities had to be paused due to the pandemic.

Contact Person

Christian Vogel
Martin Pohl

Student excursion

Ceremony of the ACL Young Talent Award 2019

Selected Publications

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Research Report 2020
of the Institute of Lightweight Engineering and
Polymer Technology (ILK), Technische Universität Dresden

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Editorial Office: Dr.-Ing. Marco Zichner, Diana Wolfrum

Typesetting by: Institute of Lightweight Engineering and Polymer Technology (ILK)

Printing by: siblog – Gesellschaft für Dialogmarketing, Fulfillment & Lettershop mbH
Großenhainer Str. 99 | 01127 Dresden

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