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Credits

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Dear customers and friends,

Demand continues to increase for our technologies capable of handling mass production of fiber-reinforced plastic components for the international automotive industry. As a result, we are currently dealing with orders for presses, but we have also been successful in attracting orders from Europe, North America and Asia for fully automated production lines for manufacturing glass fiber and carbon fiber-reinforced plastic components, and for hybrid light-weight structures.

Our aim is to always offer our customers the latest technologies. This is why we have worked closely and successfully with research institutes for many years, including the Fraunhofer Institute for Chemical Technology ICT, and with industrial partners such as KraussMaffei.

We would like to show you some of these innovative technologies in this issue. One of our unique new products is the PreformCenter, which manufactures near-net-shape carbon preforms with minimum waste in the shortest possible cycle times. The new compression RTM method represents a development of the HP-RTM method that makes it possible to produce carbon components with a higher fiber content and better workmanship within shorter cycle times. Another improvement in the field of carbon is the surface RTM method that we have been developing together with partners from the industry. Surface RTM makes it possible to create first-class carbon surfaces that can be painted directly without any additional post-treatment. A cost-effective alternative for mass production of simpler carbon components is offered by our innovative wet molding process, as used by BMW.

The tailored LFT-D process is an example of how a close partnership between a company and a research institute can pay off. Dieffenbacher and the Fraunhofer Institute ICT are currently developing the Fiberforge tailored fiber placement method for local or complete reinforcement of LFT components using glass fiber or carbon fiber tapes in order to make the method suitable for use in mass production.

I hope you enjoy reading this issue.

Hans-Joachim Schwindenhammer
The carbon components of the Roding Roadster R1 are manufactured using the Surface-RTM method.
About five years ago, you said farewell to the metal sector and concentrated on plastic forming. Why did you take this step?

Dr. Luginger: I would like to start by saying that we have not withdrawn from the metal sector completely. We continue to be active in specialized niches. For example, we sell our high-speed tryout presses two to three times each year. But it is true that we have focused on the area of composites, that is to say fiber-reinforced plastics. We took the step of expanding this area because of the emerging lightweight construction strategies in the automotive industry. Against the backdrop of discussions on CO₂ emissions and electric mobility, we became convinced that it would only be a matter of time before plastic forming also became prevalent in mass production. The past five years have shown us that this strategy has proven successful.

Since then, a large number of new developments relating to presses have been initiated. What is the proportion of projects that have the press as their core product?

Dr. Luginger: Our strategy is to expand our portfolio using future-oriented developments, and we see a growing need here. Our old company motto, „presses and more“, still holds completely true today. In terms of our hydraulic plastic presses, we provide complete, highly automated production plants with a process-related background.

Can you give us any examples?

Dr. Luginger: One example is the way we developed the processes and the plant technology for the Preform Centers. These are unique worldwide and produce near-net-shaped 3D carbon preforms with minimum waste in short cycle times. We expanded the familiar SMC procedure using compounding immediately prior to the press. Another example is the way in which we acquired the Fiberforge tape layup technology for local or complete reinforcement of LFT components, and how we are now making this suitable for mass production.

What Dieffenbacher technologies are currently experiencing the most demand and why?

Dr. Luginger: CFRP plant technology. Compared with other fiber-reinforce-plastics or aluminum, carbon
provides a significant weight reduction in components while retaining the same strength. That is why the automobile industry in particular is searching for procedures and technologies that will make it possible to use this material economically on the mass market. Audi ordered our automated Preform Center for the manufacturing of complex 3D preforms. At BMW, five Dieffenbacher wet molding lines and two hybrid lines are being used for the production of carbon components. VW and ZF Friedrichshafen are also testing CFRP usage with our automated CFRP development plants. In addition, our HP-RTM lines are being used for production at companies such as EACC in Germany and Carbures in Spain.

Only carbon? What about other technologies?

Dr. Luginger: We are currently also experiencing a renaissance with regard to SMC and LFT, but carbon the word on everyone’s lips. The developments in the use of lightweight construction, however, are heading in many different directions, meaning that traditional processes also continue to develop. These processes do not just use glass fiber; they also use carbon fiber, or work is carried out with partial reinforcements of the kind used in our Fiberforge tape layup technology.

Dieffenbacher has a claim to being a technology leader. In what direction do you think this technology will head in the future?

Dr. Luginger: Lightweight construction has recently been strongly influenced by CFRP, HP-RTM and wet molding line. But as I said, SMC and LFT are coming back into focus. Each approach has its advantages. In future, we will therefore see a mix of technologies comprising the procedure and the raw materials. As a company with close partnerships with research institutes such as the Fraunhofer Institute ICT and other innovative industrial companies such as KraussMaffei, we are ideally positioned for the future.

What is the role of the automotive industry in the development of lightweight construction using fiber-reinforced plastic compared with other industries?

Dr. Luginger: Besides the aviation industry, we are seeing high levels of interest in lightweight construction from the automobile industry. The aviation industry is not concerned with large quantities, however. In this respect, it has been the well-known car manufacturers that have been the main driving force behind developments in lightweight construction, especially in terms of mass production. Thanks to a growing demand from the railway sector, the commercial vehicle industry and consumer electronics, we are finding increased acceptance of lightweight construction using fiber-reinforced plastics even in non-automotive sectors.

In which regions is the demand for Dieffenbacher technology increasing?

Dr. Luginger: Increased demand for our technologies is coming from North America and Asia. The use of fiber-reinforced plastic components is also making inroads into the North American automotive industry. Our close cooperation with the FPC (Fraunhofer Project Center) in London, Ontario is certainly making a contribution to this development. This research organization is equipped with close-to-production Dieffenbacher plant technology, and offers the industry an opportunity to
27 lightweight components of the new BMW 7 series are manufactured on five Dieffenbacher wet molding and two hybrid lines.

Innovative Wet Molding Method for Carbon

run their own product development using fiber-reinforced plastics.

The Asian automotive industry, especially in China, South Korea and Japan, is not only showing an interest in our lightweight construction technology – it is investing in it, too. An advantage for us in Asia is that a large part of the plant equipment is built directly at our production site in Shanghai. But assembly, commissioning and service are also carried out on our site there.

What sets Dieffenbacher apart from the competition?

Dr. Luginger: I think our strength lies in the combination of our technological competence in complete systems together with a functioning worldwide organization. On the one hand, this means that we are not simply a machine supplier – we always keep the complete process chain of a system in mind, too. To do this, we maintain strong, highly selective partnerships in research and development, for example with the Fraunhofer Institute ICT or industrial company KraussMaffei. On the other hand, we are also a global player with powerful production sites in Germany, the Czech Republic, Canada and China. We can always produce in a customer-oriented way and, thanks to a worldwide network of service centers, provide a fast and reliable service.

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One of these innovative technologies for the manufacture of carbon fiber components is the wet molding method. Presses from the Compress Lite series are used with the corresponding automation in current projects. These presses have been specifically designed for the newly developed CFRP manufacturing processes and are characterized by the easily accessible automated environment, high level of precision and high energy efficiency.

The Wet Molding Method

So what is wet molding and where is it used? Wet molding is used for the manufacture of carbon-fiber components with low three-dimensional complexity. This includes structural components such as vehicle drive tunnels, or reinforcements in the roof area which must be able to withstand particularly high loads.

The wet molding method is a more economical alternative to the established HP-RTM method, with a simpler process chain. This method is an open thermoset process in which the component in the press is cured under pressure and at a high temperature.

The Process

At the start of the process chain, carbon-fiber cores composed of ultrasonic welded layers or “stacks” are prepared in a magazine. This stack magazine ensures a continuous supply during the manufacturing process.

First the stacks are transported to a camera table by a robot with a needle gripping system so the accuracy of the layers can be inspected. The camera checks the exact position of the stacks and gives a report indication on the accuracy of the layers. The stacks are then returned in sequence and corrected if required.

In subsequent step, the stacks are placed on a shuttle table equipped with a weighing system. Depending on the nature and size of the component, a double or quadruple stack cavity is possible. Two resin robots with flash cut nozzles simultaneously apply epoxy resin to the stacks.

Wet Molding – An Economical Alternative to Mass Production of CFRP Components

Mass production of CFRP components is developing in the direction of intelligent processing of carbon fibers in order to use this material as effectively as possible. Using an automated and fully integrated production line with high process stability and short cycle times can reduce manufacturing costs to a level where a wider application is possible.
The application of the resin is recorded based on weight. This procedure ensures reproducibility and ultimately contributes to the quality of the component. The resin cabin is equipped with a ventilation system with a capacity of 5000 m³/h for the venting of fumes during this open process step. After the application of the resin, the shuttle moves to the feeding position and the stacks are placed in the press by the robot. After the press closes, the stacks are pressed and cured at a mold temperature of around 150°C. The press then opens and an extraction robot places the components in a cooling press. In the final process step, the cooled carbon fiber parts are removed from the cooling press by the robot and placed on a discharge conveyor.

Benefits of the wet molding method

In the HP-RTM method, the resin is injected into the closed mold and then cured in the closed press. In contrast, with wet molding, the resin mixture – usually epoxy resin – is applied to the carbon fiber core outside of the press. This has the advantage over the HP-RTM method that resin can be applied while other components are curing in the press. The system can also be more reactive, as filling a heated mold, in which no reaction may take place, is no longer necessary. Both save time and this leads to shorter cycle of around 180 seconds, as multiple components can be pressed in a press simultaneously. This also helps to achieve a higher output.

**Fully automated tool change systems**

The wet molding lines are characterized by a high degree of automation, which includes the fully automated tool change systems. Production can be changed over from one product to another within a very short time of around 10 minutes. Wet molding thus enables economical mass production because high costs for the carbon-fiber material are offset by short cycle times and thus higher quantities.

The ever increasing demand for carbon-fiber components in the automotive industry shows that the manufacturing process in lightweight construction is far from reaching its end point. Dieffenbacher is constantly working on adjusting and further developing the various technologies to suit the needs of the market.
Components made from carbon fiber reinforced plastic (CFRP) are an integral part of lightweight design, as can be seen from the steadily growing market in this area.

In addition to their extremely high potential for use in lightweight design, they offer high levels of structural stiffness. However, the materials and hence the CFRP parts are expensive. In order to be employed for the mass production, the manufacturing process must be efficient and minimize the waste of materials. That is why the industry is focusing on automation and short cycle times.

Manufacturing Process and Requirements

The High Pressure Resin Transfer Molding (HP-RTM) process has been established as a possible method of manufacturing CFRP components.

The HP-RTM process is preceded by the preparation of the preform. This is a preformed stack of near-net-shaped carbon fiber fabric, which is later injected with resin under high pressure and temperature and molded to the component. This process step represents the largest cost factor of the manufacturing process, as in the past it was partially performed manually and this ultimately impacted on the processing speed and part quality. The

Fully Automated Preform Manufacturing for Carbon Component Production

The preform technology from Dieffenbacher means that it is now possible to manufacture complex carbon fiber preforms from woven fabric or non-crimp fabrics (NCF) in a fully automated process with short cycle times of under three minutes.
manual draping process alone involves cycle times of two to three hours.

The requirements for automated preform manufacturing are the near net shape draping of the geometry of the subsequent component, a low waste ratio and fiber orientations that meet the load requirements of the subsequent component. In addition, a level of automation that achieves short cycle times and correspondingly higher output.

Development

Dieffenbacher began to develop automated preform manufacturing in 2010. The first prototype was completed in
Cycle Times of Under Three Minutes Even During The Development Phase

2011, and already achieved cycle times of four minutes. Numerous enhancements, especially in draping technologies, meant significant improvements were achieved and successfully implemented in a second production-specific prototype based on a larger and more complex demonstrator (B-column). Depending on the component, cycle times of less than three minutes could be achieved. Several customer plants have been in operation since 2012.

Preform Process

The preform process consists of a chain of individual process steps including cutting the individual semi-finished products to size, coating with binder, creating stacks – which means merging the individual layers – the draping process and finally trimming the preform. The process also includes continuous process monitoring of the blanks and preforms.

Draping Process

The draping process step is the centerpiece of preform manufacturing. The layers, which are coated with binder, are taken from the two-dimensional to a three-dimensional contour. To do this, the stacks are preheated on a heated shuttle conveyor and then draped on the mold in sequence. This means that the individual multi-axis forming punch and clamping elements follow a defined sequence. This allows targeted manipulation of the fiber orientation and a wrinkle-free impression.

Near-Net-Shape Draping: Around 20% Material Savings

This draping process without a holding or clamping fixture makes near-net-shape draping possible. This represents over 20 percent savings on material. Given the high material costs, this is a major economic advantage.

Ultrasonic trimming of the preform may be partially or completely omitted or at least greatly reduced. The draping process can be performed on multiple levels, which means integral preforms can be implemented. This makes it possible to produce very complex preforms with local reinforcing plies and reduces the number of subpreforms with costly downstream installation steps.
Suitability for Series Production and Resource Efficiency

Its short, component-dependent cycle times that are typically less than three minutes, make automated preform manufacturing using the Preform Center suitable for series production.

In a three-layer operation, around 120,000 components can be manufactured per year. The logistics expenditure on the storage and delivery of the preforms falls away due to the inline linkage of the preform manufacturing with the press and injection process (HP-RTM). This reduces the space required and the expenditure on charge carriers.

The components are produced reliably in reproducible quality within the closed process chain and with continuous process data collection.

The fully automated Preform Center is an important step toward large-scale production of CFRP material in the automotive industry and other sectors. The very high level of productivity means production costs can be reduced significantly. Another important point is the high level of resource efficiency that results from significant improvements in the use of materials (carbon fibers and binders). Minimizing trimming and eliminating auxiliary materials such as vacuum bagging film and cutting paper from the cutting process means ongoing improvements in sustainability and reduces unmixed waste, which is easier to recycle.

120,000 Components Per Year Can Be Manufactured Using the Preform Center

The Four Key Stages of the Preform Process

High efficiency for automobile mass production.

- Near-net-shape draping technology
- Local patches and individual contours
- Multiple preform per cycle possible
- Cutting dimension of up to 4000 x 2500 mm

You can find the clip at: www.dieffenbacher.de/en/preform

Finished preform in the mold after draping process.
Premium Carbon Surfaces without Any Finish-Machining

Using the newly developed surface RTM procedure, carbon-fiber-reinforced parts for vision applications can be produced as standard. Surfaces suitable for painting can be produced off-tool without the need for manual rework. Together with other partners, Dieffenbacher has developed this procedure and brought it to the production stage.

Components with surfaces suitable for painting can now be taken directly from the tool. However, this has not always been the case. After all, components made from carbon fibers that are produced using the conventional RTM method often have sink marks due to the different shrinkage properties of fibers and matrices. Before the conventional spray-painting process could take place for these components, the surfaces had to be manually post-worked, a process that is both expensive and time-consuming. Particularly considering two painting and sanding processes were often required to achieve a flawless final surface.

The surfaces can be painted evenly

Due to the high costs associated with manufacturing visible carbon-fiber-structured components, these components have previously only been installed in premium sports cars and luxury limousines. Due to its outstanding properties, carbon is now used in a wide range of structural applications, where its properties are brought to bear while the material itself is concealed: namely achieving a high level of stability while maintaining a low weight.

Thanks to a new pressing method, series production of visible parts made of carbon-fiber-reinforced plastic ready for immediate painting is possible from a technical perspective in a single process step. And all with an enormous cost saving of up to 60 percent compared with the conventional process. This achievement marks an important step on the road towards affordable lightweight construction.

The innovative production cycle is based on the RTM method for the time being: A preform is produced from the carbon fibers and placed in the mold. The mold is then closed. In the first process step inside the press, resin is injected and pressed by the fiber layers. After a short reaction time, the matrix is cured and the tool halves are pulled apart again to leave a previously defined gap.

Then step two of the process begins, in which the surface is recoated with a primer. This step evens out any sink marks and other surface imperfections, forming a layer that is suitable for painting. To maintain the carbon look, a clear varnish can simply be injected in this second stage of the process. The thickness of the coating on the surface material depends on the component configuration and on how the fiber layers are set up; generally, coatings are between 0.15 and 0.22 millimeters thick. This process delivers a premium level of quality and meets the requirements of the automotive industry.

Solid Partnership

Dieffenbacher developed the surface RTM method together with eight partner companies.

The first prototype was unveiled jointly at the K2013 event in Dusseldorf, Germany: the carbon-fiber-reinforced roof of a Roding Roadster R1 lightweight sports car. The roof component came out of the press completely flat and in a form in which it could be painted immediately.

By developing this method, the team has succeeded in producing fiber-reinforced visible components for the vehicle manufacturing sector - components that are suitable for painting and still cost effective when it comes to producing in large quantities.

Our Partners

- Alpex Technologies GmbH
- Chomarat
- Henkel AG & Co. KG
- KraussMaffei
- Mühlmeier GmbH & Co. KG
- Roding Automobile GmbH
- Rühl Puromer GmbH
- Zoltek Corporation
The HP-RTM method can be used to mass-produce components made from fiber-reinforced plastics such as CFRPs. At the start of the traditional RTM process, a preformed fiber layer—the preform—is inserted into the tool. The press then closes to produce the exact thickness required of the component. Next, resin is injected into the tool to impregnate the fiber layer and fill up the remaining space in the tool, at pressures up to 80 bar for HP-RTM.

The high pressure is essential to ensure that the resin reaches every corner of the profile, even with more complex geometries, and to achieve a high level of fiber impregnation. The disadvantage of this method is that fibers shift under the high pressure, which can result in distortions. These distortions can have a negative impact on the distribution of forces within the component and reduce the overall component stability.

By developing the RTM method further, Dieffenbacher succeeded in finding a solution to this problem. Whereas traditionally the press closed to the desired thickness of the component, with the compression RTM method, the press initially moves to a gap impregnation position, which is 0.5 to 1 millimeter wider than the final thickness. The flow path for the injected resin within the tool is thus wider and offers less resistance to the flow of

Compression RTM – An Efficient Method

When it comes to mass-producing components made from carbon-fiber-reinforced plastics, the HP-RTM method has proven particularly effective. With the introduction of an alternative process, it is now possible to achieve even shorter cycle times and improved component properties.

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the resin. As a result, the injection pressure can be reduced to between five and ten bar, which does not distort the fiber composite of the preform. The resin can also be injected more quickly because flow resistance is much lower.

The speed at which the resin can be injected is a key advantage of this process. The faster the resin fills the profile and the more quickly the fibers are impregnated, the more fast curing reactive resin systems can be used. By speeding up the curing process, shorter cycle times can be achieved.

However, the low injection pressure used in the compression RTM method is not yet sufficient to ensure that the fiber bundle of the preform is completely coated with resin. The liquid mixture of resin and curing agent is initially spread across the preform like a sheet and only penetrates the surface superficially. The high pressure required to ensure full penetration of the mixture with the conventional RTM method is generated by the clamping force of the press with the compression RTM method. The press closes to the desired thickness of the component and, at the same time, the compression stroke presses the resin through the preform. This ensures that all of the fibers are coated.

Another advantage of the compression RTM method is that it can be used to manufacture components with a higher fiber volume content in comparison to the conventional RTM method. The compression RTM method can easily produce components with fiber volume contents of up to 60%. These results can no longer be achieved using a simple injection process due to the extremely high levels of flow resistance. Increasing the fiber volume content maximizes the strength and rigidity of the component and improves its potential for use in lightweight construction.

In addition, the compression RTM method effectively prevents dry areas being left on the surface of the component. With the traditional injection process, the dry preform must be compressed simply through the closing of the profile. The high level of contact pressure between the fiber layer and the inside wall of the profile makes it more difficult for the mixture to fully penetrate the surface of the component during the injection phase.

The innovative compression RTM method places considerable demands on the press. Not only must the press apply the pressing force required to keep the profile closed, it must also ensure that the gap is accurate to the highest degree and that the impregnation gap remains completely parallel. As the press makes its closing stroke, the parallelism of the closing movement must be maintained. Even the slightest deviations in the movement can result in asymmetric and undesirable flow characteristics when using low-viscosity resin.

The tolerance requirements for the highly rigid CFRP are usually significantly higher than the requirements for conventional fiber composite components. Dieffenbacher has responded quickly to this situation by developing the new Compress Lite series (DCL), a specially tailored press. The press is equipped with a compression lifting table that can be modified dynamically thanks to the multi-cylinder arrangement of its pre-bending line. This arrangement means that the pre-bending line of the lifting table is adapted to the pre-bending line of the moving parts of the presses, thereby optimizing the thickness tolerances. To optimize the tolerances, the setting parameters simply need to be entered in the press control system. The change will be active from the next cycle, and the result can already be verified from the next component.

Conventional presses were simply not able to achieve this level of accuracy. Changes in the pre-bending line, either from altering the pressing force or from installing different sized profiles, had to be compensated for by post-processing the tool. This is generally a thing of the past. Thanks to the dynamic adjustment of the pre-bending line, it is also possible to support the flow process in the various pressing phases. Actively altering the pre-bending line, for example during the injection phase, can affect the flow pattern or can facilitate the material flow during the compression stroke.
Teamwork Makes It Easier

The Fraunhofer Institut für Chemische Technologie (Institute for Chemical Technology) in Pfinztal and Dieffenbacher have been working closely together for more than 15 years. Their common goal is to develop processes and procedures relating to fiber reinforced plastics for mass production. The requirements of the aerospace industry and large-scale production in the automotive industry are very different.

Prof. Dr. Frank Henning, Deputy Managing Director at the ICT (on the right in the picture) and Matthias Graf, Director of Technology and Business Development at Dieffenbacher (left in the picture) are an established team. In this brief interview, they explain the reasons behind this as well as the nature of this long-standing research partnership.

What methods are you currently focusing on in your joint research and development?

Graf: A common theme is the manufacture of thermoplastic plastic components, which are reinforced with continuous fibers. The continuous fibers extend over the entire length or width and therefore produce significant improvements in terms of strength. This means that the thickness can be reduced and the component can be lighter, fulfilling the same function. What is special about it is the innovative fiber application system using the Fiberforge system. This can produce any fiber orientations in the component.

Are there also any developments in the mass production of carbon fiber?

Graf: Yes, we set up our new Preform Center at the Fraunhofer Institute for Chemical Technology (ICT). Here we develop applications with the customer. Carbon fiber fabrics are custom-made and formed into three-dimensional structures in the Preform-Center using a fully automated operation. The resin is then injected using high pressure on the Dieffenbacher press to manufacture the finished component.

What do you see as the advantages of your working relationship?

Graf: Working together allows us to enlarge the development team and involve young scientists from a wide variety of fields. The complementarity means topics can be considered holistically and this produces optimal results. This is important, if in addition to developing the machinery, the production process and to some extent also the material formulation need to be developed or adapted. As a medium-sized machine manufacturer, working together also allows us to make use of the ICT research center. The collaboration means we have access to excellent laboratories and facilities.

And how are the tasks divided up?

Henning: We take the lead for the materials development in the technologies that Mr. Graf mentioned, as well as for SMC and D-SMC, Dieffenbacher’s area of competence is the system design. We’re also working together on knowledge – What does the customer really need? How will the market develop? I personally see Dieffenbacher as an innovative mechanical engineering
company, which brings the numerous inquiries from the industry to the Institute in order to present challenges and pose fundamental questions. We examine these requirements using our collective specialist knowledge and in this way we obtain good concepts and results. I would say, our work complements, extends or reinforces development at Dieffenbacher. It’s certainly worth it in cases where a medium-sized company would not be able to justify the required investment to address material technology questions.

How would you describe this cooperation in day to day activities?

Henning: In the context of collective professional project management, the project managers jointly decide milestones and goals and approve budgets. Project management is carried out on both sides in internal meetings. Both teams meet regularly to discuss the results, so that these can shape the development and research process. However, it’s a lot less complicated than it sounds. It is a process that is continually adapted to the specific conditions, and with active involvement from both sides.

What were the first joint developments which emerged from the collaboration?

Graf: The partnership between Dieffenbacher and the ICT started with developments in LFT-D technology, a broad-based start to the collaboration during which a lot of the issues relating to extrusion were worked on. Subsequent projects focused on the SMC technology, more specifically the so-called in-line process variants. Then, we jointly developed high-pressure RTM technology in the area of high-performance fiber composites.

In doing so, we developed the process further to Compression-HP-RTM, in which the resin is metered into the slightly opened mold and the press uses the closing stroke to generate the high pressure on the component. This method has now become firmly established and requires precise parallel motion control. Dieffenbacher is currently a world leader in this technology.

What changes have these developments meant for the Dieffenbacher company?

Graf: These projects made Dieffenbacher decide to broaden its scope of process technologies for lightweight automobile components, in order to also be able to perform technology assessments for customers. This expertise was jointly extended to fiber reinforced thermoplastics to be able to support component manufacturers by providing in depth advice on all areas of lightweight applications.

What topics are you currently working on jointly?

Henning: We’re working to further develop the Dieffenbacher preform technology. Automated production of the preform is a key technology for the large-scale production of CFRP components. We’re also working together on research projects to continue developing new strategies for the construction of highly complex preform parts.

Graf: With Daimler AG, we successfully completed a large research project in February and presented it to the industry. Our leading role in this field is internationally recognized and has allowed us to win lots of new orders in recent years.
Another important project is the process development for the manufacture of thermoplastic CFRP components using Fiberforge tailored blanks in combination with LFT-D material. For us, this is an important topic for the future.

Since the establishment of the Fraunhofer project centers in Canada, we also have joint research projects there with customers and leading material manufacturers. Here, we’re developing for the first time new material versions with carbon fiber reinforcement for the LFT and SMC process. Moreover, we have placed two young Canadian Dieffenbacher associates there to work on the joint projects in addition to the research work and also to look after our machines and perform engineering research modifications.

The Fraunhofer Institute for Chemical Technology ICT at a glance

The Institute is one of the largest and longest established institutes of the Fraunhofer Gesellschaft as it was founded in 1959. It currently has approximately 23,000 employees and a revenue of two billion euro.

In 2015, approximately 850 people are employed at the Fraunhofer ICT and its four branches. At the main site in Pfinztal, approximately 550 associates currently research and develop energetic materials, energetic systems, applied electrochemistry, polymer engineering and environmental engineering.

The total area of the Institute in Pfinztal is 200,000 square meters. Of this, 25,000 square meters consists of laboratories, offices, technical centers, workstations, testing facilities and infrastructure. This excellent infrastructure is complemented by a number of laboratory and industrial standard series production facilities. The Institute lays particular emphasis on the development and implementation of new materials, methods and products all the way up to regular series production. The Fraunhofer ICT boasts well-equipped laboratories designed according to the latest developments in security and energy technology, and all the necessary analysis and test methods for research in our areas of work.

www.ict.fraunhofer.de/en.html
Fiber Tapes Hold Potential for Lightweight Construction

When companies and institutes enter into a close partnership with one another, synergy effects that facilitate the development of new technology, are often generated. The partnership between the Fraunhofer Institute for Chemical Technology ICT in Pfinztal and Dieffenbacher is just one example of such collaboration. These two entities have made it their goal to make carbon-reinforced and fiberglass-reinforced thermoplastics suitable for use in structural applications in the automotive industry.

In the past, long-fiber-reinforced thermoplastics (LFTs) have primarily been used in the aircraft industry for producing elements such as window frames and seats; In the automotive industry, the materials have featured in elements such as underbody shields and covers. However, LFTs have not been widely used in the automotive industry for load-bearing structures to date, as they lack the mechanical properties compared to other materials.

This is something that is set to change through the use of suitable combination of materials. Compared with the conventional carbon-fiber-reinforced applications, this combination of materials also brings considerable benefits in terms of cost.

Fiber Tapes for Improved Component Stability

Unidirectional fiber tapes made of carbon fiber or glass fiber are combined with the thermoplastics in such a way that reinforcements can be provided in the body component at specific points in line with the load profile, to achieve an increased level of structural rigidity within the component. Using Fiberforge tape layup technology, the fiber tapes are laid in a production plant and pressed together with the LFT mass to form the component in
Components made from continuous fiber reinforced tapes.

a single process step. The tape layup system operates fully automatically to produce custom-designed layers (or "layups"). The system is based on a table capable of moving in any direction (both rotation and XY) on its plane. The individual layers are built up layer by layer with a depositing arm. The machine unwinds the tape from the coil, cuts it to the specified length and places it on the table at the defined position. Each weld is done within of milliseconds to allow almost immediate handling of the after the layup process is complete. The layup is thus stable for the subsequent processes.

The tapes are spot welded in milliseconds

by layer with a depositing arm. The machine unwinds the tape from the coil, cuts it to the specified length and places it on the table at the defined position. During this process, the machine travels over the table, ensuring that the layup meets the requirements of the relevant component to be produced in terms of fiber orientation, construction and thickness. As the tapes are laid, the layers are ultrasonically welded together at strategic spots to ensure that the finished layup can be picked from the layup table by a robot without disturbing the layup. The resulting semi-finished product—known as a "tailored blank"—is thus produced after a specific cool-down period. It is then formed by reheating to the forming process temperature using an infrared heating device, inserted into the forming tool and shaped into the final component, either on its own or together with a hot LFT-D mass. The entire forming process can be carried out in a cycle time of 30 seconds or less.

Cycle Times Of Under 30 Seconds

The layup is then heated to the appropriate temperature, and then compressed in a consolidation press and seal-welded flat to form a laminate. The resulting semi-finished product—known as a "tailored blank"—is thus produced after a specific cool-down period. It is then formed by reheating to the forming process temperature using an infrared heating device, inserted into the forming tool and shaped into the final component, either on its own or together with a hot LFT-D mass. The entire forming process can be carried out in a cycle time of 30 seconds or less.

Tape Layup Process

Continuous Fiber-Reinforced Tape
Tape rolls are stored in a magazine for the layup process. The tapes are pulled down at high speed onto the table, aligned by rotating the table, and then fixed locally using ultrasonic welding heads.

Tailored Blank
After preheating, the fabric is pressed onto the so-called tailored blank in a consolidation press.

Three-Dimensional Molded Components Made From Continuous Fiber-Reinforced Tape
The tailored blank is brought to the process temperature by infra-red heating, inserted into the mold, and formed into a preform.
This system technology provides a high level of flexibility when it comes to shaping components. Several different combinations of materials can be produced on a single machine: pure LFT-D components, components made purely of fiber tape, LFT-D components with long-fiber reinforcements at specific points and reinforcement by means of fiber tape over a wider area, with local functionalization through LFT. Different material thicknesses can also be achieved within the same component through this process.

**Continuous Development for the Automotive Sector**

The collaborative work that is taking place between the Fraunhofer Institute and Dieffenbacher aims to make this method suitable for use in large-scale production within the automotive industry. Further aims include achieving a high level of productivity in order to achieve up to around one million parts per year, as well as a high level of automation. Using Fiberforge tape layup technology, components can be laid within precise contours, at speeds that are higher than those achieved by other robot-based systems.

Furthermore, laying components with precision in line with the end contours reduces the amount of offcuts generated from the expensive carbon-fiber-reinforced material, allowing the material to be used efficiently during the production process to ultimately save on costs.

What’s more, the thermoplastic tapes used can also be recycled. However, keeping the amount of recyclable material used at a low level is vital to ensure production is both cost effective and efficient in its use of resources. For this reason, partners from the semi-finished materials industry are also involved in the project, to help define the optimum widths and material blends.

In addition to focusing on improving process speed and minimizing waste...
produced when shaping components, the development partners have been continuously working on optimizing the methods used by systems, as well as enhancing component geometries and further developing components. Even as cycle times become shorter and shorter, complex geometries nevertheless can thus be achieved in line with requirements.

The Fiberforge tape layup technology is already fully functional and ready for production

At the same time, it is important to determine which types of component are actually sought after in the relevant industry. The Fraunhofer Institute for Chemical Technology ICT assumes responsibility for investigating the boundary conditions placed on machines by the specific components and materials in question, while Dieffenbacher works on implementing these conditions into an efficient production process. In the automotive industry, fiber composites are one of the few materials that only become an actual material during the process itself and define their properties within the finished component. That is why the close relationship between processing technology and material is so important for further development in this case.

In the case of Fiberforge tape layup technology, producing a specific range of components in a fully functional form that is ready for series production is considered the norm. The potential for development here currently lies in further increasing quantities and shaping components in terms of their spatial dimensions.

Dieffenbacher delivers the latest plant technology in the field of composites to China

Dieffenbacher received the order for a fully automated LFT-D plant for China. The project partner is a newly established joint venture of the companies CSP and Victall. The American company CSP (Continental Structural Plastics), to whom Dieffenbacher has supplied ten presses and six LFT-D plants over the course of a long-standing partnership, is a major global supplier of composite components in the automotive industry. The Chinese company Victall operates primarily in the field of railway engineering. The new plant will enable the partners to expand their range of components for China’s rapidly growing automotive industry.

The scope of supply includes a 4,300 t Compress Plus press and a subsequent punch press LFT in-line compounding, convection ovens and complete automation. The line is the first in the world being equipped to support the application of carbon fiber and higher temperature resins in addition to mainstream glass/PP materials.
Our Focus is On People

Dieffenbacher is one of the largest and most sought after employers in its region. We’ve achieved this mainly because we were aware from the outset that our associates are our most important asset. We’ve maintained this philosophy despite our rapid development into a global company.

Eppingen 1873. In a small town in the Heilbronn region, Jakob Dieffenbacher founded a machine shop that performed forging and fitting work to meet the regional demand. Towards the end of the 19th century, it had begun to make its first mass-produced products here and, before the start of the First World War, hydraulic oil presses and fruit presses.

In the 1920s and 1930s, Dieffenbacher made a name for itself both at home and abroad by supplying entire plants for processing edible oils. In 1928 the first hydraulic Bakelite press for the plastics industry was marketed. Single and multi-opening particle board presses finally became core products for Dieffenbacher in the 1960s and quickly conquered the global export markets. In 1990, Dieffenbacher introduced its first continuous press for wood-based panels, heralding a new era for the company.

Eppingen 2015. Both the site and the region have become too small for Dieffenbacher because the company has developed into an international machine and plant constructor with 1800 associates and 17 production and sales sites worldwide. We are a leading manufacturer of press systems and complete production systems for the wood, automobile and supplier industries. What hasn’t changed is what’s been driving our fifth generation family owned company for over 140 years: developing concepts and technologies that not only satisfy our customers, but delight them.
To meet this requirement, we need committed associates who combine passion with plenty of expertise and think in terms of solutions. Because when it comes to designing and producing our innovative production plants, that are sometimes larger than several football fields, qualified and motivated employees are the key to success.

**Attractive Work Places**

Our employees are important to us. That’s why we want to offer them as pleasant a working environment as possible, and an attractive and safe workplace.

We’re doing everything we can to achieve this, as a study by FOCUS, one of the major German weekly magazines, confirms: We were one of the best employers in 2014! This award testifies to the high status of our associates and also provides us with confirmation and motivation.

Exciting tasks and projects are the main precondition for an attractive workplace. We have those at Dieffenbacher - and they’re also an important part of

**Qualified Associates**

Dieffenbacher GmbH is an extremely technically oriented company. Some 82% of associates have had technical training, while 18% of associates have a commercial background. The proportion of engineers in the workforce has risen steadily in recent years and now stands at around 28%.
the company’s success because we are successful at innovative products and solutions.

Dieffenbacher is One of the Best Employers

We invest heavily in research and development, work closely with relevant research institutions, always use the most up to date technology and set future trends.

In addition to these exciting tasks, we support our associates and create an environment that will make their work more pleasant.

Further Education
We promote the continuous improvement and personal development of all associates through targeted qualification measures and vocational training. The range of training measures includes both courses held by our own instructors on internal topics as well as courses from external providers.

Leadership Development
To secure the succession of our leadership positions over the long term, we prepare suitable associates for this responsibility at an early stage and encourage their potential. By continuously training our managers, we are creating a motivational corporate culture for our associates.

Flexible Working Time Models
Flexible working hours and part-time working enable us to promote a work-life balance. We support associates with children when they return to work.

Company Pension Scheme
Dieffenbacher contributes to a company pension for each associate.

Corporate Health Management
We enable our associates to participate in health-promoting preventive measures to ensure the health of every individual, their well-being in the workplace and long-term performance.

Active Promotion of Young Talent
At Dieffenbacher we bestow importance to attracting, training and promoting our own young talent to secure the company’s future. The training takes place primarily in the industrial and technical sector. Careers include industrial mechanic, electronics engineer for industrial engineering, mechatronics engineer, machining specialist, technical product designer and IT specialist. In addition, we host work placement students in the fields of mechanical engineering, industrial engineering, electrical engineering and business information.

To attract the best young talent, we have a presence every year at numerous training and higher education fairs. The focus is on institutions of tertiary education that offer courses in electrical engineering, mechanical engineering, industrial engineering, and process engineering. There are cooperation programs with students at the Universities of Karlsruhe and Göttingen and also at the Faculty of Engineering at the Pforzheim and Heilbronn Institutions of Tertiary Education. We also work with
Eppingen high schools and are making a valuable contribution to the personal development of young people. We also offer internships and final academic projects and award grants.

### Guarantees of Future Success

To facilitate entry to our company by engineering graduates, we offer an international trainee program. During this two-year program, our new associates pass through different departments. In addition, coordinated work assignments in our subsidiaries and with our customers in Germany and abroad are also planned. Throughout the training period the trainees are supported by a mentor, who is available to answer any questions, including technical ones.

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**Social Media**

We use different social media channels to both contact our target groups and engage with them directly.

- [Facebook](http://www.dieffenbacher.de/en/facebook)
- [Twitter](http://www.dieffenbacher.de/en/twitter)
- [LinkedIn](http://www.dieffenbacher.de/en/linkedin)
- [XING](http://www.dieffenbacher.de/en/xing)
- [YouTube](http://www.dieffenbacher.de/en/youtube)
- [Kununu](http://www.dieffenbacher.de/en/kununu)
Our Mission Statement

“\textit{We are an independent and international corporate group that uses leading technologies to provide its customers with complete production lines and assists them with excellent services during the entire product lifecycle.}”

During the last 10 to 15 years, our company has made enormous progress. We have advanced from mechanical engineers to complete plant manufacturers and have created innovative products, new business segments and achieved rapid global growth. During this time market conditions have changed and we are facing increasing competition, pricing pressure, faster delivery times and a shortage of skilled professionals. Therefore, it is very important to review our corporate strategy on a regular basis. A well formulated mission statement provides orientation during turbulent times. This vision gives each of our associates the necessary reminder of who we are and where we want to go. Our mission statement also has a significant impression on our customers: it tells them what is different about Dieffenbacher and what makes us special.

This sentence says a lot. It includes all the aspects of our standards and all aspects of our activities. If we take a closer look at the individual words, the dimensions become clear.

\textbf{Independent}
Not only in the sense of being a family-owned enterprise. We are not obligated to any shareholders or foreign stockholders therefore we can make decisions freely and independently for the benefit our tradition-rich company.

\textbf{International}
We are a global enterprise. We have 17 locations in all major market regions which gives us the size and strength to be appreciated as reliable plant engineers and partners around the world. Cross-cultural attitudes and actions are just two of our strengths.

\textbf{Leading technology}
Second-best is not good enough for us. For all the products that we develop and improve, we aspire to get maximum value for our customers by always using the latest technology.

\textbf{Complete production}
The whole is more than the sum of its parts, said Aristotle. Merely installing all the individual components of a total plant is not enough. Our core competence lies in understanding the complex systems and procedures.

\textbf{Excellent service}
We take care of our customers and their plants. This is proven by customer surveys that confirm our flexibility, good advice and uncomplicated, rapid provision of spare parts and modernization concepts.

\textbf{Total lifecycle}
We are not interested in quick sales. What counts for us is the responsibility to provide our customers with a plant that can be used for competitive production today and in 25 years.
Guidelines and values for responsible action

Our day-to-day operations are based on honesty and trust. We have specified six clear guidelines in our principles for responsible business activity that govern the way we act and live.

1. We treat our customers fairly and with respect and dignity

They are the focus of our efforts. We depend on them. We grow with them. For this reason we always serve our customers with products and services of the highest quality, according to their requirements, to enable them - as well as us - to gain a competitive advantage. Fair treatment of customers also means being willing to clarify and resolve dissatisfaction with products or services.
2. We Encourage and Support Our Associates

They are a vital basis for our success. Without their commitment, their individual capabilities, and their loyalty to the company, Dieffenbacher would not be able to maintain its top position. We do everything we can to provide a safe work place and healthy working conditions. This is why we consistently foster the professional qualification of our associates and encourage them to take responsibility. It is our commitment to always be curious and open-minded concerning innovations - always looking for ways to improve. We appreciate each and every one of our associates as a valuable and important part of our corporate family, vital for taking us forward, regardless of the corporate group location or their origin.

3. We act with prudence and are success-oriented and loyal to the owners

Their capital is the basis for all business activities. We want to deploy their resources prudently. This is why we are always committed to profitable solutions and effective action to ensure sustainable growth. Only in this way can we protect our independence and safeguard the future of the company.
4. As a family business we have a great responsibility

We are firmly rooted in the region and are an example of continuity and reliability to our customers, associates, and society. We take full responsibility for our actions. For example, we act responsibly by not selling for quick profits, but by providing the best possible products which we will proudly stand by twenty years later.

5. We are innovative

We work constantly to improve our technologies, products, and services. For us, stagnation is regression. We promote new ideas and guide them through a regulated process to produce high quality products. Only those solutions that meet market and customer requirements can help us face global competition.

6. We advocate compliance with ethical standards

As a responsible company, we act according to the principles of a fair society. With our products, we always aim to protect the environment as far as possible and conserve resources to avoid unnecessary burdens on future generations. We respect the laws, always act honestly, and keep our promises. We do this not only in our own country, but also respect the cultures, conventions, and rules in all other regions in which we operate. We stand for equal opportunities and fair competition.
Lightweighting
Your World

SMC | CFRP | LFT | Hybrid
Process technology and automated systems
for manufacturing fiber-reinforced components

www.dieffenbacher.com