Hennecke
Polyurethane Technology

116 INNOVATIONS

>> Hennecke customer journal for technologies and trends on the PU market

COVERSTORY

Project R.A.C.E.

Serial production of complex, structural hollow parts

ENGINEERING

Revolutionary discharge system

Hennecke presents the
ZERO AGE APPLICATOR

PROJECTS

Energy-efficient prefabricated houses

System expertise from Hennecke
and AutoRIM

Dates

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8.11. - 10.11.2016

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14.03. - 16.03.2017

ISH
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14.03. - 18.03.2017

As at October 2016

Dear customers,
dear readers,

The total consumption of polyurethane continues to develop in a positive way. By 2019 alone 5.3 percent growth is expected annually. Similarly, the polyurethane engineering industry is growing by 4.5 percent annually. An industry with a lot of movement. Why is this so normal some 80 years after first synthesising this versatile raw material? The answer is simple: developments in all fields of application are being accelerated by companies like Hennecke GmbH - regardless whether a proven process methodology is being developed further, known materials are substituted by polyurethane or completely new product approaches are being searched for and found. Here, the close cooperation with strong industry partners is one of the most important factors for us. An ideal example of this is "Project R.A.C.E.", in which complex fibre composite hollow components are being produced in record cycle time (see page 4). However, this issue of our customer magazine INNOVATIONS shows even more examples of successful teamwork. Together with our partner company AutoRIM Ltd., we could achieve absolutely awe-inspiring improvements in insulation properties through comprehensive production upgrades with one of the largest manufacturers of prefabricated building elements in the United Kingdom (see page 10). In principle we do not rely on strong partners alone when developing work, but also drive forward promising applications independently. A good example is the production of an INSITU demonstrator at the Hennecke TECHCENTER which will pave the way for long-fibre-reinforced plastic components with requirement focused fibre composite (see page 25). Hennecke's extensive F&E capacities also create the ideal environment for optimising our machine and plant engineering. Hennecke engineers use it for small and great revolutions. A new discharge system for continuous hard and soft foam applications is such a crucial step (see page 18). You see, innovation is a source of growth. We are happy to demonstrate you this for your tasks and product ideas. For now I wish you interesting insights when reading our customer magazine.

Rolf Trippler
Managing Director Sales

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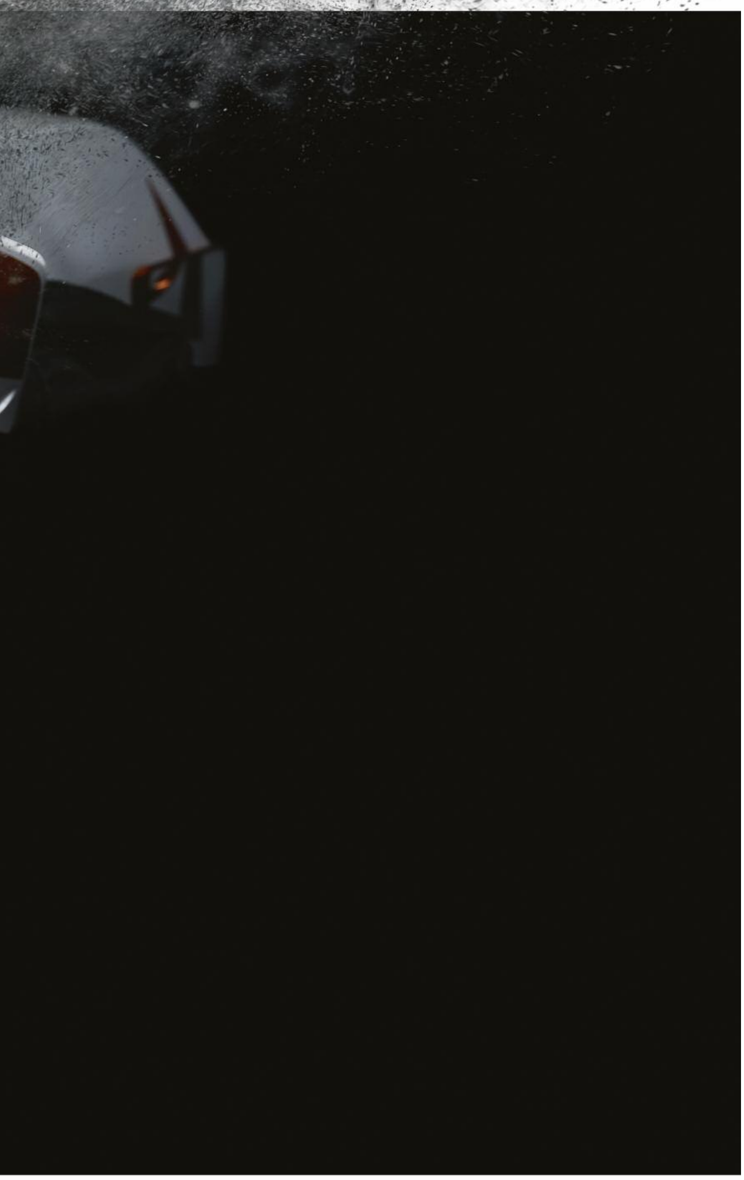
Project R.A.C.E.

Serial production of complex, structural hollow parts

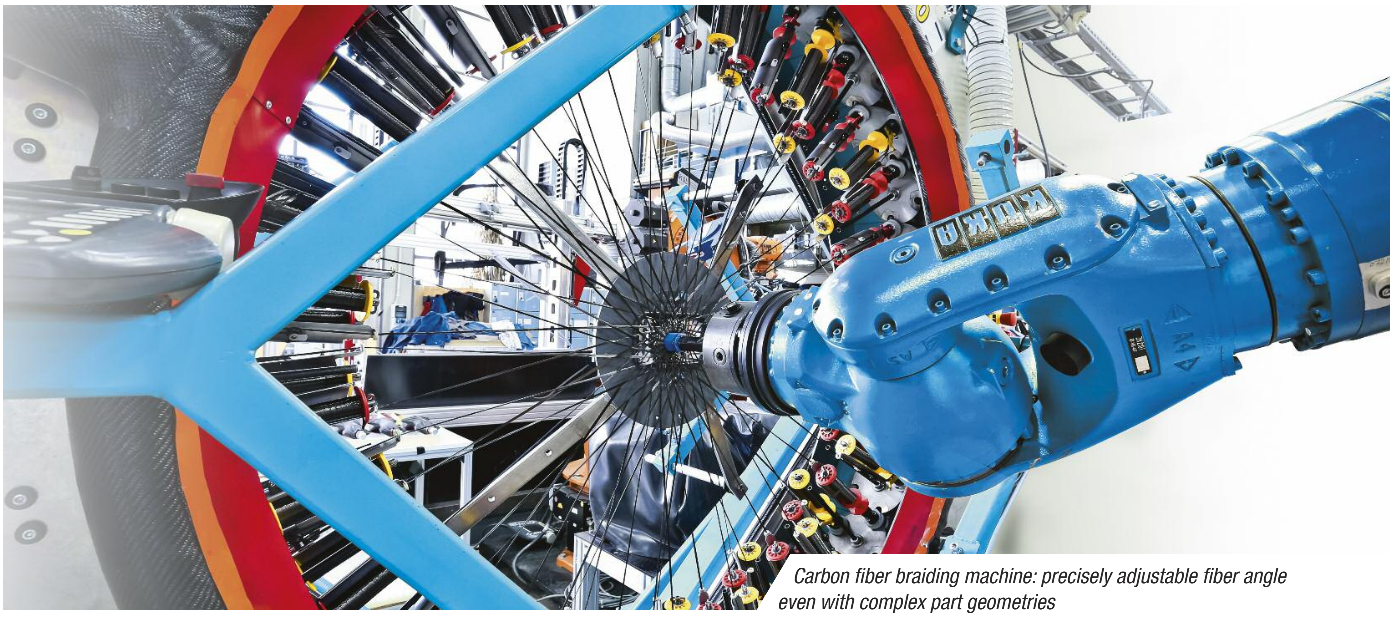
The KTM 1290 Super Duke R impresses with its powerful 1300cc, 170 HP V-engine and its unbelievable acceleration. This motorcycle is a high-performance machine and therefore the ideal application for ultra-lightweight high-performance components. In cooperation with top industry partners, Hennecke will for the first time present a high-pressure RTM lightweight construction process live at the K show. In the future, this will bring fiber composite parts to efficient series applications where high performance is required.

Carbon components are already widely used in motorsport. In the R.A.C.E. project (Reaction Application for Composite Evolution), Hennecke and its partners have now made an important development step in the industrialization of the new CAVUS technology from KTM Technologies, which will allow even complex fiber composite hollow parts to be produced with the automated high-pressure RTM process. They can be implemented in many further integrally manufactured fiber composite hollow parts as, for example, in roof constructions, structural components, or even monocoque geometries. Now, a structural component for the Super Duke R is to be produced using the CAVUS technology. The motorcycle license plate holder to be substituted consists of a hollow and clad steel structure to save weight on the one hand and to accommodate for wiring for turn signals and the license plate light on the other hand. At the same time, the part has to be very stiff, because enormous stresses occur during operation. The traditional license plate holder weighs more than 765 grams, however with the project R.A.C.E., Hennecke and its partners produce the part with increased performance and a total weight of only 265 grams. This alone is a weight saving of over 60 per cent! Stefan von Czarnecki, Director of Sales and Business Development of KTM Technologies, explains the company's claim in the field of lightweight construction: "For us, competitive lightweight construction is a central focus in the development of high-performance products.



With an innovative team, we realize parts in new technologies where we are constantly pushing the limits of what is possible for our customers. We at KTM technologies also rely on powerful partners for our development projects in order to retain our leading position in lightweight construction in the future."The challenge for the new license plate holder lies in the interaction between the right layout coupled with a production-ready design of the component and the combination of efficient processes based on the innovative CAVUS technology from KTM Technologies. CAVUS denotes the automated process chain for the production of complex structural hollow parts: from the core production and the manufacture of the preforms with carbon fibers e.g. in braiding technology through the HP-RTM process to the release of the core material. This opens up completely new creative possibilities for design and function. The process starts with the sand core. Just like in the construction of a sandcastle, one needs a binder to give the sand a solid form. Ivo Herzog, Managing Director from H2K Minerals, explains how stable such a core structure is under pressure: "H2K Minerals is able to produce pressure-resistant complex geometries using sand.

Sand core from H2K Minerals: pressure-stable, water-soluble and eco-friendly



Carbon fiber braiding machine: precisely adjustable fiber angle even with complex part geometries

The sand cores will withstand an enormous injection pressure up to 500 bar. The binder used is water-soluble. At the end of the process, it can be flushed out easily in an eco-friendly manner with regular water and without any use of solvents."

The second part in the process is the tailor-made carbon preform. Dr. Stefan Carosella, Head of Composite Material from the Institute of Aircraft Design Stuttgart, explains the production: "It is a braiding process, in which the carbon fibers are woven around the sand core. In the process, the position, angle, and orientation of each individual fiber is extremely important in order to properly absorb forces that are acting on the part."

Up to now, the resin injection process Resin Transfer Molding (RTM) has been used to produce long and endless fiber-reinforced flat components. Here, non-impregnated reinforcement fibers in the shape of a prefabricated and contour-aligned preform are placed in a mould. The fibers can be interwoven or directional. After closing the mold, it is flooded with a reactive resin system. After the component has cured, it can be removed from the mold. Hennecke was able to significantly optimize this process in terms of cycle time by developing the HP-RTM technology.

In the R.A.C.E. project, the matrix material Vitrox® from the company Huntsman is used. This is an RTM polyurethane material with the so-called Snapcure effect. Snapcure enables quick and sudden hardening of Vitrox®. "The R.A.C.E. project is an excellent platform where high-speed PU-matrix materials such as Vitrox® can demonstrate their full performance," says Hubert Reitberger, Product Manager Advanced Composite Resins from Huntsman Polyurethanes. "Self-releasing systems with outstanding mechanical properties combined with optimized curing times are the key to mass production with a short cycle time."

The HP-RTM process starts with the automated insertion of the prefabricated preform by a robot. The press then closes the mold and the injection process starts. The entire curing process takes just

Precise injection of the raw material system in seconds: the Hennecke STREAMLINE

Automated demolding of the cured part

125 seconds. With the elast 400 from the company ENGEL, the process is performed with an extremely compact press. "ENGEL machines are characterized by highest precision, energy efficiency and reliability," says Matthias Mayr, Head of Application Engineering & Project Management at the Center for Lightweight Composite Technologies from ENGEL. "Combined with our automation capabilities, they are the ideal basis for an effective mass production in the area of HP-RTM processing. We have integrated an elast 400 into the production cell which is best suited for both automated and laboratory operation."

High demands are also made on the mold, Gaetano Donizetti, Sales Manager at the company PERSICO, reports: "To withstand the carbon fibers, the aim is to realize a robust, and highly polished surface. This enables the production of high-quality components and surfaces. For this, the ability to demold and the injection points have to be chosen correctly."

The innovative sealing in this mold is new to the world. It has to resist an internal mold pressure of about 100 bar for long periods of time. Here, a new sealing material from Murtfeld is used. "For the first time in the R.A.C.E. project, Murtfeldt Plastics is proud to present a sealing material that can withstand internal mold pressures of more than 100 bar for long periods and is still resistant to damage from residue materials or even carbon fiber," says Ralf Burghoff, Technical Assistant to the Management from Murtfeldt. "Murlock® is another key to high-volume rates of high-pressure RTM processes."

Finally, the metering machine plays an important role. The Hennecke STREAMLINE realizes precise injection of the raw material system in seconds. Karolin Jacobs, Mechanical Design Metering Machines from Hennecke: "The STREAMLINE machine offers a wide range of special features which significantly influence the HP-RTM process. Pressure control, sensors in the mixhead outlet, hydraulically controlled back-pressure function and mold filling monitoring - to compensate for weight fluctuations in the preform - are essential to the perfect component."

The project R.A.C.E. is an impressive demonstration of how a decisive development step in the series production of fiber composite hollow parts on the basis of CAVUS technology can be performed through joint efforts of highly specialized project partners. For Rolf Trippler, Managing Director Sales at Hennecke GmbH, project work is therefore an important part of the self-image of the polyurethane specialist: "Hennecke has consistently extended its technology leadership in many applications also through close cooperation with various industry leaders. The R.A.C.E. project represents this in an impressive way. Hereby I would once again like to thank all parties involved for the successful implementation of the project."

Extremely energy-efficient prefabricated houses

System expertise from Hennecke and AutoRIM

The company Scotframe with its headquarters in Inverurie, Scotland, is one of United Kingdom's leading manufacturers of wood-frame structures for building prefabricated houses. Under the brand name Val-U-Therm, the manufacturer sells a wide-ranging system of highly insulating closed timber frame wall, roof & floor panels with polyurethane cores, which also score highly in the areas of environmental friendliness and sustainability. Scotframe has trusted in machine technology from Hennecke and AutoRIM in its manufacturing since 2008. In the newest version, Val-U-Therm "Plus", the company was able to once again considerably improve the already outstanding insulation properties of the building components and, as a result, markedly exceed even the specifications of the passive house standard. This is made possible by the installation of new, highly precise mixing and metering technology, which, among other things, enables processing of the environmentally-friendly blowing agent pentane.

Injection of the polyurethane mixture into the cavity of the wall elements using a hand-held MXL mixhead

Scotframe Val-U-Therm is a hybrid of wood-frame and Structural Insulated Panels (SIPs) technology. This 'best of both worlds' approach uses the structural principle of a wood-frame design consisting of a supporting frame made from wooden beams, which is panelled and reinforced from both sides with OSB plates. In a manner similar to SIPs, the thermal insulation is incorporated into the cavity between the inner and outer planking so that it is level with the supporting structure. This means that the wood frame constructions achieve very good insulation values with comparatively low wall thicknesses. The roof and floor components are manufactured according to the same principle. A great benefit of the wood frame design is the high degree of prefabrication. As the Val-U-Therm components are already prefabricated with high-quality thermal insulation, windows, doors and sometimes façades, all that is left to do at the construction site is put the building components together. Again a special method of connecting the panels allows the shell of the building to be erected within a few days. Due to the dry construction method, there is no need for the otherwise typical drying times during the building phase. Even though top-class building materials are used, the industrial pre-fabrication of the walls and the repeating connection details provide significant cost benefits compared with conventional construction.

For eight years Scotframe has relied on polyurethane machine technology from Hennecke in the production of Val-U-Therm hybrid Eco SIP building components. The corresponding PANELFORMER model hydraulic press is provided by Hennecke's partner company and specialist in system integration AutoRIM. The press provides over 150 tonnes of closing force and can be used on panels up to 8.1 m x 3.1 m in size.

PANELFOAMER with hydraulic lifting device for transporting the building components

Superior production solution for processing pentane: the Pentane Process Technology and PENTAMAT from Hennecke

A hydraulic lifting device developed by AutoRIM itself provides a reliable form of transport for the building components into the PANELFOAMER and out again. In order to be able to lift the components as close to parallel as possible, the presses are equipped with a tooth rack drive system as standard. Despite the high pressure generated during the foaming process, the entire construction is extremely resistant to distortion.

In the production of the Val-U-Therm panels, up to six wall components are stacked on top of one another in the press and stabilised by the press force. An employee uses a hand-operated Hennecke mixhead to pour the quantity of PU mixture that has been precisely calculated beforehand into the predrilled filling holes and into the respective cavities in the wall components. Ventilation holes allow the air to escape out of the cavities as the PU foam expands. The polyurethane entirely coalesces with the cover surfaces and wood frame as it hardens and, as a result, not only insulates but also stabilises the wall. The managing director of Val-U-Therm, Bryan Woodley, is enthusiastic about the machine technology: "The installed system technology from Hennecke and AutoRIM has been working reliably ever since day one."

Due to the increased demand for ever more efficiently insulated houses and designs that are compliant with the passive house standard, the managers at Val-U-Therm decided to extend their product range of hybrid Eco SIP building components with a version featuring even better insulation: Val-U-Therm "Plus". For this, production was modified for the use of pentane as a blowing agent. With pentane, even better insulating properties can be achieved in the manufacture of PU insulation, due to finer cell structure in the hardened foam, while also minimising the impacts on the environment. Along with optimised insulation, the use of pentane as a blowing agent also makes a significant contribution to effectively reducing the specific GWP (global warming potential) of the modern building components. For gas loading using pentane, the prefabricated house specialists rely on the blowing agent metering unit PENTAMAT 30i. Instead of metering blowing agent directly in the mixing chamber, processing using PENTAMAT blowing agent metering units takes place in batch processing within a polyol component. Here, the percentage of blowing agent in the component flow can be varied with great precision, reproducibly and in almost any ratio.

One thing was clear to Woodley from the start in the "pentanisation" of production: "There is no plan B when it comes to processing pentane. You have to do it right from the very beginning. We were impressed by Hennecke's system technology and refined safety concept, as well as AutoRIM's many years of expertise in the installation of systems of this kind." In fact, with Pentane Process Technology (PPT), Hennecke offers its customers superior safety solutions for processing pentane. In the production of the Val-U-Therm "Plus" panels, for example, the development of dangerous concentrations of gas is effectively prevented using nitrogen

Erected in record time: complex extension to the "Meldrum House Country Hotel"

immediately before the building components' cavities are filled with foam. As before, the system operator only needs to plug the mixhead output pipe into the filling holes to do this. Nitrogen is automatically metered according to the respective output quantity of the reactive mixture before the foam is poured in. This means that nothing has changed in the workflow. The press has also been equipped with reliable pentane sensors by AutoRIM.

40 per cent lower energy consumption than the passive house standard: the Maryville Passive House

Along with the conversion to pentane, the company decided to make a significant update to the metering technology. For this, the AutoRIM specialists installed the top of the range high-pressure metering machine in Val-U-Therm production: a TOPLINE HK 720 with an output rate of up to 1440 cm³/s. The state-of-the-art metering machine is used together with an air-cleaned MXL 14-type mixhead, which enables synchronous switching between shot and recirculation with its hydraulic control piston. Together with an optimised mixing chamber geometry this ensures that the shot weights are adhered to precisely and the product quality remains constant. The package is rounded off with an automated supply station for the raw materials. The sum of the measures is reflected in a thoroughly impressive improvement in the insulation values for the end product. The lambda value compared to the conventional Val-U-Therm components has fallen from 0.025 to a striking 0.023. The first commercial applications of the Val-U-Therm "Plus" building components make their potential clear. One successful example is the Maryville Passive House project in the area of Loch Lomond, Scotland. Here the Val-U-Therm "Plus" building components provide a highly insulated and airtight high-tech outer shell that is free of thermal bridges. In combination with other structural measures the annual energy requirements could be reduced to 69 kWh/m² per year. This means that the heat energy consumption of the Maryville Passive House is 40 per cent lower than the passive house standard (120 kWh/m²a). Another example is the construction of a complex extension to the Meldrum House Country Hotel in Oldmeldrum, Scotland. A ballroom for up to 200 people was erected here in record time, with its outer shell also consisting entirely of Val-U-Therm "Plus" building components and likewise achieving impressive energy-saving potential values.

Glass encapsulation from a single source

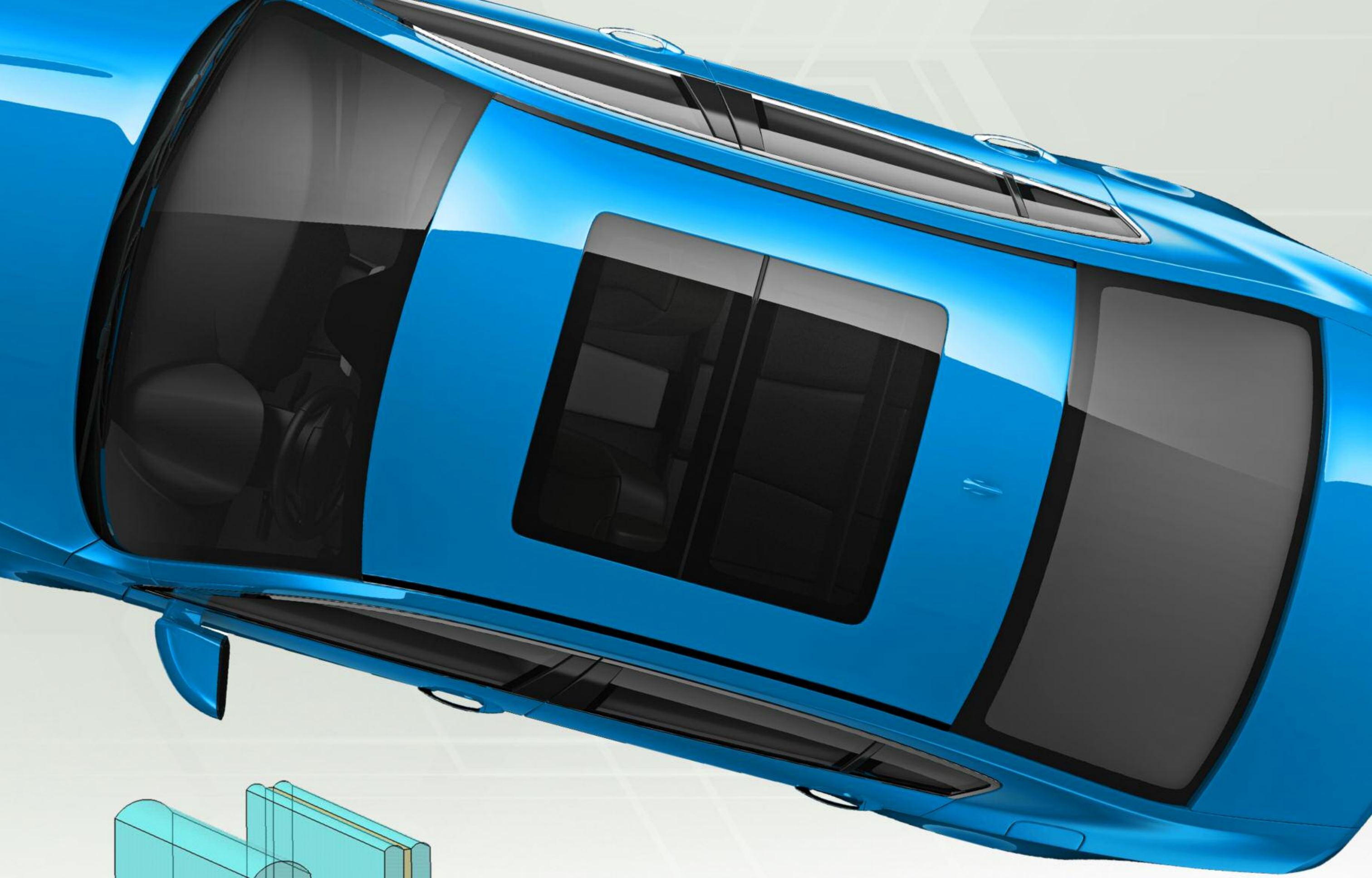
Encapsulating vehicle windows with machine technology from Hennecke and BBG

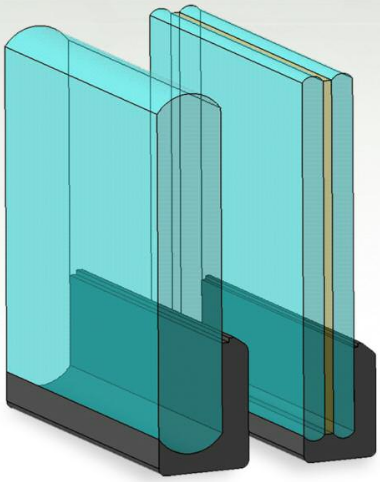
One of the current trends for new vehicles is fitting them with sliding and panoramic roofs made of glass. The glass encapsulation method is used to manufacture these roofs. The vehicle windows and fastening plates are encapsulated in a mould with a rigid polyurethane variant so that a pre-finished component is produced. Until now, the manufacturers of the roof glass had to assemble and adapt the production technology from different manufacturers themselves. With the GlassLine, the system supplier BBG has been offering the world's first polyurethane casting machine specifically designed for encapsulating vehicle windows since 2015. In combination with the high-quality BBG mould carrier systems and BBG moulds, users can thus draw on efficient end-to-end solutions.

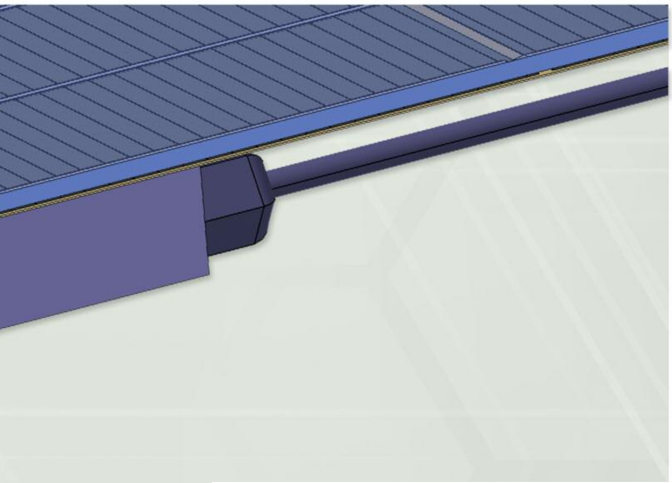
End-to-end solution for encapsulating vehicle glass:
GlassLine metering machine and BBG mould carrier system BFT-PV7

Thanks to the GlassLine with its tried and tested Hennecke technology, the mould, machine and plant manufacturer BBG is able to offer end-to-end solutions for encapsulating vehicle glass from a single source. Due to the close cooperation of both partners and common standards, BBG can now guarantee a consistently high quality for complete lines. Up to now, the company was only able to give this assurance for the mould carrier systems and moulds for polyurethane processing, which it has been very successfully developing and manufacturing in Mindelheim and marketing across the world for a number of years now. Hans Brandner, managing partner of BBG, is convinced of the innovation's market opportunities: "Glassline is a technological high-end product, the only one of its kind in the world. It combines Hennecke's comprehensive experience in terms of reaction moulding machinery and our long years of expertise regarding the encapsulation of automotive glass. In this way we define a new standard for glass encapsulation."

In its standard form, the two-component metering machine is designed as the "GlassLine 650/270" for a maximum output of 650 cm³/s polyol and 270 cm³/s isocyanate. Around 80 percent of all passenger vehicle and utility vehicle glass panes can be encapsulated this way. Special variants of the GlassLine for glass in soft-top convertibles with different mixture ratios and outputs are also available. The GlassLine is based on a TOPLINE metering machine from Hennecke, which has been specifically optimised for glass encapsulation in close collaboration with BBG. The machines of the TOPLINE series offer high-end metering and mixing technology with top-quality metering pumps. Due to the modular structure, they can be easily extended in accordance with the plug-and-play principle for a higher production capacity. They can be expanded up to eight casting stations without any problems. All process parameters are recorded and documented as standard in order to enable seamless quality control. During the development of the GlassLine, special emphasis was placed on its user-friendliness. Along with an ergonomic machine layout, operators benefit from the innovative control concept WINTRONIC. This guarantees maximum machine availability due to integrated safety, auxiliary and trouble-shooting functions. In addition to the process data acquisition, there is an option for incorporating the control into higher-level production systems. A large touchscreen panel of the latest generation with an ergonomic and intuitive user interface ensures a logical and simple display of the complex processes thanks to user-orientated visualisation.The GlassLine is equipped with a type MT 12-2 Hennecke mixhead, which has a flow-optimised nozzle geometry. This ensures a perfect mixing result. At the same time, the components polyol and isocyanate can be fed at a lower pressure, as a result of which the energy consumption drops by 30 percent compared with conventional models. With a simple adapter plate, the mixhead can be easily mounted to all moulds on the market. Since the start of the project cooperation in 2015, BBG has already sold several complete systems. Among others to automotive glass processing companies in Hungary, the Czech Republic, China and the USA.







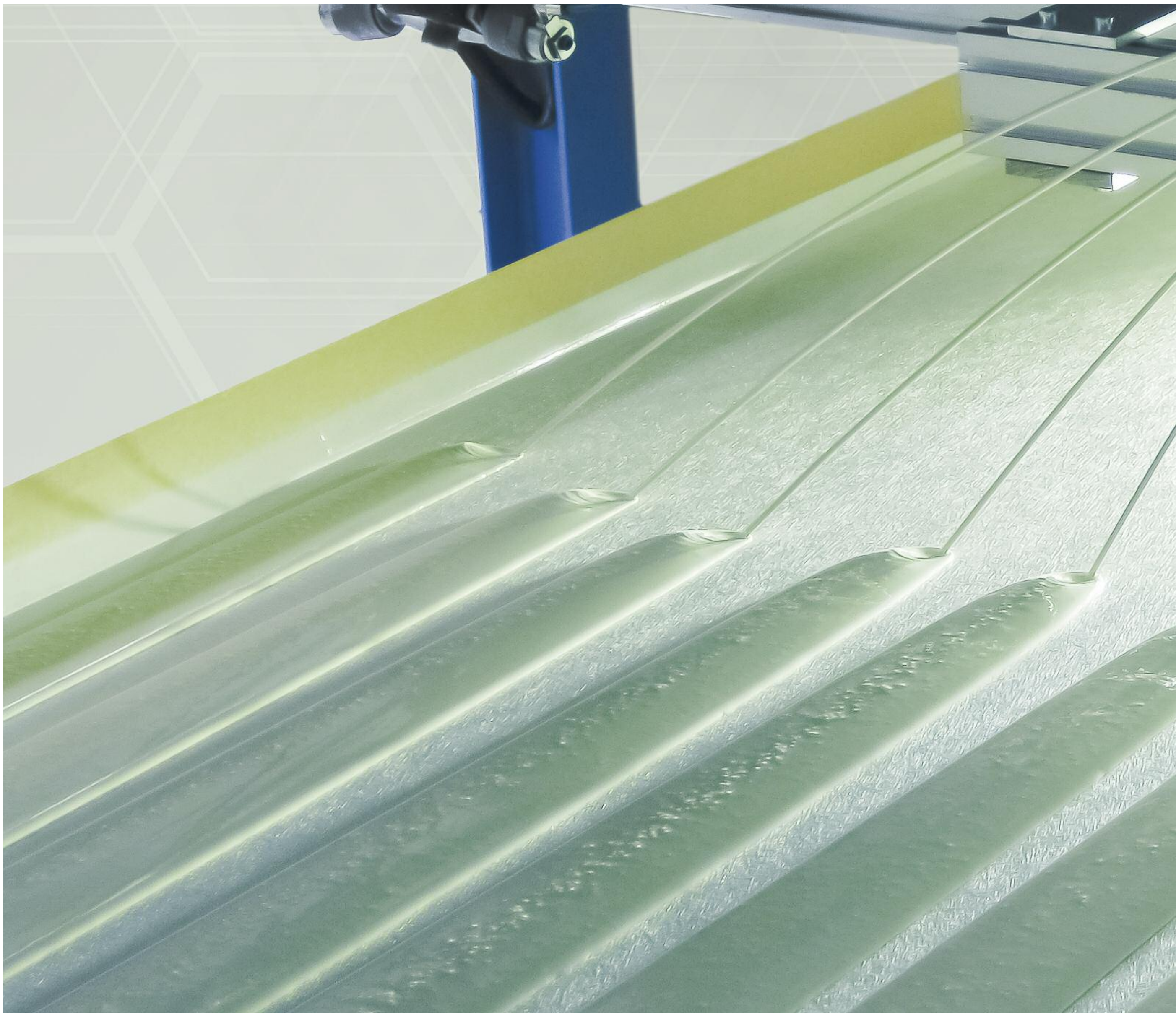
The glass encapsulation process is also used in rainproof inroof photovoltaic modules (e.g. for carports)

BBG

BBG GmbH & Co. KG, a manufacturer of moulds, machinery and plants, is a renowned specialist for the plastics-processing industry, focusing on polyurethane. BBG, the family-owned business, which is located in Mindelheim/Allgäu and is run by Hans Brandner, the managing partner, supply their products to their customers all over the world, with the Asian market playing an important role in addition to the markets in Europe and North America. With a headcount of 150 worldwide, BBG generated sales to the tune of 23 million euros in 2015.

Hennecke presents the "ZERO AGE APPLICATOR"

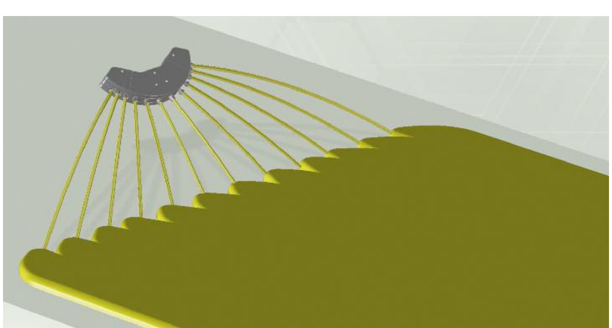
Revolutionary discharge system for continuous flexible and rigid foam applications



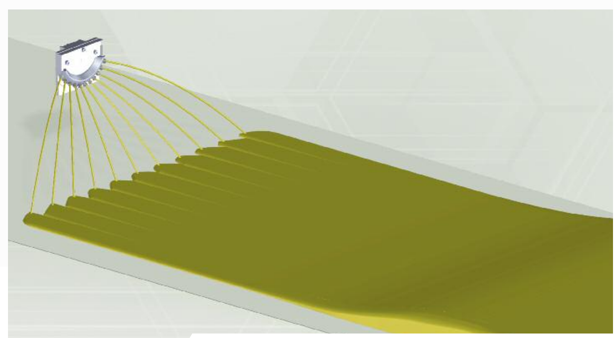
When it comes to the continuous production of high-quality flexible foams for the furniture industry, Hennecke has been the global market leader for several years. More than 600 plants sold and generations of satisfied customers worldwide speak for themselves. On top of that, plants for the continuous processing of rigid polyurethane foam for the manufacture of sandwich panel insulating elements are also regarded as the undisputed standard on the market for efficient and flexible production. With the new Zero Age Applicator, Hennecke's polyurethane specialists are now presenting a revolutionary distribution system for both rigid and flexible foam applications which offers a convincing alternative to the discharge systems previously available.

In the development of the new discharge system, the focus was placed on the way in which the liquid raw material mixture is dispensed within the production line. This requires a uniform distribution over the entire foaming width combined with a foaming reaction that starts precisely at the same time. Discharge systems used up to now have either used several mixheads or various different mechanical distribution systems to achieve the best possible combination of these two properties.

The Zero Age Applicator, which Hennecke offers in two specially adapted variants, now enables a decisive improvement and moves a step closer to the envisaged ideal in this interplay. With this system, several injectors are used at the same time which are arranged in a semi-circle in the discharge unit. The homogeneously mixed material is thus dispensed onto the bottom sheet in several streams across the entire foaming width. The decisive factor is that the reaction starts at the same time across the entire foam width. More precisely: the foam cells form in one virtual line without any time delay, or indeed with a "zero age difference".



The ZERO AGE APPLICATOR type F for the production of slabstock foams



The ZERO AGE APPLICATOR type R for the production of sandwich panel insulation elements

In the area of continuously manufactured sandwich panel insulation elements, this allows for an extremely homogeneous foam structure and therefore an improvement in the rigid PU foam's insulating properties. In addition, the useful life could be optimized in comparison with standard discharge systems. During the manufacture of slabstock foams, the new system ensures improved efficiency of raw materials as well as a significant shortening of transition pieces when changing formulation or colour, ultimately resulting in less waste. Through extensive flow simulations and a range of test runs under real production conditions, also with regard to easy handling, cleaning and reusability, the new system was gradually developed to be market-ready for a wide range of applications. With this, Hennecke is once again proving its full professional expertise in the area of continuous production solutions in the PU sector.

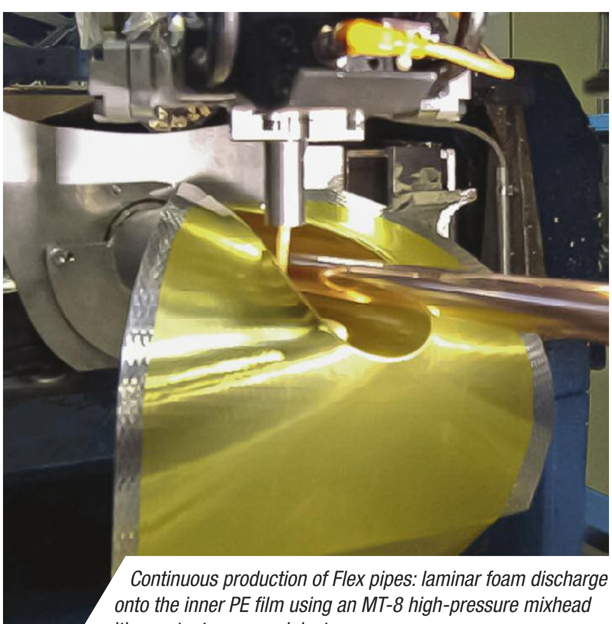
Well insulated

Polyurethane high-pressure technology optimises the insulation properties of plastic-sheathed double-walled pipes

Combined heat and power is the motto when it comes to the future of energy generation. In order to save on raw materials and CO_2, the residual heat that occurs when electricity is generated will no longer be able to escape unused in cooling towers but will be utilised as district heating or cooling. Insulated pipes are necessary to make sure that the heating or cooling takes place where required. The demands placed on these plastic-sheathed double-walled pipes, as they are called, in terms of insulation are steadily growing. Hennecke high-pressure metering machines for the processing of polyurethane (PU) ensure high quality.

The PU specialists at Hennecke anticipate strong growth in the market for insulated piping systems in the years ahead. Here, one factor is gaining in significance: energy loss over time. In addition, the operating costs of a piping network play an increasing role. Efficient systems ensure that the conveyed energy arrives with almost no loss. For this reason, pipes with very high insulation properties are more and more in demand. In addition, various efforts are being made around the world to protect the climate, and at the same time companies can thus make a contribution toward the effective reduction of CO_2 emissions. Apart from being used in district heating technology, pre-insulated piping systems are also employed in on and offshore applications for transporting drinking water as well as oil and gas products, in the process industry and in shipbuilding.

European governments and the European Union have now been promoting combined heat and power systems for a few years. It is to be expected that this technology will also be used increasingly in Eastern Europe and other parts of the world. Today, modern combined heat and power stations, for example in Denmark, have an overall utilisation rate of more than 75 per cent. By comparison, many conventional power stations in Europe without combined heat and power only have a utilisation rate of between 25 and 30 percent because here residual heat is not used.



Continuous production of Flex pipes: laminar foam discharge onto the inner PE film using an MT-8 high-pressure mixhead with constant pressure injectors

The plastic-sheathed double-walled pipes that are required in district heating networks commonly exist in lengths of six, twelve or sixteen metres. They are made from different materials. The component pipe is made out of steel, copper or plastic, the heat insulation is made of foamed PU and the casing pipe generally consists of polyethylene (PE). The component pipe sticks out on both sides beyond the casing so that the pipes can be joined together on the construction site. After the component pipes have been fixed together, a PE fitting is positioned over the non-cased section and the cavity is filled with PU foam.

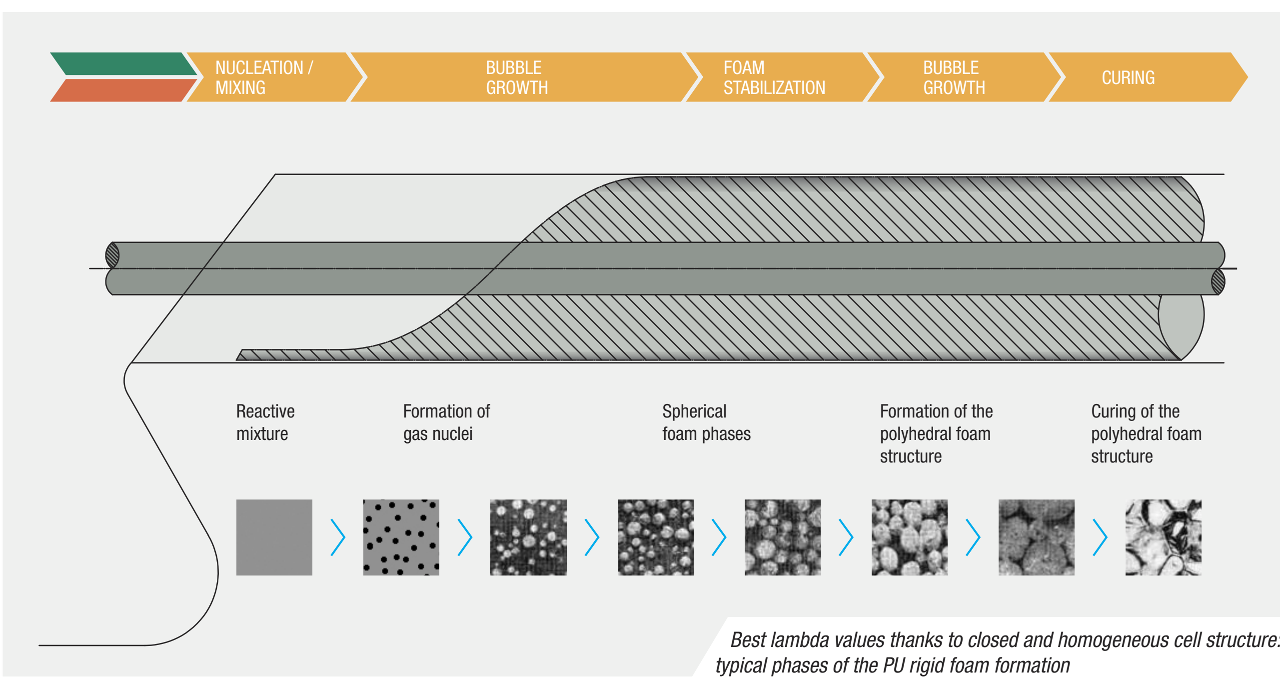
In the meantime, PU has superseded classic materials for pipe insulation such as mineral wool. The most important reason for this is the low lambda value. This represents the heat conductivity of materials. The lower the heat conductivity, the better the heat insulation is. With lambda values of 0.020 – 0.035 W/(mK) – depending on the blowing agent – polyurethane is superior to many other insulants. If one considers the increased longevity of PU foam insulated pipes (approx. 30 years on average) in addition to these outstanding lambda values, it becomes evident that the material provides significant energy savings over time. On the other hand, the improved insulating properties also permit a reduction in foam thickness and as a result in pipe manufacturing costs. Yet another advantage resulting from the reduced foam thickness is that less the cost of transport is reduced and laying the pipes is made simpler.

Different manufacturing processes

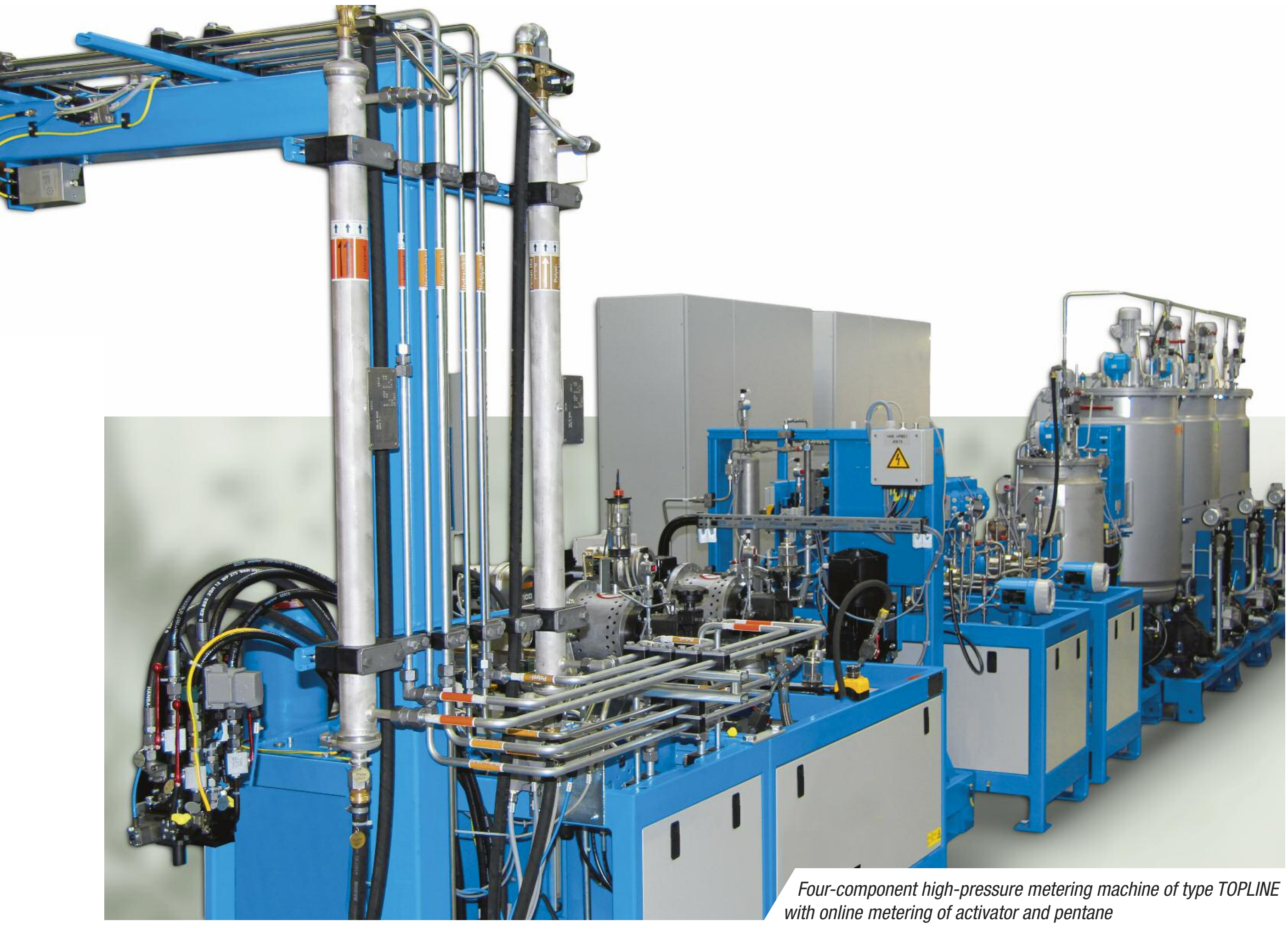
Continuous or conventional manufacturing processes are used to produce the insulated pipes. In the conventional process, pipes with fixed lengths are manufactured one at a time. The component pipe is equipped with spacers and then fitted with a PE casing pipe. PU foam is then injected at high speed into the cavity between the component pipe and the casing pipe, which are held at a slight gradient. The foam then spreads from bottom to top. The challenge with this method is to fill the pipe with the largest possible quantity of reactive mixture within a specified time. At the same time, turbulence during the filling process must be effectively avoided to prevent any possible shrink holes from forming or fluctuations in density and hence irregular insulation. The Hennecke MXL mixhead offers all possible options for this. The conventional process is usually used for small production runs, since it has the lowest investment volume and at the same time is the most flexible and is also easy to set up and retool.

Hennecke has developed mixhead drawing technology to improve quality in single-piece production. In this process, PU foam is introduced into the cavity between the component pipe and casing pipe, much as with the conventional technique. However, the component and casing pipes are not centred by spacers. Instead they are pushed into one another and statically fixed. After this, a mixhead that is mounted on the end of a lance system is introduced into the cavity. When the mixhead is subsequently withdrawn, it dispenses a very fast-reacting foam system evenly along the entire pipe length. The foam does not have to perform any longitudinal or flow movement. Due to the laminar mixture application, the foam in the pipe attains a very uniform density distribution of 58 kg/m^3 at lambda values up to 0.022 W/(mK). Compared with the conventional process, this homogeneity results in a saving on raw materials of between 10 and 15 percent. This is because with conventional production, more foam has to be cast in to achieve a defined core density everywhere in the pipe. Today, the mixhead withdrawal technique is used predominantly for pipes of small to medium nominal diameters for district heating pipes and pipelines. In the mixhead withdrawal technique, the mixture is applied using the purpose-developed MRL high-pressure mixhead, the geometry of which is matched to the pipe section.

The MRL series is cleaned with compressed air and equipped with spring-loaded, pressure-controlled nozzles. These make it possible to variably control the output in an ongoing production process while maintaining a constant mixing pressure and to keep materials circulating "on call" in low-pressure circulation without additional control elements on the mixhead. With the continuous method, the pipes are produced continuously rather than one at a time and are cut to the required length after cooling. Initially the inner pipes are endlessly fixed. At the same time, a foil is pre-formed into a U-shape. In the next step a mixhead pours the PU foam onto the foil. Then the filled foil is closed so that it envelopes the inner pipe. Afterwards, the pipe, foil and rising foam pass through a calibrating unit for curing. The foam-insulated pipe is then put into an extruder where it is coated with polyethylene. The pipe is drawn uniformly during the entire manufacturing process. The PU foam merely has to rise, as opposed to flowing a given distance as with the conventional method. As a result, even density distribution and insulation is achieved. In order to improve the insulating quality even further, the plant control permanently adapts the PU formulation to the environmental temperature. In addition, the foam front is monitored and also flows into the plant process control system.



Best lambda values thanks to closed and homogeneous cell structure: typical phases of the PU rigid foam formation



Four-component high-pressure metering machine of type TOPLINE with online metering of activator and pentane

Higher mixing quality

In the past, the PU components polyol and isocyanate were mixed with the continuous production process using low-pressure technology. In this case, blending takes place by means of a dynamic stirrer; however, deposits will form on this over the course of time. These reduce the mixing energy and hence also the mixing quality. Moreover, an uneven cell structure arose due to the escape of pentane in the mixing chamber. Further disadvantages included trapped air caused by the stirrer, the fact that the mixhead has to be cleaned with solvents after just brief operation, and the impossibility of varying the output during a production run. On the other hand, with the Hennecke high-pressure technology polyol and isocyanate are atomised with high energy according to the impingement mixing principle. This leads to a significantly improved mixing quality. Here, pentane can also be metered much more precisely. The PU foams have a completely homogeneous cell structure. The cell sizes are smaller and better distributed than with the low-pressure technology.

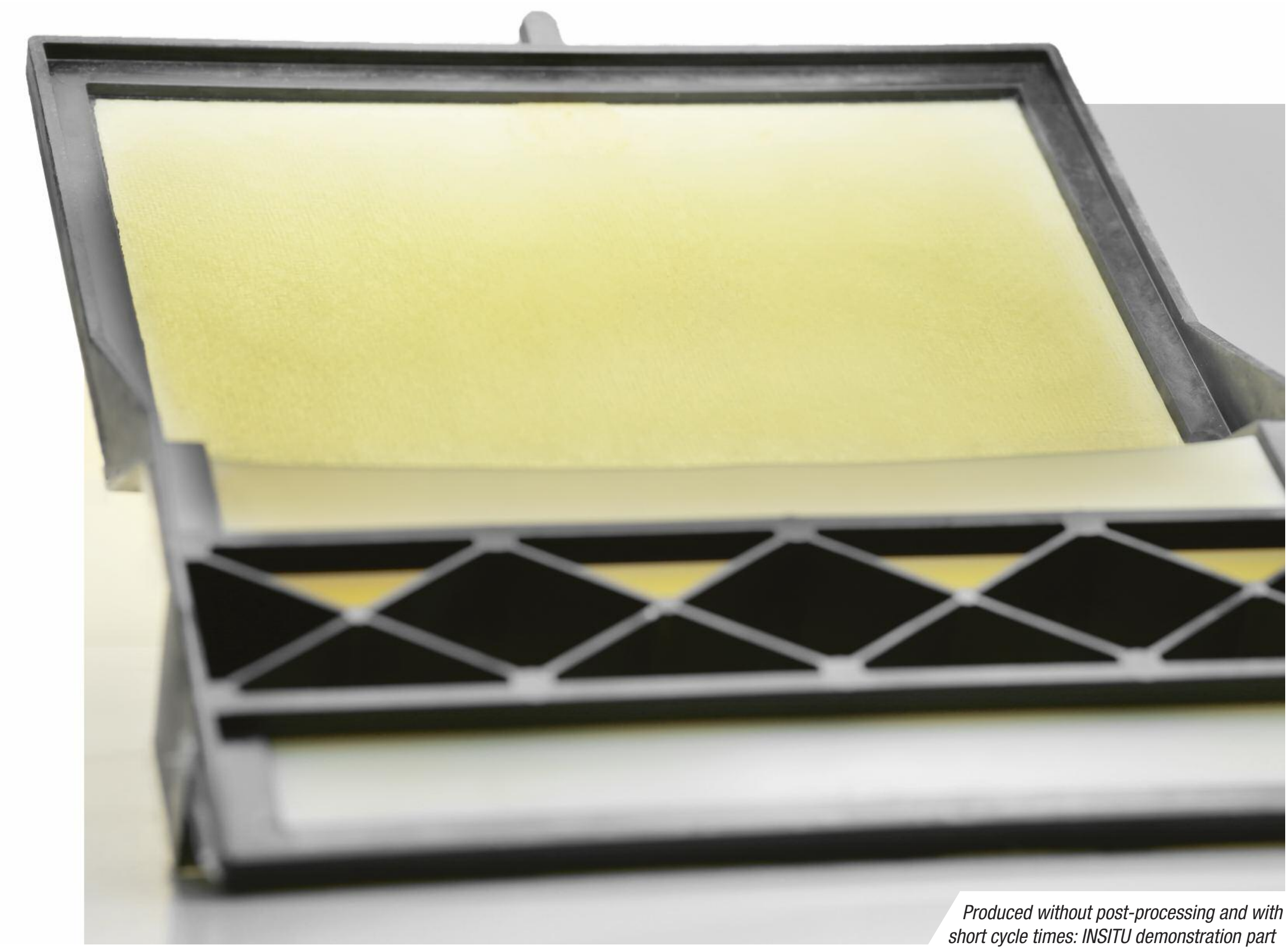
In addition, the equipment is more convenient to operate, providing broad output variability, simple metering of additives such as activators, less cleaning of the mixing chamber and the elimination of solvents.

For two decades, Hennecke has supplied leading pipe manufacturers throughout Europe with high-quality production plants and is the market leader in this sector with 14 installed and continuously-producing plants. The specialist for polyurethane technology offers corresponding equipment for all common processes for the production of PU-insulated pipes – including the processing of cyclopentane with the patented Pentane Process Technology (PPT). Depending on the production method and individual customer needs, TOPLINE HK high-pressure metering machines can be supplied in different sizes with different premixing units as well as various mixhead types.

Fully automatic, with no requirement for post-processing and with short cycle times

Production of thermoplastic fibre composites in the injection mould

Long fibre-reinforced plastic parts with requirements-based fibre composites are an elementary component of lightweight construction technology. However, long cycle times in production currently prevent large-scale manufacture of these parts. A demonstrator component that has now been produced in an injection moulding machine using a two-stage process shows that it is possible to manufacture these components fully automatically, in a reproducible manner, with no requirement for post-processing and with short cycle times. The core of the process is a metering machine that mixes a polyamide 6 system in a high-pressure process and a push trolley mould with a dual cavity for the fibre composite process as well as for the injection moulding process.



Produced without post-processing and with short cycle times: INSITU demonstration part

The large-scale processing of fibre composite materials with short fibres on injection moulding machines is an established process. Up to now, the resin injection process Resin Transfer Moulding (RTM) has been used to produce long and endless fibre-reinforced flat components. Here, non-impregnated reinforcement fibres in the shape of a prefabricated and contour-aligned preform are placed in a mould. The fibres can be interwoven or directional. After closing the mould, it is flooded with a reactive resin system. After the part has cured, it can be removed from the mould. Hennecke has considerably reduced the cycle time of this process by developing the high-pressure RTM process (HP-RTM). But a disadvantage remains: the components produced in this way require final machining to create the contours.

Since the company uses polyurethane or epoxy systems, depending on the application, as a matrix material for the HP-RTM process, it cannot be readily transferred to an injection moulding machine. Due to the shrinkage and adhesion properties, these two matrix materials cannot be used there. So instead, the company uses caprolactam with the in situ process, because this material can be both reactively and thermoplastically processed. With in situ injection moulding, impregnation of the fibre reinforcement takes place in the injection mould. The use of caprolactam in combination with an activator and a catalyst allows polymerisation into polyamide 6 in the mould. In the second step, the same mould creates the final functionalised shape in a conventional thermoplastic injection moulding process with polyamide 6. Fibre laying within the part is thus only necessary at those places where it must actually absorb forces.

The injection moulding machine from ENGEL, which is designed for the insitu process and installed in the Hennecke "TECHCENTER" application centre, has two injection units. One is the Hennecke metering machine of type STREAMLINE, the other is a thermoplastic standard injection moulding unit for the polyamide 6. With the metering machine, Hennecke offers a processing system for all common matrix systems of fibre composite components. These include polyurethane or epoxy resin / hardener systems and – as in this application – polyamide 6 raw material systems. The STREAMLINE adapts to the respective production requirements by its modular structure and can thus e.g. also be integrated into an automated production line. The metering machine comes with standard equipment including a self-cleaning high pressure mixhead and a touch-screen control based on a Simatic PLC from Siemens right from the factory. Thanks to the efficient temperature control system for tank and pump by means of hot air technology, the metering machine achieves effective component tempering and mixing even at low output rates. Mass flow measurement for the main components in the metering machine also allows density-independent formulation preselection and hence precise metering. Viscosity variations do not play a role as the continuously recirculated main components are kept at a homogeneous temperature of up to a maximum of 100°C. The basic machine configuration also includes a vacuum unit to prevent air inclusions from occurring when the components are stored in the day tank. A feed pump ensures uninterrupted supply to the main metering unit – in spite of the vacuum. All subassemblies are mounted on a mobile frame, thus enabling relocation on the production floor at short notice as well as a flexible operation in the technical centre at any time. The in-house Hennecke push trolley mould for production of the demonstrator component comprises a dual cavity for the injector side and a single cavity for the lower mould. The mould is designed to be pressure stable for the HP-RTM process and is contour-aligned with variotherm heating. Here, the low-viscosity caprolactam places particular requirements on the seals. Other challenges are the different pressures and temperatures of the two processes.

To produce the demonstrator component, firstly the pre-fabricated dry fibres are placed in the lower mould. The mould is closed with the injector side for the HP-RTM process. In comparison with a thermoplastic melt, caprolactam has lower viscosity and can therefore infiltrate even very fine fibre filaments without damage and without displacing the structures in the mould. The caprolactam reacts in the mould via in situ polymerisation to form thermoplastic polyamide 6. The resultant preform remains in the bottom side of the mould. The injector side of the mould is changed for the second step. Now the final and demoulding shaping takes place using thermoplastic injection moulding with polyamide 6.

In this combination of the reactive system and its suitability for large-scale series production of the thermoplastic world, Hennecke sees considerable added value for the user. In particular, because the interplay between the requirements-based fibre composite on the one hand and cost optimisation on the other is the key to large-scale series production with short cycle times in the trend topic of lightweight construction. The substantial advantages of the process are also the diversity of processing options and the very large degree of freedom in the design of moulded parts. We now need to further develop the raw materials and the fibres to optimise the process. In addition, not all fibre types can be combined with the raw material system caprolactam. Together with users, Hennecke will continue to actively advance the further development of in situ technology so that this promising technology will soon reach market maturity.

Push trolley mould with dual cavity for the injector side and single cavity for the lower mould

The raw material caprolactam in detail

Polyamide 6, also known under the brand name Perlon, results from the ring-opening polymerisation of ε-caprolactam. The ω-aminocaproic acid that is required to initiate the chain is obtained from the hydrolytic ring opening of ε-caprolactam. This reacts together with caprolactam to form polycaprolactam or polyamide 6.

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