Ballistic panels are being used as armor for civilian and military vehicles, ships and aircraft. The image shows a test blast to demonstrate the safety for vehicle occupants. © TDW Schrobenhausen

Pressing of Ballistic Panels Made of Fiber-Reinforced Plastics

Safety First

Demand for fiber composite panels to protect military vehicles, armored limousines, ships and helicopters is steadily on the rise. For over four decades, they have been manufactured on Wickert composite presses. The most recent contract: a line for a German defense company that went into operation in late 2021. The project demonstrates what is being demanded of press technology.

The very first armor made of fiber composites dates back to ancient times. At that time, several layers of linen were joined with glue to form a stiff fabric laminate that warriors wrapped around their bodies. It is said that Alexander the Great protected himself with what was referred to as a linothorax.

Today, alongside bullet-proof personal vests, lightweight ballistic panels are in particular demand for protecting vehicles, ships and aircraft. They are made from high-performance materials such as aramids and high-performance polyethylenes, for example. Combined with glass, ceramic and metal fibers made of aluminum oxide, silicon carbide, boron carbide, aluminum and armor steel, they are heated in automated systems and compressed under pressure to form fiber composite panels.

Specialty companies produce the ballistic panels customized for specific applications. Such applications include sensitive areas on warships, container ships and military trucks, plus the bodies of luxury limousines and the outer shells of helicopters. The liners are designed to provide protection against bullets, explosives, fragments and missiles, yet at the same time be very lightweight.

A Niche Market Experiencing Steady Growth

Growing weapon systems, an increase in terrorist threats since September 11, 2001, and the threat of piracy to civilian merchant shipping are all driving demand. "Wickert has been manufacturing composite presses to produce ballistic panels since the 1980s. For a long »

time this was a niche market that featured a relatively consistent contract volume. However, the market has picked up noticeably in recent years and has continued to grow ever since," explains Stefan Herzinger, managing partner of Wickert Maschinenbau.

Just one current example: in September 2020, Wickert delivered a WKP 52000 composite press to a German defense company. The heart of the contract, which was executed as a turnkey project, is a Wickert standard press modified to produce ballistic panels.

Weighing 150 t, the press features a sub-piston frame design with a full hydraulic closing system that boasts a press force of 52,000 kN and 1600 x 2500 mm heating plates. Also included in the contract was a fully automated parts loading and unloading system and a heating/cooling system with thermal oil.

The hydraulic composite press was designed and manufactured at the company's headquarters in Landau in Germany. Here is where Wickert has always manufactured the equipment according to the customer's specific requirements. Processing temperatures of up to 500 °C and press forces of between 20 and 100,000 kN are possible, as are plane parallelism of up to 0.025 mm/m. The dimensions of the presses and their precision heating plates are freely selectable. Multiple options for automation and networking, and the integration of other manufacturing processes such as RIM and RTM injection, ensure high productivity and a broad range of applications.

High Demands of Press Technology

Ballistic panels are manufactured with the ultimate goal of producing products offering a consistently high level of protection. To achieve this, the system technology must meet three requirements in particular:

- The blanks and semi-finished products must be heated and cooled as consistently as possible.
- The pressure during pressing should be as equal as possible at all points of the entire panel.
- The system must close precisely. This requires the highest possible plane parallelism.

Temperature Tolerance of Only ±3 °C across the Entire Panel

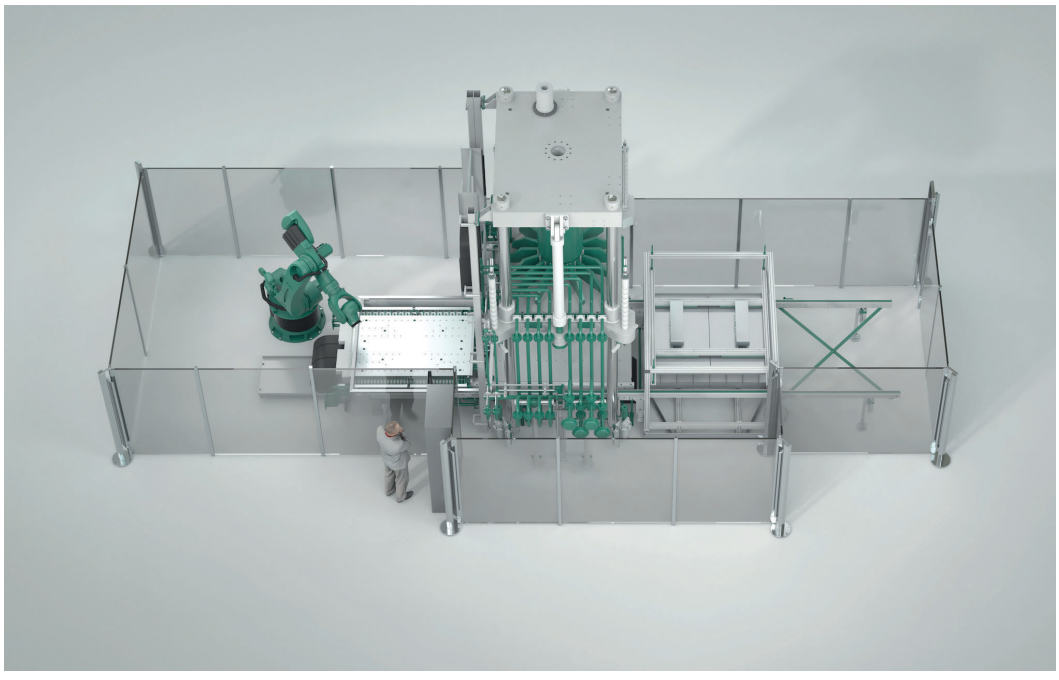
To achieve homogeneous temperature distribution, the panel uses heating/cooling plates with a total heating capacity of 360 kW, drilled from the blank and designed for long service life. This tempering process is costly, but "Wickert guarantees a very homogeneous temperature distribution with a tolerance of ±3 °C over the entire panel," emphasizes the managing director.

The WKP 52000 stands out due to its very high force density. Six press cylinders made of high-strength steel generate the pressing force and apply it evenly to the product. Stefan Herzinger explains that fitting cylinders with the required output into the compact press in a very confined space was a challenge. "In the end, we succeeded. We have made optimum use of the available space, and now not even a sheet of paper will fit in there."

To ensure that the force distribution can be controlled as precisely as possible, Wickert has also included a fine pressure setting of a mere 960 kN. "Normally, the minimum press force is

Stefan Herzinger, managing partner at Wickert: "Precise force distribution requires sensitive pressure adjustment." © Wickert

The composite press that was delivered to a German defense contractor is a smaller model of the WPK 60000 shown with automated loading and unloading. © Wickert



View inside an automated composite press: generally, the systems are customized for each customer specifically. Process solutions that can be integrated include infrared heating systems, transport and robot systems, plus intelligent networking with higher-level control systems.

10 % of the maximum output, meaning that in this case it would be 5200 kN," explains Herzinger.

The clamping system is fully hydraulic and is equipped with an additional suction process. Consequently, it not only moves extremely fast at 40 mm/s, but can also be controlled with extreme sensitivity.

The main piston is sealed by a redundant system that reliably keeps it from leaking. The hydraulic system is driven by an axial piston high-pressure pump, allowing power and speed to be freely preselected for all driving functions. This ensures that the hydraulic system works quickly, sensitively, reliably, and precisely, and that the output can be reproduced accurately at any time.

Highest Accuracy in the Press Cycle

The press accuracy contributes significantly to the quality of the production process. "Using high-quality standard components from a coordinated modular system and our expertise in integrating peripheral components are important prerequisites," Herzinger adds. Not to mention more than 120 years of experience in press and plant engineering.

The delivered press also scores points in the press run with a plane parallelism of 0.5 mm/m, so that the upper and lower dies close exactly.

A Cycle Takes between One and Two Hours

The blanks, which are manually prepared from up to 60 layers of fibers impregnated with a special plastic, are automatically loaded into the press using loading baskets. The tempering system heats them up in the die first to 40 °C and then, in a second step, to 160 °C. This causes the plastic to melt; and the blank is pressed under pressure into the desired shape. The semi-finished product then cools down again in the mold to 40 °C. Then it is automatically removed and cooled down to room temperature.

This cycle takes between one and two hours. The 1600 x 2500 mm ballistic panels then only need to be cut to the required size.

Originally, the press was delivered for pressing one panel at a time. "For a relatively low added cost, there are also versions with up to seven levels. This allows seven times the number of pieces to be produced in a single cycle," explains Herzinger.

Quality and Assurance

Sensors are used to record all process data for quality assurance and detailed documentation of the manufacturing process. There are three sensors integrated in the product itself, providing information on the temperature of the panels during processing. The entire system is controlled centrally with the aid of an intuitive "Press Easy" control system. A VPN also enables remote access, which is used for remote maintenance as well. The entire system is safeguarded by a security fence, monitored doors, light barriers and scanners. Moreover, it also features a mold safety system with four-way measurement to prevent misalignment. ■

Info

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