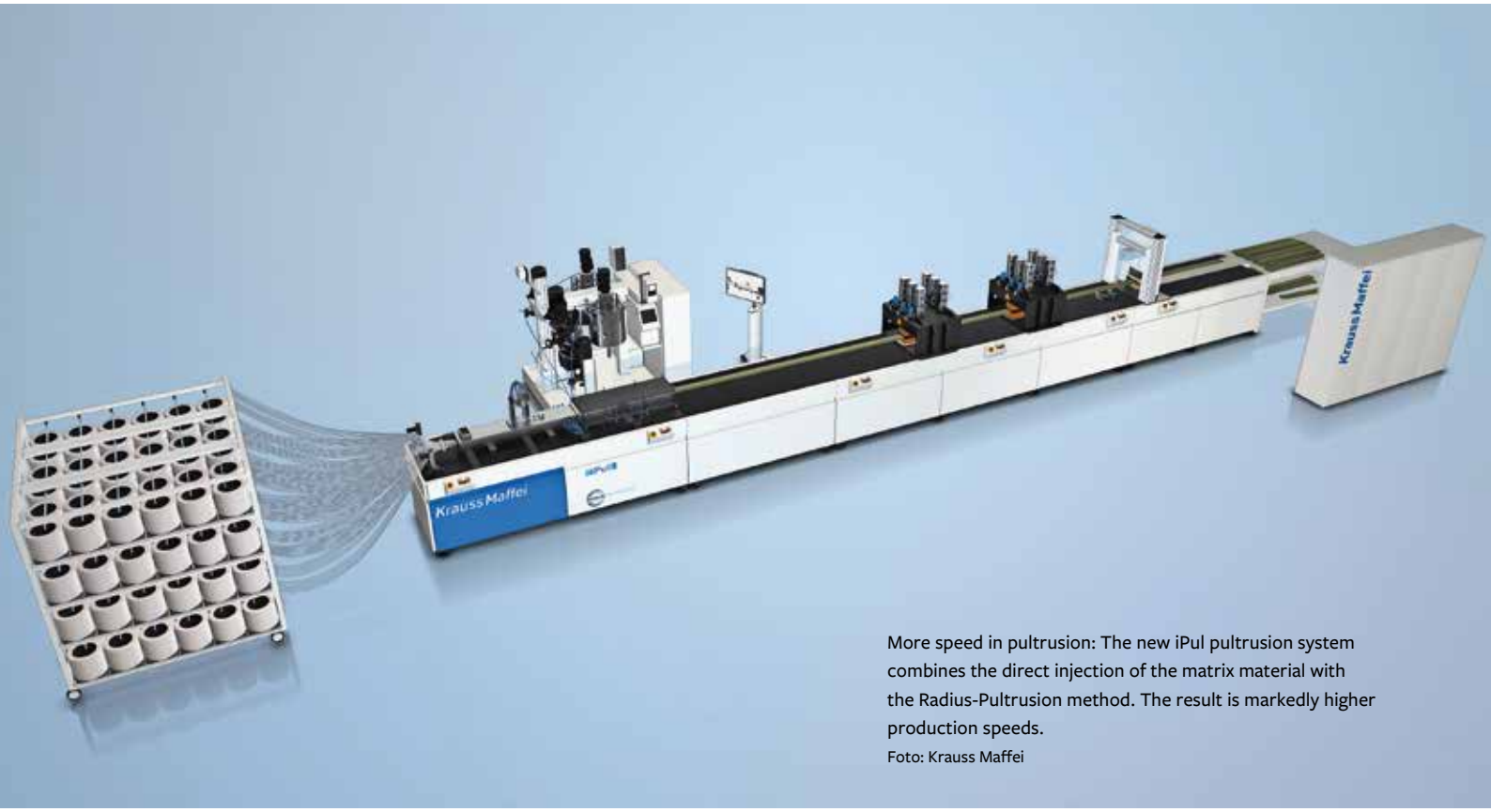


More speed in pultrusion: The new iPul pultrusion system combines the direct injection of the matrix material with the Radius-Pultrusion method. The result is markedly higher production speeds.
Foto: Krauss Maffei

More speed straight ahead – and around the bend

Pultrusion with speeds of up to three meters per minute opens up completely new opportunities, particularly in window construction

JOSEF RENKL

Very small and very large windows present problems. For smaller windows, conventional PVC profiles often seem heavier than the glass pane, and in the case of larger windows it is an issue of stability. In both cases, fiber-reinforced pultrusion profiles provide the solution. KraussMaffei is now launching „iPul" to carry out the process known as pultrusion. iPul is an efficient complete system that allows for a production speed of up to 3 m/min. In addition to the construction industry, the technology is also an attractive method for manufacturing wind turbines, vehicles and airplanes.

Pultrusion refers to a tried-and-tested approach. Since the 1960s, it has been used in industrial settings to manufacture fiber-reinforced plastic profiles. In this process, rovings, i.e. continuous fibers, made mostly of glass, carbon or aramid, pass through open tubs with the matrix material and are then formed into the desired shape in a heated mold. On the other side of the mold, grippers continuously pull the cured profile further. The name „pultrusion" is a portmanteau referring to this pulling motion and the preceding extrusion process. Astonishingly enough, hardly any further developments made over the past few decades to increase the production efficiency and convenience of the technology. The production speed has remained at 0.5 to a maximum of 1.5 m/min for a long time. The approximately 300 pultruders in the world have been

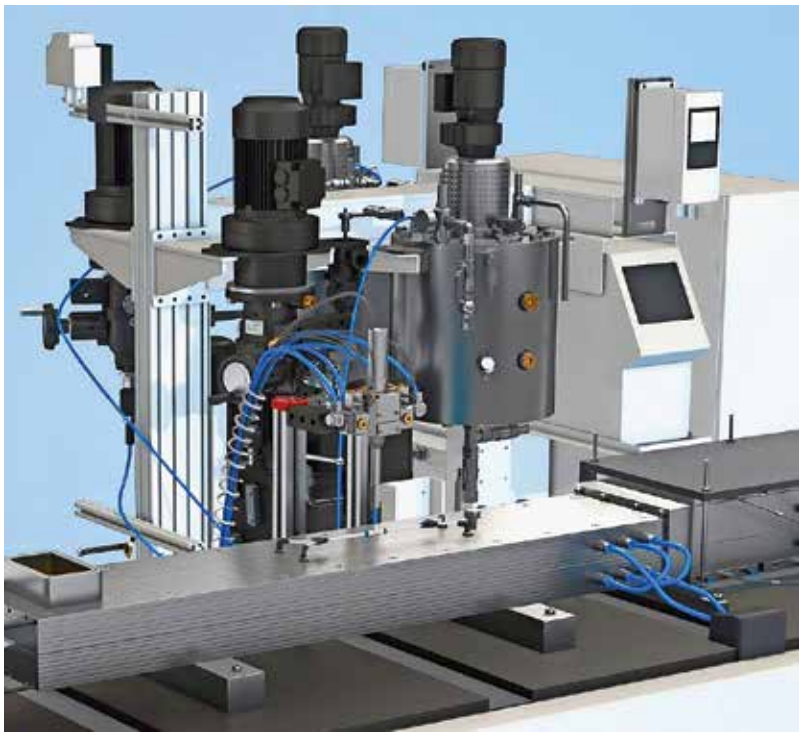
> „iPul opens up completely new markets for pultrusion."
>
> **Wolfgang Hinz,** Business Development and Sales Management of Pultrusion at KraussMaffei

building up their production systems from individual components from various providers. These systems thus cannot be coordinated. For the staff, the equipment's open tubs also mean a more severe odor to withstand. KraussMaffei has now combined its expertise in metering technology (polyurethane, epoxy, polyamide) for fiber composite solutions with its extrusion experience in order to launch the very first complete system. The system both encapsulates the soaking of the fibers with the matrix material in an injection box and increases the production speed to as much as 3 m/min. Together with cooperation partner Thomas Technik, KraussMaffei is also providing systems for manufacturing curved profiles (Radius-Pultrusion).

Core component: Injection box

The core component of iPul is the injection box, which is itself part of the mold, because this part of the process brings the fibers closer to the final profile form. The rovings are pulled from their (often more than) 100 coils into this injection box. This can also be done using fiber rovings and fabrics. The box can be necessary in order to increase the stiffness of a component through multi-directional fiber-orientation or if a surface is required with a clear fiber characteristic.

The process of soaking the fibers with the matrix material takes place directly and continually in the injection box. This allows systems with higher reactivity to be processed. These systems can be selectively configured to match the property patterns of the end product. Many pultruders are still using polyester or vinylester, but the mechanical property patterns of these materials are not as high-performance as today's requirements demand. KraussMaffei, on the other hand, relies on the thermosets common in other methods: epoxy resin and polyurethane. One example of a clear advantage of polyurethane is the improved mechanical property patterns. Conversely, it allows component designers to create profiles with thinner walls, using less complex and therefore more cost-effective fibers. Wherever a thermoplastic matrix is required, e.g. because the finished product is supposed to be welded or recycled in the future, polyamide 6 can also be used. A newly developed mixing head in which the individual components of the reactive materials flow together works cost-effectively, at a lower pressure and with flexibility and precision. This allows the injection points to be slightly adjusted on a product-specific basis. Since a certain pressure facilitates the infiltration of fibers with the plastic, the injection box with a length of approx. 50 cm has been designed such that it tapers off in the direction of transport. The continuous pull on the finished



The process of soaking the fibers with the matrix material takes place directly and continually in the injection box. This allows systems with higher reactivity to be processed. These systems can be selectively configured to match the property patterns of the end product.
Foto: Krauss Maffei

Wolfgang Hinz (r.), Business Development and Sales Management Pultrusion at KraussMaffei says, „By using the new iPul pultrusion systems, we are aiming for a significant increase to more than three meters per minute."
Foto: Krauss Maffei

Foto: Krauss Maffei

More speed during pultrusion

Three questions for Josef Renkl, Head of Pultrusion Development at KraussMaffei

Mr. Renkl, what led to the development of iPul?

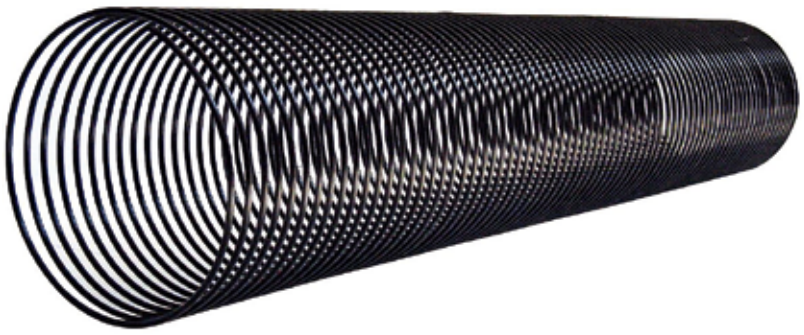
» Josef Renkl: As a provider, KraussMaffei has complete in-house knowledge both of the metering technology for fiber composite solutions and of extrusion systems that is necessary to give a boost to pultrusion innovation. The result is the first complete system on the market. iPul is thoroughly coordinated to production efficiency.

What do you see as the greatest advantages of the new system?

» Josef Renkl: Primarily the closed injection box and the high production speed. Until now, the speed had been in the range of 0.5 to 1.5 meters per minute. Depending on the application and matrix material, we can use iPul to reach speeds of around three meters per minute. This opens up completely new markets for the technology.

What do you consider the main application areas?

» Josef Renkl: The construction industry is an interesting option, for example, window profile manufacturing, and the mobility sector is another. Since we can also produce curved profiles from various plastics, even frames for airplane bodies, for example, can be made with a diameter of three or four meters.



Pultruded pressure jacket for a deep-sea pipeline: Longer risers and flowlines are possible alternatives to steel.
Foto: Thomas Technik

Experience pultrusion live

COMPETENCE
Day KraussMaffei is showcasing further developments as well as the iPul pultrusion system in live operation KraussMaffei at Pultrusion Competence Day on June 28, 2017 at the Munich location. Customers and partners are welcome to attend the technology day.

profile and the cross-section narrowing result in a pressure of up to 100 bar. This pressure causes the matrix material to wrap around the fibers optimally.

In the following curing mold, the profile passes through three individually adjustable heating zones and is then conveyed from the pulling unit at a constant speed to any potential post-mold processing and further to the saw, where it is cut and then prefabricated. All machine components can be operated centrally via a control system.

Very wide application range

The new pultrusion process shows its advantages in all situations where high strengths are required and mostly metals have been used up to this point. One example is on large-format windows with narrow frames, for which conventional PVC profiles do not provide the necessary stability and which are therefore usually manufactured with extruded aluminum. In contrast, fiber-reinforced profiles offer physical advantages—including one advantage that everyone has felt: metal is colder than plastic. The superior isolation capability of the pultruded components (thermal conductivity of 0.5 W/mK in comparison to 236 W/mK for aluminum), which is crucial when energy is being conserved, goes hand-in-hand with increased dimensional stability for temperature fluctuations (thermal coefficient of expansion [in 10–6 K–1]: 5 in comparison to 23 for aluminum). The stiffness is about as high as when aluminum is used and the corrosion and chemical resistance are even higher. Additional properties include lower electric conductivity and permeability in comparison to radio waves, meaning that wireless reception and similar signals can continue to be used without interference.

The construction industry is a very interesting target market for this technology—particularly because the pultruded profiles may be significantly more cost-effective than aluminum and because the production speed using iPul is about the same as that of the PVC extrusion mass procedure. There are hardly any maintenance costs for the fully assemb-

led element and one can imagine a wide variety of applications where a metal substitute could be used: fence posts and pickets, wall panels, support systems for sheetrock and even concrete reinforcement.

The quality of the finished product is created through the combination of fiber and matrix. This is the reason why KraussMaffei conducts development projects with three material manufacturers in order to adjust recipes for each respective plastic to meet special requirements. In construction, these include Covestro (for polyurethane + glass fibers) and Evonik (epoxy resin + glass fibers)—and the project with Huntsman (epoxy resin + carbon fibers) involves pultrusion for aviation applications. The collaborations involve research on the manufacturing of pultruded reinforcement elements for particularly large-format rotor blades in wind power systems.

And because mobile machines also require strength with low dead weight, the construction of motor vehicles and aircraft presents an additional application area. One example is special structures for truck trailers, where in the past it was possible to use double-T beams. Frames for airplane bodies are another example. Here, however, the straight shape of the profiles is no longer sufficient. It is necessary to introduce a curve instead. The required diameter is about 3 to 4 m.

Global system provider

To be able to implement this two and three-dimensional curved shape, KraussMaffei is cooperating with the inventor of Radius-Pultrusion, Thomas Technik. The company introduced this method in 2008. The plan is to take marketing to the next level for this method by taking advantage of KraussMaffei's global presence. Every linear system made by Thomas Technik is also prepared for Radius-Pultrusion operation.

The critical advantage for Radius-Pultrusion: The mold moves. This movement is used first to pull the fibers into the cavity and then transport them into the gel/hardness zone from the mold insert toward the mold end, where the finished profile is gripped.

Before now, it was very difficult for new companies to start using pultrusion because there was no complete system supplier with a sales and service structure like KraussMaffei. KraussMaffei also provides customer service in all stages—from the design of the profile, to the selection of the matrix, to the system construction and even commissioning and training. This makes the process of expanding a customer's portfolio through the addition of fiber-reinforced profiles (for PVC extruders, for example) less of a major step. ■

Fiber-reinforced profiles work well for windows thanks to their excellent heat isolation, dimensional stability despite temperature fluctuations as well as corrosion resistance.
Foto: Covestro/Int

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METERS/MINUTE
The speed during pultrusion had been stuck in the 0.5 to 1.5 m/min range for years. KraussMaffei is introducing, for the first time, a system with an injection box that enables a production speed of up to 3 m/min.

Josef Renkl
Head of Pultrusion Development
Krauss Maffei

Web
www.kraussmaffei.com/pultrusion