high-performance

Towpreg manufacturing for scalable performance and precision

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Towpreg is reshaping the future of composites. As industries push for lighter, stronger and more precise components, in-house towpreg manufacturing is emerging as a key strategy to meet rising demand with greater control and efficiency.

Towpreg manufacturing is evolving rapidly to meet the increasing demand for high-performance and lightweight composite materials. A growing number of industries are seeking higher volumes of towpreg, along with mounting pressure to reduce production costs. Based on extensive field experience, a clear trend is emerging: companies are conducting more in-house developments in testing and production of towpreg to increase output and gain better control over quality and cost in composite part production. This is particularly evident in aerospace, defence and transportation applications, where manufacturing efficiency and precision are paramount.

Towpreg materials are widely used in the production of composite pressure vessels, for space or hydrogen storage, dynamically loaded parts such as shafts and springs, structural components like pipes and rotors, and in emerging applications like electric motors and eVTOL vehicles. Consistent quality, faster cycle times and mechanical performance remain key drivers of towpreg adoption across transportation, automotive, aerospace, energy and industrial sectors.

Understanding towpreg technology

Towpreg (Figure 1) – short for "tow pre-impregnated" – refers to continuous fibre, typically carbon or glass, impregnated with a precisely controlled amount of resin. This ensures even resin distribution and results in predictable, uniform mechanical properties, which are critical in safety-sensitive and high-performance components such as pressure vessels or aerospace structures.

Towpreg manufacturing generally involves 4 stages: fibre preparation, resin impregnation, partial curing (B-stage) and spooling.

Fig. 1: Towpreg material

Accurate control of the fibre-to-resin ratio at every step is essential. Modern equipment must offer high levels of flexibility, precision and repeatability to maintain consistent production standards.

Step-by-step overview of towpreg manufacturing

Mikrosam has developed modular and scalable towpreg production lines (Figure 2,3) tailored for various industrial needs. One example delivered to a customer in Asia integrates several essential components into a compact automated cell. The process includes:

- The unwinding unit, which ensures even fibre feeding and spreading with stable tension. It features real-time tension control, spool diameter tracking, and fibre break detection, supporting speeds up to 30 m/min without damaging the fibres.
- The impregnation unit, the heart of the line, which provides accurate resin dosing across a wide viscosity range. It supports various impregnation methods and adapts to multiple resin systems, with constant monitoring of temperature, pressure and dosing speed.
- The rewinding unit which allows programmable winding on various


Fig. 2: Towpreg making machine at Mikrosam

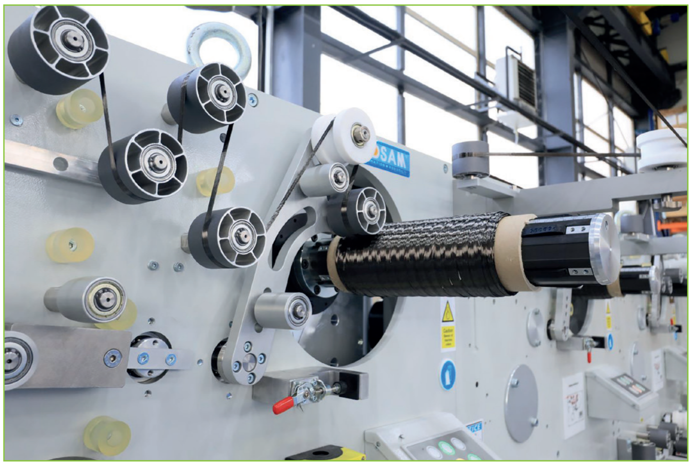
Fig. 3: Rewinding unit – towpreg making machine

spool configurations (4, 8, or 16 spools). It supports parallel or tapered winding and includes temperature-controlled rollers for consistent material spooling.
- The control and quality systems. Mikrosam's proprietary control software handles recipe management and production monitoring. Each spool is linked to its full production history, ensuring traceability. Integrated high-resolution inspection tools maintain quality assurance throughout the process.

Materials and supply chain considerations

Mikrosam has tested in-house towpreg production with resin systems from leading suppliers such as Huntsman, Westlake Epoxy and others, in combination with fibres from Hyosung, Teijin, DowAksa and many others. The company also sourced towpreg from manufacturers including TCR, Red Composites, Kümpers GmbH and Microtex for use in variety of the machines in customer development projects. This broad know-how has allowed to understand and prepare tailored solutions based on specific customer requirements.

Notably, the growing demand for towpreg often exceeds current market supply. As a result, many companies are investing in their own manufacturing capabilities to ensure consistent availability and quality. This is enough initially to satisfy demand, reduce lead-times and reduce costs. Over time, it should be the material suppliers to take on lead in these initiatives and provide larger quantities at competitive prices to spearhead wider adoption.

Applications in filament winding

Towpreg filament winding (Figure 4) offers several advantages over traditional wet winding. These include consistent resin quantity, faster production speeds and cleaner environment. The tackiness of the pre-impregnated fibre may help prevent slippage, ensuring precise fibre orientation in complex, multi-axial winding configurations. It must be balanced with the shape of mandrels and number of interpolated axes used.

High-speed winding at rates up to 5 m/s is achievable with varying winding angles, enabling efficient production of cylindrical components with high strength-to-weight ratios.

Towpreg lends itself to high-tension winding, where several technical challenges are encountered. For example, in rotor manufacturing, windings must withstand tensions of 300 to 500 Newton or more per fibre to ensure the finished part is sufficiently robust for further use and


Fig. 4: Towpreg robotic filament winding machine

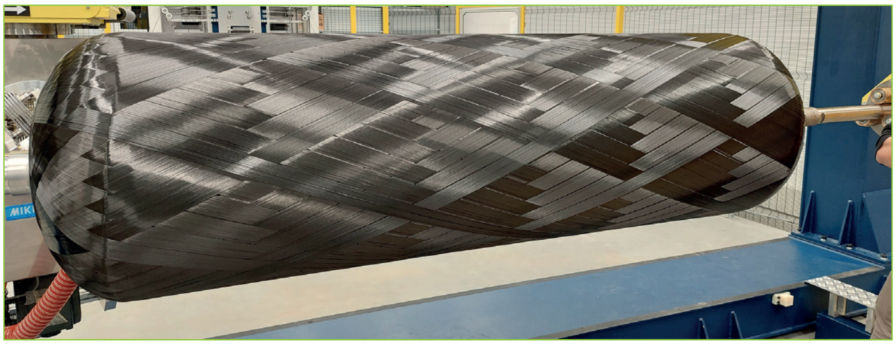

Fig. 5: Towpreg filament winding machine at Cryomotive, Germany

remains stable under high temperatures and demanding conditions. Conversely, Mikrosam sometimes need to reduce the tension during unwinding from the creel to between 40 and as low as 20 Newton. Thus, the towpreg spool coming directly out of the towpreg making equipment is not immediately suitable for high tension winding.

Mikrosam has developed custom high-tension addition to the filament winding machines which increases the tension of the towpreg fibres during winding to beyond 100N. Customers have used this mechanism to successfully deliver products on the market for the last 6+ years. Additionally, over the last 12 months, the company has also employed this system in a custom-designed machine to successfully produce parts for electric motors with tensions exceeding 500N per towpreg fibre. The higher speed of winding and larger material deposition has led to a new challenge – how to obtain larger spools of towpreg. For example, if 10 spools per spindle on a 4-spindle machine are used, this will lead to at least 30-40 min of spool replacement downtime during each winding cycle. Larger spools help minimise replacement and improve overall efficiency. More customers are recognising the strategic benefit of using towpreg for more applications and initiating in-house towpreg manufacturing, ensuring consistent quality, supply control and cost-efficiency.

Hydrogen pressure vessels

Despite market volatility, hydrogen storage remains a fast-growing application for towpreg. Composite tanks – particularly Type IV and Type V – demand uniform mechanical properties, low hydrogen permeability and high durability. Mikrosam's customer Cryomotive (Germany), uses the company's machine (Figure 5) to manufacture 400-bar Type III tanks with carbon/epoxy over aluminium liners. This ensures repeatability and shorter production cycles. Also, H2Storage (Netherlands) employs Mikrosam technology for tanks over 300 l in volume for transportation industry (Figure 6), focusing on reliability and production efficiency. These are but the most recent examples, in addition to the many Mikrosam's customers using towpreg in defence and space applications.

Fig. 6: Towpreg filament winding development for H2 Storage, Netherlands

Advanced use in automated fibre placement

Towpreg materials are gaining attention in Automated Fiber Placement (AFP) applications vs traditional thermoset UD slit prepregs, mainly due to the relative cost delta vs thermoset prepregs. Mikrosam has conducted testing with various towpreg material suppliers in its AFP laboratory to evaluate their performance and suitability.

One of the main shortcomings of towpreg materials is their lack of stiffness and lower width tolerances. Successful AFP application demands high fibre stiffness and precise width tolerances so the towpreg fibres can be smoothly transported through the AFP head. Precise resin content is another important aspect for all towpreg or prepreg materials and must be consistent with the requirements from aerospace, defence, automotive and hydrogen industries.

Material producers are striving to deliver better-quality and better-suitable towpreg for AFP technology at prices and specification closer to thermoset UD slit tape prepreg standards.

Unlocking the full potential of towpreg

Towpreg materials are rapidly gaining traction as industries seek the ideal balance between performance, scalability and cost-efficiency.

Mikrosam brings extensive experience across hydrogen storage, defence and aerospace applications – sectors where the demand for advanced pre-impregnated fibre materials is accelerating. As more companies invest in in-house towpreg production or adopt commercial towpreg for filament winding processes and AFP processes, deep expertise in material science and production engineering becomes increasingly critical. To unlock the full potential of towpreg composites in this fast-evolving market, continuous innovation – both in materials and manufacturing technologies – is essential. ◻

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