SPOTLIGHT ON

Cevotec

Composite pressure vessels (PVs) are the key storage system for hydrogen-powered mobility. Automation specialist Cevotec has developed an industrial solution that, in combination with the established filament winding (FW) process, improves the storage efficiency by up to 20% through reducing the composite fibre material consumption of the tank while simultaneously increasing available storage capacity.

The number of countries committing to emission neutrality by 2050 is growing. Deploying hydrogen as an energy carrier is a promising approach to achieve this goal, especially for the transportation sector. Fuel cell electric vehicles (FCEV), in particular for long-haul transport like trucks, buses and trains, as well as hydrogen-related aircraft programmes, are on the rise. However, one of the challenges is to efficiently and safely store hydrogen for mobile applications.

Hydrogen is typically stored in Type 4 pressure vessels, which have a very high consumption of carbon fibre material due to their working pressure of up to 700 bar. This negatively influences the production costs and environmental footprint of hydrogen pressure vessels, with carbon fibres representing over 50% of the total tank costs. To decrease the material consumption, Cevotec developed an industrial automation solution to reinforce the domes of pressure vessels, using Fibre Patch Placement (FPP) technology.

PVs are typically manufactured by winding filaments of impregnated fibres around a polymer liner with different principal fibre orientations. The primary stresses in the tank laminate are in the circumferential and longitudinal direction which are covered by the hoop and low-angle helical layers (LAHL). The high-angle helical layers (HAHL) significantly absorb the stresses occurring in the boundary area. In the cylindrical region, however, the fibre orientation of the HAHLs deviate from the main stress direction, so only a small fraction of their load-bearing capacity is used. Due to the continuous winding process, they are covering, nevertheless, the whole tank and not just the dome area which leads to a considerable amount of inefficiently used fibre material.

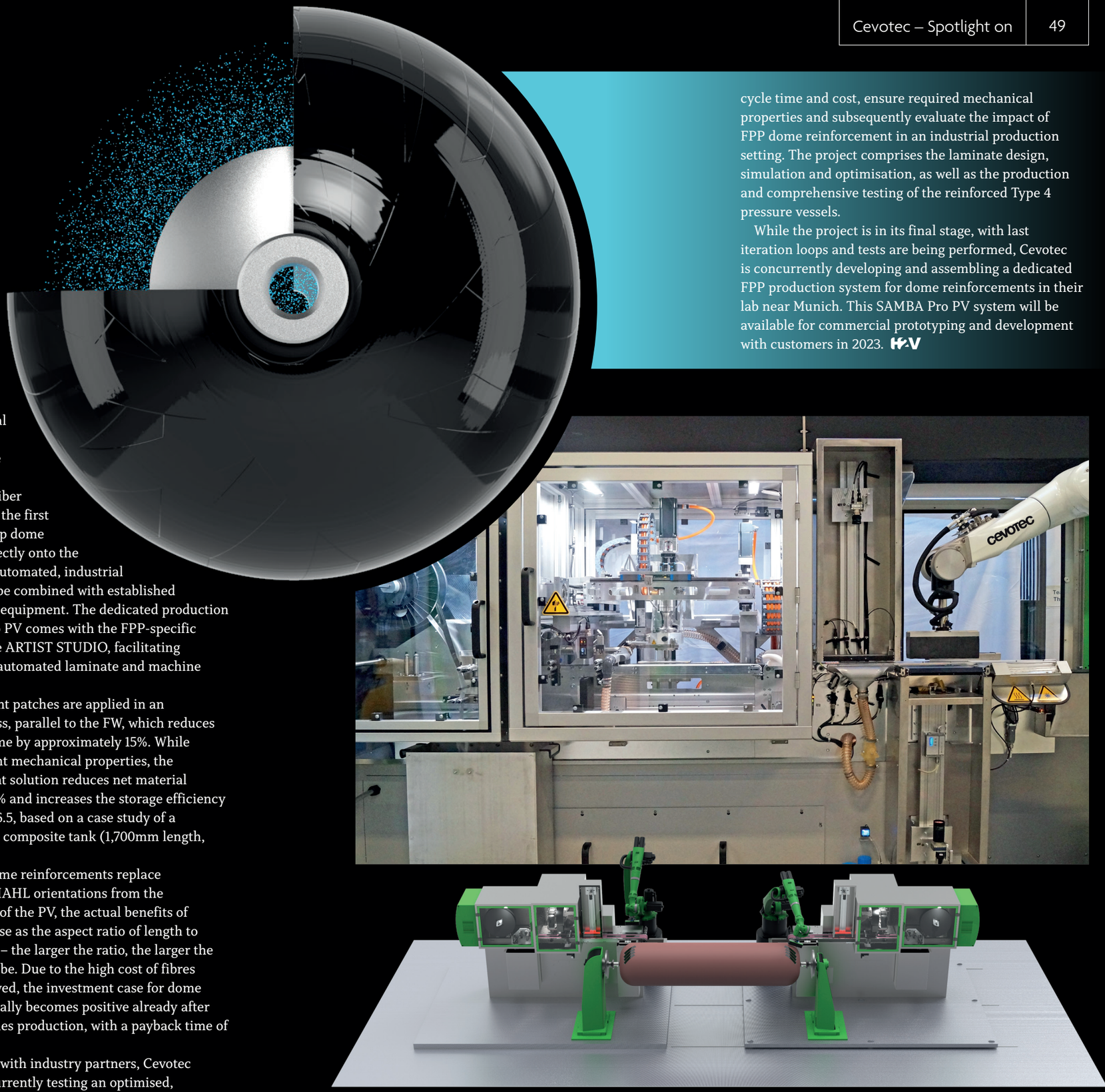
As a solution, local dome reinforcements can replace the HAHLs. The reinforcements only contribute to the dome area while the cylindrical part will then be covered only by the hoop windings and LAHLs. Cevotec's Fiber Patch Placement is the first technology to lay-up dome reinforcements directly onto the liner using a fully automated, industrial process which can be combined with established wet or tow winding equipment. The dedicated production system SAMBA Pro PV comes with the FPP-specific CAD-CAM software ARTIST STUDIO, facilitating efficient as well as automated laminate and machine data creation.

The reinforcement patches are applied in an independent process, parallel to the FW, which reduces the overall cycle time by approximately 15%. While achieving equivalent mechanical properties, the dome reinforcement solution reduces net material consumption by 13% and increases the storage efficiency by 19% from 5.5 to 6.5, based on a case study of a typical commercial composite tank (1,700mm length, 400mm diameter).

Since the FPP dome reinforcements replace inefficiently used HAHL orientations from the cylindrical portion of the PV, the actual benefits of this solution increase as the aspect ratio of length to diameter increases – the larger the ratio, the larger the efficiency gain will be. Due to the high cost of fibres and the amount saved, the investment case for dome reinforcements usually becomes positive already after the first year of series production, with a payback time of 10-20 months.

In a joint project with industry partners, Cevotec developed and is currently testing an optimised, full-scale demonstrator. The goal is to optimise the fibre lay-up, also by simulation, in order to minimise cycle time and cost, ensure required mechanical properties and subsequently evaluate the impact of FPP dome reinforcement in an industrial production setting. The project comprises the laminate design, simulation and optimisation, as well as the production and comprehensive testing of the reinforced Type 4 pressure vessels.

While the project is in its final stage, with last iteration loops and tests are being performed, Cevotec is concurrently developing and assembling a dedicated FPP production system for dome reinforcements in their lab near Munich. This SAMBA Pro PV system will be available for commercial prototyping and development with customers in 2023. H2V



© Cevotec | Figure 1. The SAMBA Pro PV: FPP automation system for dome reinforcements.