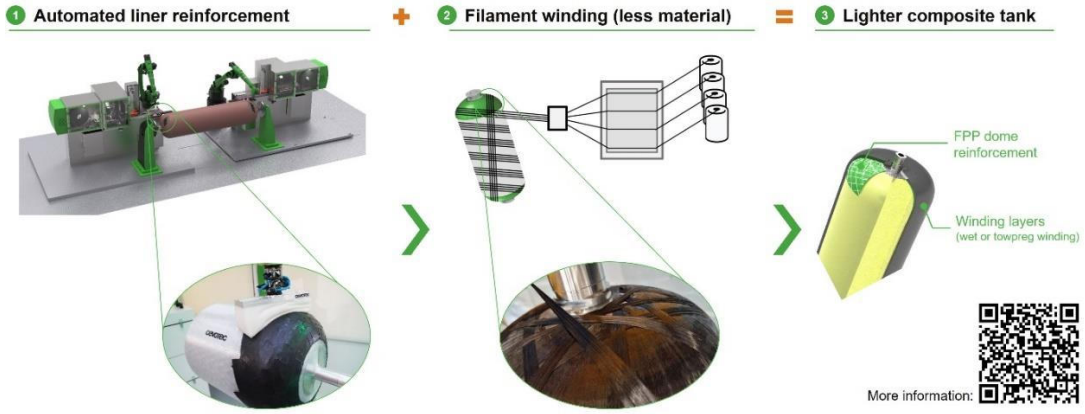
FPP dome reinforcements prove 15 % material reduction for H_2 tanks

Cevotec has partnered with a tank manufacturer, winding equipment provider Roth Composite Machinery and the composite engineering service provider CIKONI to investigate and showcase the effect of dome reinforcements using Fiber Patch Placement technology for composite tanks.

Background & motivation

Cevotec has developed an industrial solution to reduce the amount of carbon fiber needed for a composite tank by locally reinforcing the tank's dome areas. Fiber Patch Placement (FPP) 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 towpreg winding equipment.



This approach reduces net fiber consumption by approx. 15 % or more, depending on the vessel characteristics, which translates into considerable weight and material cost savings while maintaining equivalent mechanical properties. Due to the material reduction, the reinforced tanks also feature more storage volume in the same built space and have an improved CO_2 footprint.

To underpin Cevotec's approach, an optimized full-scale demonstrator has been successfully developed in collaboration with all partners. The primary goal of this extensive project is to optimize the fiber lay-up to minimize cycle time and cost at equivalent mechanical properties. Additionally, the effectiveness of FPP dome reinforcements within an industrial production environment has been thoroughly evaluated. The project comprises all aspects from the laminate design, simulation and optimization to the actual production and testing of reinforced 300 bar composite tanks. With the successful completion of the third iteration, the intended results have been achieved.

Project approach

The reference vessel (v00) chosen by the consortium's tank manufacturer to confirm and quantify the mentioned concept is a type IV pressure vessel (PV) with characteristics displayed in the following table.

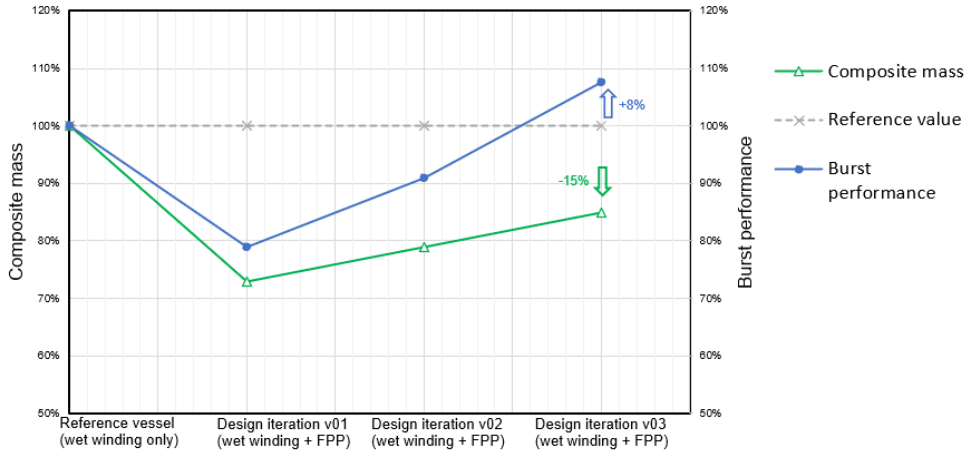
Characteristic	Value
Outer diameter	316 mm
Length	894 mm
Total vessel weight	17.6 kg
Total vessel volume	46.5 l
Ratio L/D	2.83
Nominal working pressure (NWP)	300 bar
Required burst safety factor (BS EN 12245)	3.00

This vessel represents a challenging set-up for the reinforcement solution: Compared to 700-bar-class vessels, this class of vessels has a thinner composite overwrap with a lower number of layers to be replaced by dome reinforcements. To achieve the optimal material saving design, different laminate iterations were pursued. The table on the next page gives an overview of the reference vessel and the three iterations. In light of the results of the first iteration loops, a third iteration (v03) was carried out and successfully achieved the burst safety factor required by BS EN 12245.

Name	No. of FW plies	Composite mass (incl. FPP reinforcement)	Burst performance (3*NWP)	Storage efficiency mass H_2 / mass of (total vessel + H_2)
Reference v00	*undisclosed*	100 %	**100%**	**5.2 %**
FPP v01	9	73 %	79 %	*irrelevant*
FPP v02	11	79 %	91 %	*irrelevant*
FPP v03	12	85 %	**108 %**	**6.1 %**

Project results

The achieved results for v01, v02 & v03 are charted in the graph below. v01 offered a CFRP material saving of 27 %, while reaching 79 % of the required burst pressure. v02 was designed using an enhanced simulation model and provides a higher specific benefit with mass reduction of 21 %, while reaching 91 % of the required burst pressure. In v03, after burst results, **15 % material savings** have been achieved with a promising burst **safety factor of 108 %.**



The storage efficiency is a key indicator for a pressure tank, setting the mass of the compressed H_2 in relation to the total mass of the storage system. For v03, **storage efficiency is 6.1 %, which represents an increase of 17 %** compared to the 5.2 % storage efficiency of the reference vessel.

This material saving benefit will translate to an even higher advantage for vessels with an increased L/D ratio. The longer the vessel, the greater the saving potential from eliminating high angle helical layers from the vessel. This effect, extrapolated based on actual project data, is illustrated in the table below. The saving potential is unique to each composite vessel and increases also with operating pressure, as higher pressure typically requires a thicker laminate, which provides increased savings potential.

Characteristic	Project value	extrapolated **Example 1**	extrapolated **Example 2**
Length (mm); Diameter (mm)	894; 316	1,264; 316	2,528; 316
Aspect ratio (L/D)	2.83	4.0	8.0
Composite weight savings	15 %	16.7 %	18.8 %

Furthermore, due to the material savings, the **CO_2 footprint can be reduced significantly**. Assuming a medium-sized tank for commercial vehicles featuring a carbon fiber weight of 75 kg per vessel (like presented in a former Cevotec case study) and a yearly production of 10,000 tanks, the reinforcements enable material savings of approximately 113 tons each year.

Our Offer — **You want to learn more & maximize the savings on your composite H_2 tank? Contact us for a personal consultation with our experts!**

FPP technology & equipment
advantages@cevotec.com

Winding equipment & integration
info@roth-composite-machinery.com

Laminate design & simulation
info@cikoni.com