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GreenPower RTD 2010

High pressure gas storage vessel based on carbon fiber braided architectures for hydrogen fuel cell vehicle application.

Paul Velut[1], Robert Tween[1], Blaise Fridérici[1], Yves Leterrier[1], Jan-Anders Månson[1], Rexhep Gashi[2], Bahaa Roustom[2],

(1) Laboratoire de Technologie des Composites et Polymères, EPFL, CH-1015 Lausanne
(2) Belenos Clean Power Holding Ltd, C/o EM Microelectronic-Marin, Rue des sors 3, 2074 Marin-Epagnier

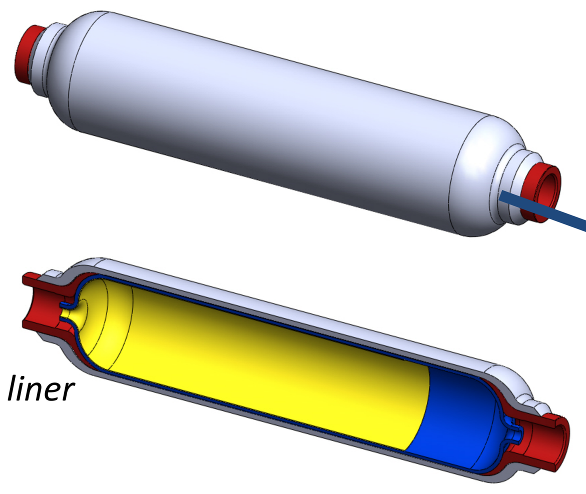
BELENOS Clean Power Holding Ltd
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

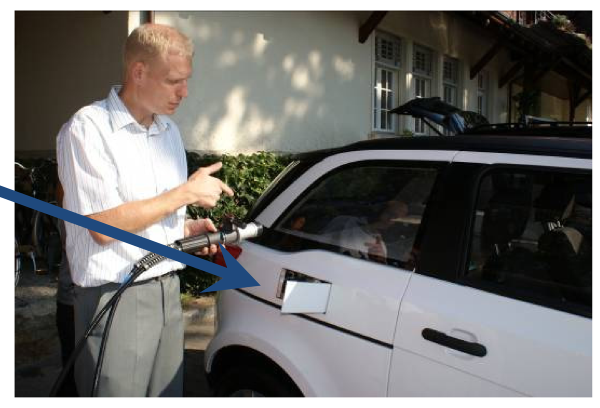
Objectives and Challenges

Development of a **high pressure storage** vessel based on Carbon Fiber Reinforced Plastic with self-sensing liner for lightweight vehicles.

- First demonstrator : 1L – 100 bars
- Final demonstrator : 100L – 700 bars
  → 700km autonomy

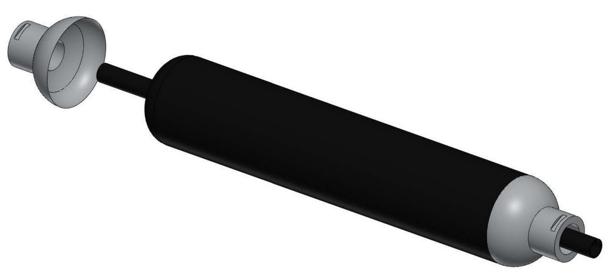
Evaluation of novel carbon fibre architecture with geometry dependant fibre volume fraction and orientation as an alternative to metal for high pressure storage vessel (submitted to hydrogen embrittlement).





Carbon Vessel Demonstrator Manufacturing

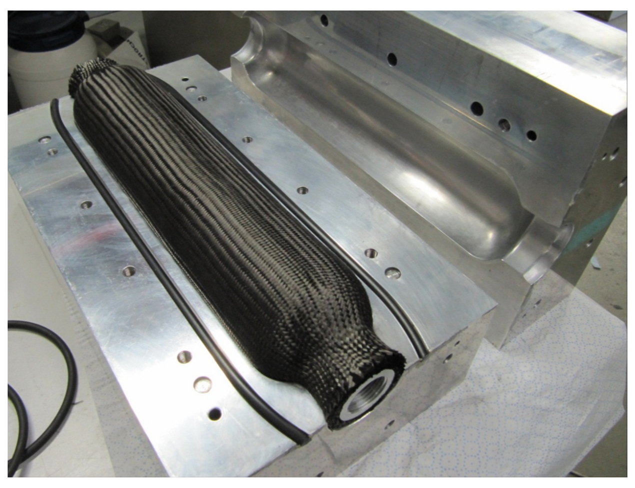
Braid lay up



PA liner and aluminum connectors

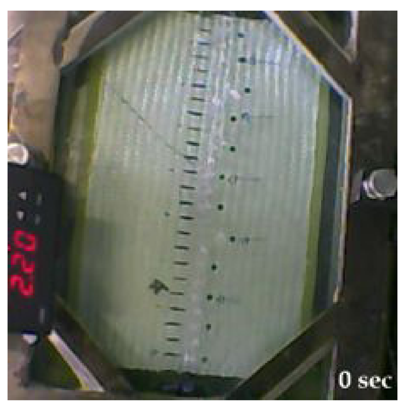
Carbon braid

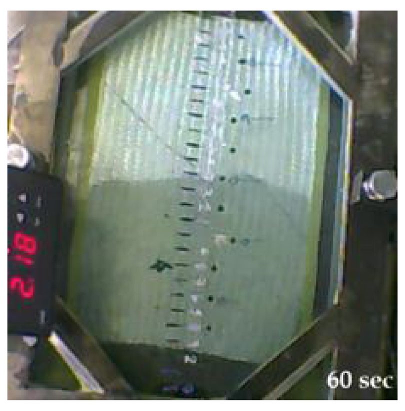
Carbon braid lamination over the PA liner

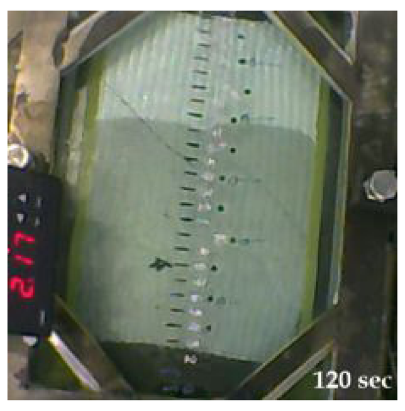


Resin Transfer Molding : Fabric impregnation with epoxy resin

RTM process







The impregnation of the fabric by the resin is driven by DARCY'S LAW.

$$v_0 = -\frac{K}{\eta}\nabla P$$

The **Permeability** is linked to the fabric type and architecture. As well as to the **Volume fraction.**
Pressure in the mold can be adjusted.

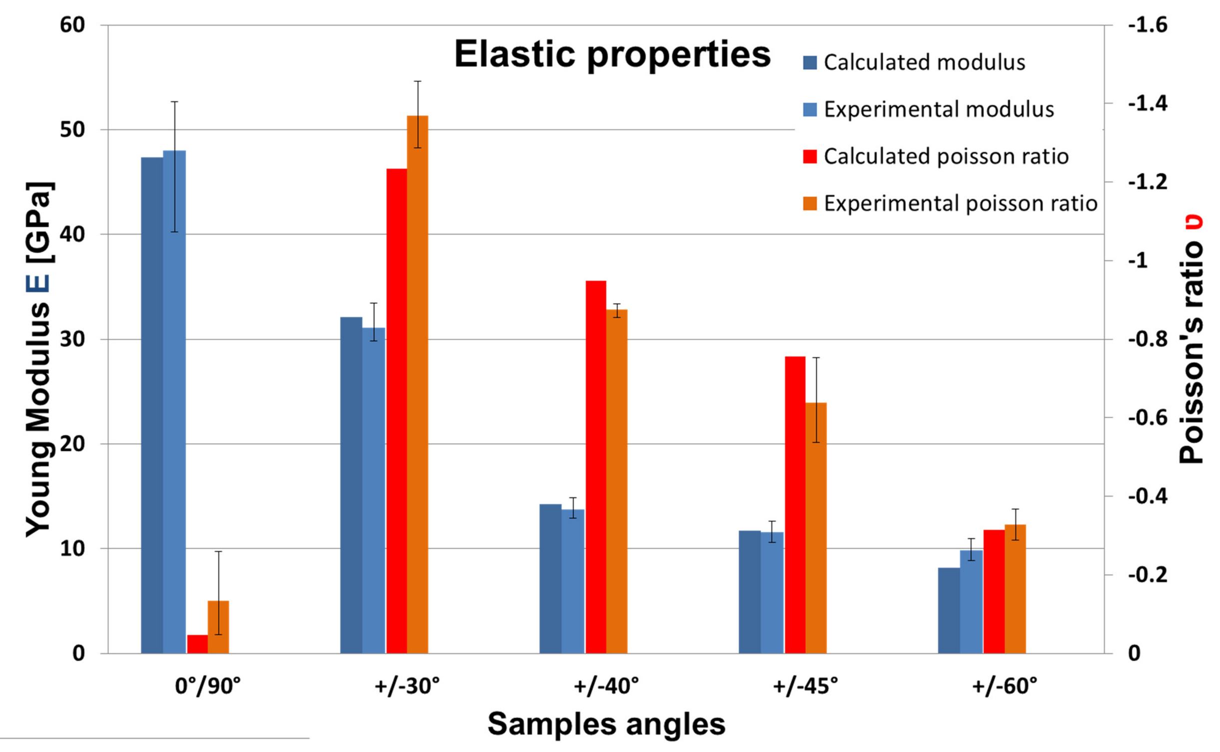
The **Viscosity** is a resin property driven by temperature. Curing time of the resin is also shortened as the mold is heated.

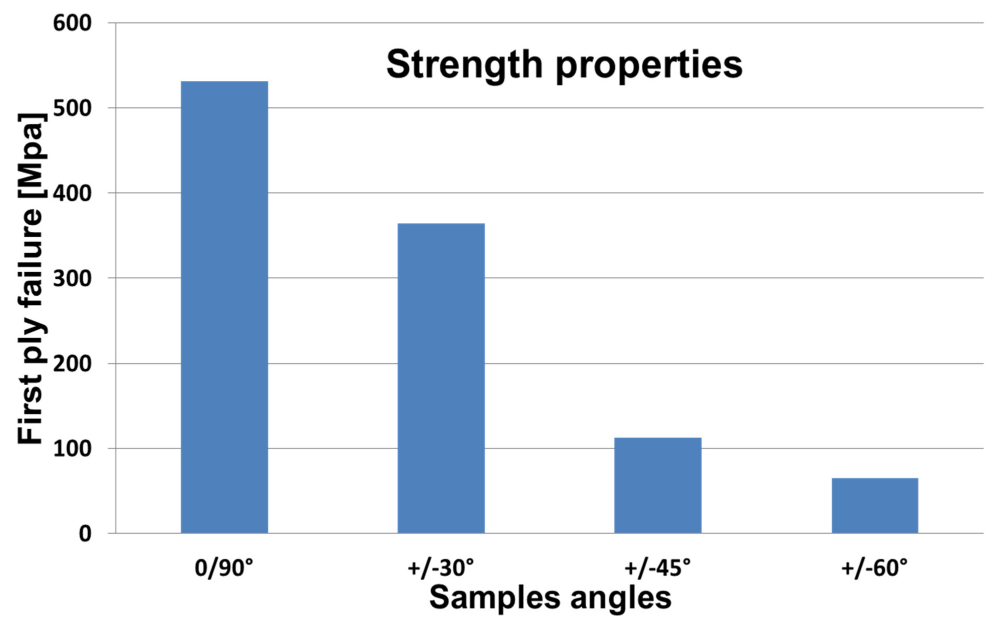
- RTM rate of production is higher than concurrent method.
- Composite material of high quality is achieved :
- Low porosity content
- High Fibre Volume fraction (55%)

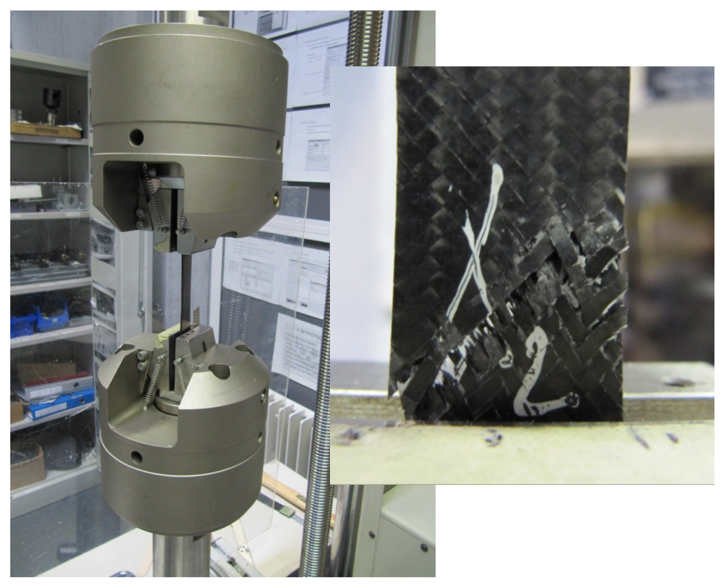
Material properties

Mechanical analysis

Elastic and breaking behavior were determined both by testing and calculation for several braid configurations.
These results are then injected in the numerical model .



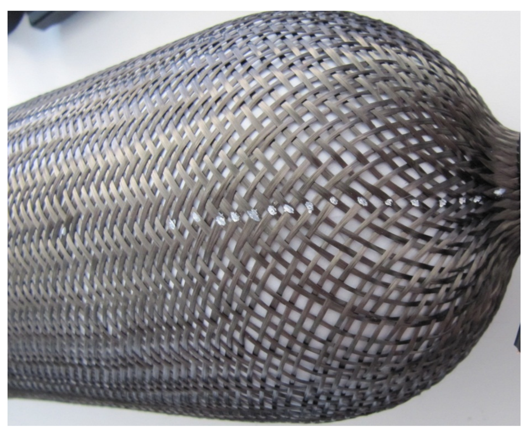




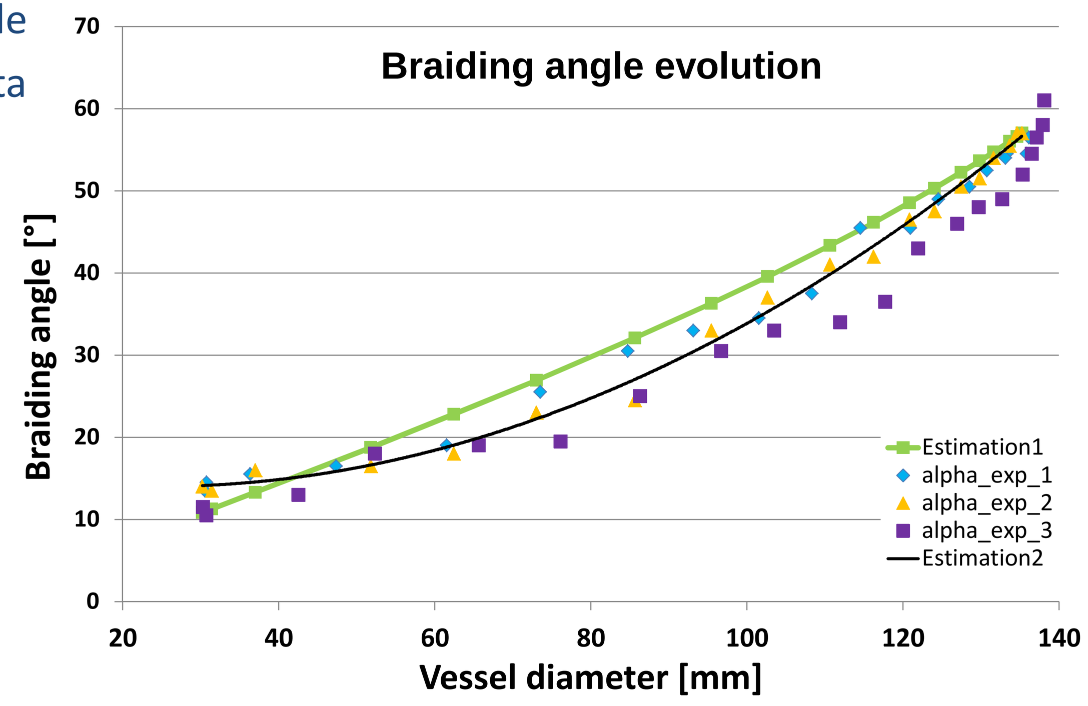
Tensile test for elastic and strength measurement [ASTM-D3039]

Braid angle

The braid angle is strongly dependent of the geometry.
Abacus were obtained from angle measurement along the vessel and the data injected in the numerical model.



Carbon braid laminated over vessel shape

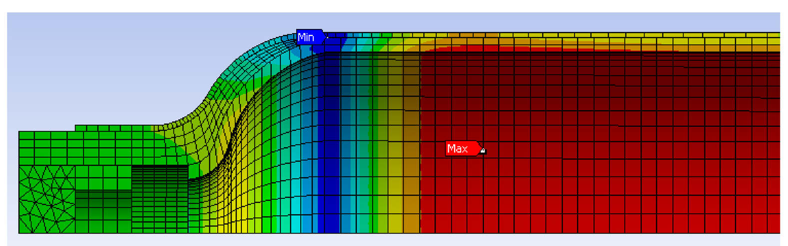


Numerical simulation

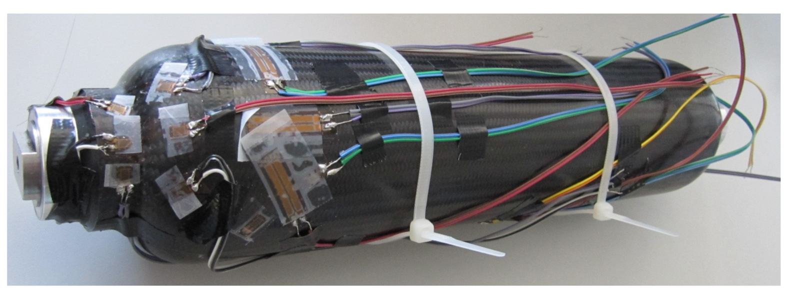
Mechanical properties, fibers angles and volume fractions are injected in a numerical model. ACP, the composite module for ANSYS was used.

Demonstrator simulation

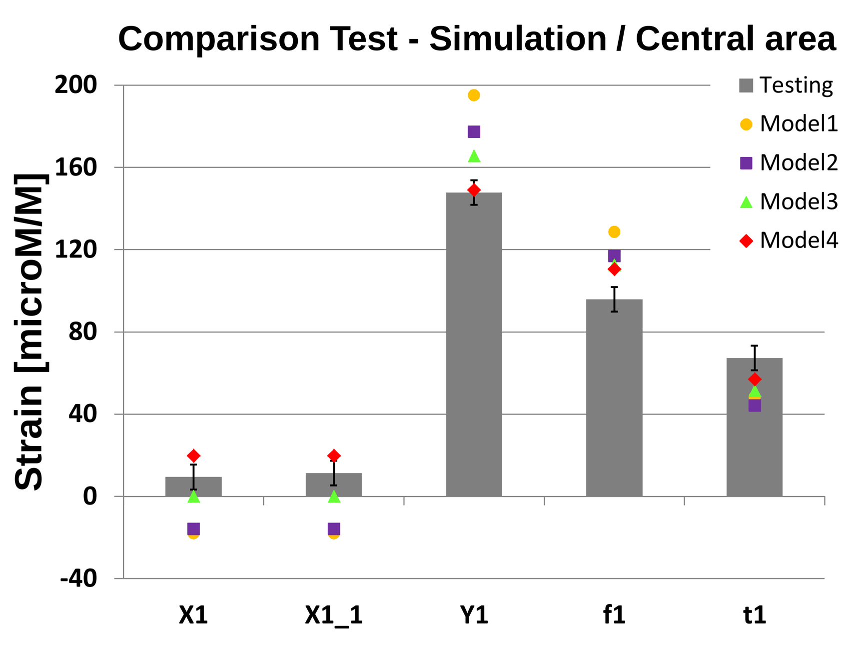
Result comparison between the model and the demonstrator



Stress distribution in demonstrator at 100 bars

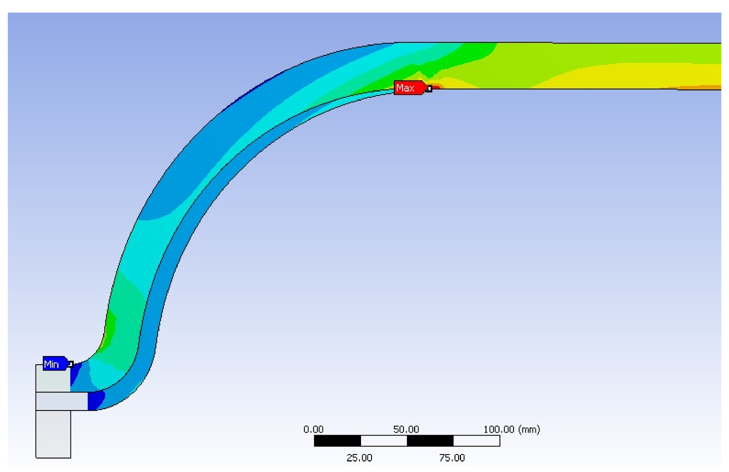


Demonstrator vessel instrumented with strain gauges



Correlation test/simulation at 8 bars

Belenos full size demonstrator



Research of an optimal shape for the final demonstrator with an axisymmetric model.

Conclusions & Future work

- **Manufacturing process with braid architecture was demonstrated.**
- **A method was implemented to simulate the braid including variable Vf and orientation**
- **An optimal braid will be designed and produced by a braider.**
- **Cost modelling will be performed for evaluation with existing solutions.**
- **Self sensing liner will be integrated.**

Acknowledgements
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