From steel to composite: cost and weight reductions using filament winding for wave energy converters

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Motivation

Ocean energy has a large potential to contribute to the transition to a zero-carbon society and bring stability to the clean energy mix.

Wave energy in particular can complement wind and solar power with a reliable base load to reduce the required storage capacity.

Development of a pre-tension cylinder in composite material aiming for a weight and cost reduction that fulfills the performance requirements of the wave energy converter, such as pressure cycles and wear distribution.

Challenges

Pre-tension cylinder (PTC)

- A pressure vessel that applies a force along the mooring line to the seabed
- High internal pressure (up to 300 bar)
- Maximum linear velocity, of piston inside PTC, as high as 4.5 m/s
- Smooth and wear resistant internal surface against which a piston can operate for several million cycles
- Estimated subsystem mass reduction of 25%

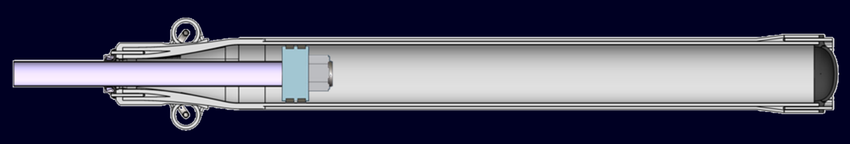
COMPACT

Liner

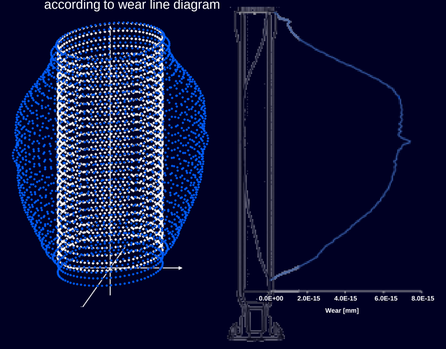
Material selection in this component's development is critical and very important due to highly aggressive wear distribution: there is constant contact between the piston seals and guide rings and is heavily dependent on contact pressure.

Specifications:

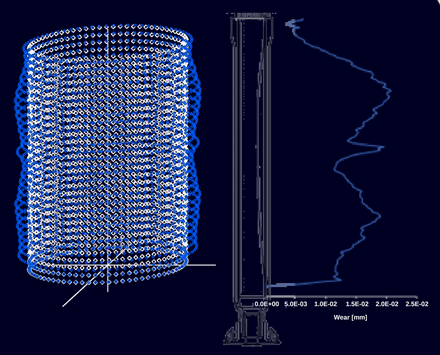
- Avg. sliding speed = 1.15 m/s (max. 4.5 m/s)
- Maximum design media temperature = 100 ºC
- Diameter expansion at test pressure < 6 mm
- Lifetime > 20 years



Scheme of wear distribution scaled according to wear line diagram



Liner material	Steel
Seal/guide ring material	PET



Liner material	HDPE
Seal/guide ring material	Steel

Figure 3. Wear distribution over stroke (*specific material grades)

Filament winding

Manufacturing challenges: achieve fibre angles along cylinder's centreline axis as low as possible.

- Current fibre angle is around 15º due to "cylinder's" shape
- Dimensions:

Nominal internal diameter	850	mm
Minimum internal diameter	440	mm
Length	9800	mm

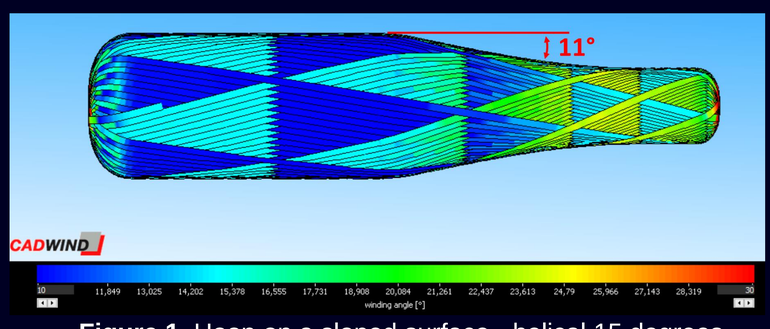


Figure 1. Hoop on a sloped surface - helical 15 degrees

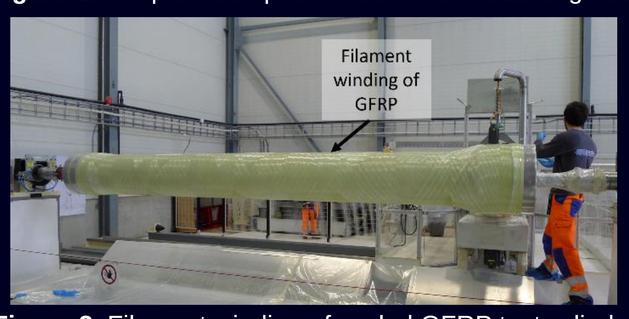


Figure 2. Filament winding of scaled GFRP test cylinder

Bolt connection

Test and simulation driven development of composite embedded steel bolt interface.

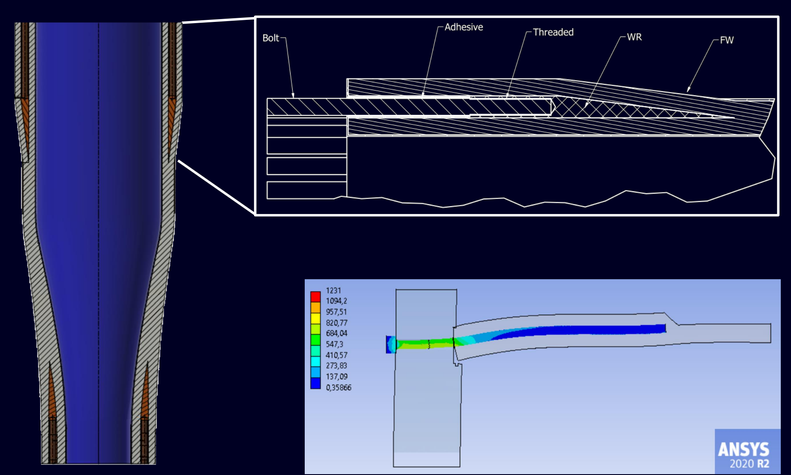


Figure 4. PTC section

Figure 5. Barrel endcap joint Equivalent Stress (MPa)

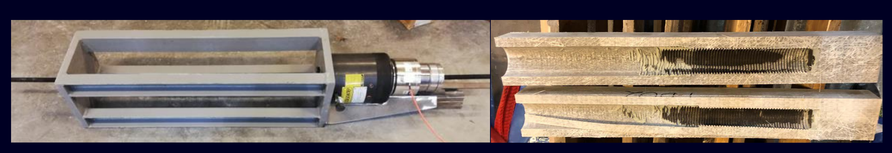


Figure 6. Bolt pull-out testing jig (Preliminary tests)

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