wind

New glass for meeting new challenges

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Larger blades require advancing material science, smart engineering, and partners to deliver cost-effective, sustainable solutions rather than taking shortcuts that could mean higher costs, emissions, and complexity.

From pushing sailing ships across the oceans to equalizing the atmosphere, humanity has found that the wind is crucial to life moving forward on Earth. Change and progress seem to always be connected with its power. Nevertheless, there is one thing that the wind can help us settle: global warming – and this decade is critical for action.

Lighter, longer blades; beyond a challenge, a calling

While there is a huge community of scientists imagining and designing solutions toward a world where global warming is limited to 1.5°C pre-industrial levels, we know that a big part of the answer lays in how we produce and use energy [1].

Because of its potential, wind energy is growing at a fast pace. However, it is said that we need to be installing 390 GW of new wind energy capacity every year to reach carbon neutrality within the next decades – 3 to 4 times more than current forecasts [1]. Yes, we must solve this problem, and that's why we are here: to work together to create novel solutions through material science.

Short answer to a big challenge: $A = \pi r^2$

When the first large-scale, commercial wind farms began operation, turbines were rated at 1MW or less and had wind blades that ranged from 10 to 15 metres in length [2]. Since then, the one thing that OEMs have done for years is to increase the diameter of wind turbines.

Simply put, ($A = \pi r^2$): the larger the radius (r), the more energy is generated (it follows the square area of the rotor). Sounds like something simple, but larger turbines mean longer wind blades, and here lies one of the biggest challenges blade designers face periodically: if they merely use the same materials to bring a longer wind blade to life, more length will consequently mean more weight, which is unacceptable as being lightweight is key for the turbine efficiency.

In the last years, this challenge led to the search for different higher-performance materials, such as carbon fibre. While it is an answer to the performance + lightweight equation, carbon fibre brings its own challenges as it is more expensive, has a more limited supply chain, and has a far higher carbon footprint: ~19–43 kg CO_2e per kg of product, compared with ~2–5 kg CO_2e (glass) [3]. All right, so if existing high-performance materials cannot entirely tackle this challenge, then what will?

Smart engineering

Back in the 2000s, when the diameter of rotors was around 80 metres, and blades longer than 60 metres were a distant dream, Owens Corning reimagined its high-modulus glass (H-glass) formulation and fabric design in collaboration with blade designers. That has enabled a leap in the glass modulus performance (82 GPa to 87-89 GPa), and after that, we started seeing rotors with a diameter of more than 200 metres, and wind blades that were longer, lighter, and cost-competitive [4].

Fig. 1: According to GWEC 2022 Wind Report and Owens Corning estimates

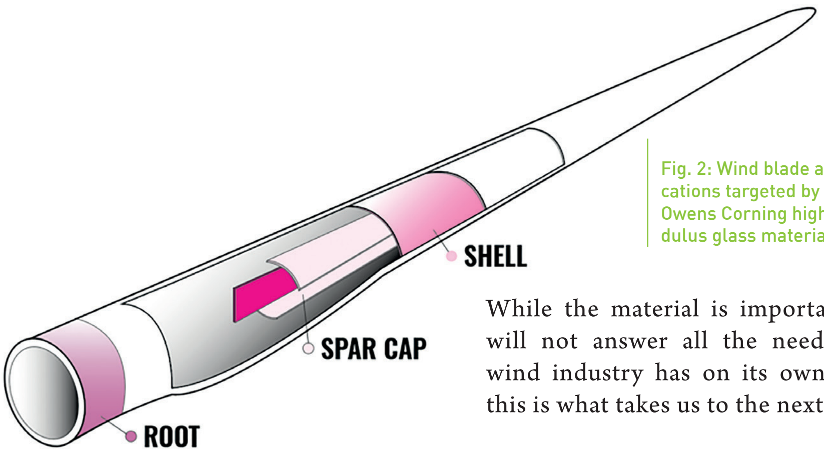

Fig. 2: Wind blade applications targeted by the Owens Corning high-modulus glass materials

If, at the turn of the millennium, it was known glass fibre could play a pivotal role in enabling more cost-effective high-performance wind blades, this still holds true today and is what will keep the balance between length, lightweight and cost effectiveness. This is how it can be done.

Three steps to increase wind blade lengths, more cost-effectively

- Innovation is thriving in the glass fibre industry, meaning that there is space left for next-generation high-modulus glass materials tailored for wind blades. In 2021, the Owens Corning Wind team finished the design of H^2 glass (currently in mass production in China), with a modulus of 91 GPa. Now, the same team has also completed the design of H^3 glass, another leap that reached a 95 GPa modulus performance. Both materials have been verified by the most reliable, accurate testing protocols of sonic modulus, and have an industry-leading stable-specific modulus that enables reliable blade design for roots, shells, and especially spar caps.

While the material is important, it will not answer all the needs the wind industry has on its own, and this is what takes us to the next step.

- While glass fabrics play a role in adding performance to different wind blade parts, when it comes to spar caps, a structural element of wind blades, there is a need for new product form factors that can deliver the performance it requires. This is where the fabric machines come out and give space to pultrusion lines: one of the most stable, repeatable, and cost-competitive manufacturing processes for composites. The use of pultruded planks in the production of spar caps help not only to enable longer blade designs due to a higher fibre volume fraction in comparison to fabrics, but also supports a more efficient and reliable construction, since there is no need to deal with glass or carbon fabric layers and wrinkles when assembling the spar cap. This leads to productivity gains at blade production sites as a more standardized plank can be placed into blade moulds in a more streamlined process than used previously. Chinese OEMs and blade makers have embraced what higher-performing glass can bring to spar caps. By basing designs primarily on glass pultruded planks for spar caps like the ULTRASPAR™ pultruded planks, designed and made by Owens Corning, featured at JEC World 2022 – the industry has been able to cost-effectively scale up to the higher demands of the Chinese wind market.

- Finally, the last and most important part is what really makes it all possible: partnership. Numbers can tell an amazing story alone, but if we come together to make them a reality, then we make history. Blade designs substantially evolved, but there was also a jump in the materials used to assemble them, and we don't believe our needs are completely addressed – high cost, limited supply chain, and poor on emissions. Now, there is an opportunity to make blades for the world that can scale to meet the challenges we have.
Beyond a challenge, it is a calling that has to be answered because, as the world and climate continue to change, we must too. □

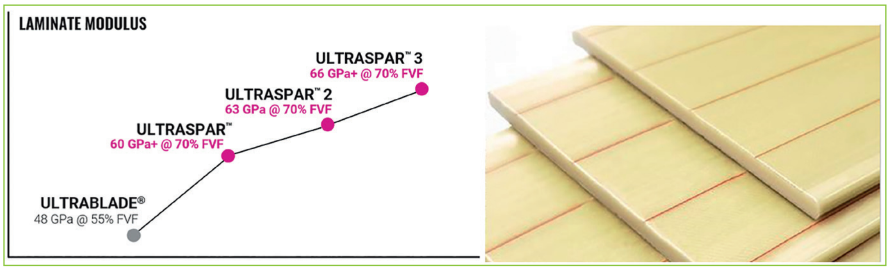

Fig. 3: From H-glass fabric to H^3 glass pultruded planks for spar caps [5]

More information:
www.owenscorning.com/wind

References

[1] Source: GWEC Market Intelligence; Global Wind Report 2022.
[2] Source: Renewable Energy world – history of Wind Turbines (accessed in 2022).
[3] Carbon fibre climate impact estimates dependent on the PAN source and fuel sources of oxidation and carbonization processes.
[4] Compared with carbon fibre.
[5] Based on ULTRASPAR™ 3 performance. The plank performance can be optimized and vary depending on pultrusion design, glass fibre input, glass sizing, resin system, and processing conditions.