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FEATURE

Carbon transforms wind farm access

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A new form of marine craft, one minute a veritable greyhound of the seas and the next a steady platform for embarking from, has arisen over the last few years for serving offshore wind farms. Advanced low-weight composites are key enabler for these wind farm service vessels (WFSVs).

Among the most advanced are carbon composite vessels developed and produced by Danish Yachts A/S, which have been established in North Sea service since 2013. This company's radical SWATH (Small Waterplane Twin-Hull) design and carbon/epoxy sandwich structure have earned high praise from users, but the four craft initially produced are regarded as first-generation and recently their design has been refined in a joint programme carried out by Danish Yachts and composite engineering specialist Gurit AG. Fabrication of the resulting second-generation craft has since commenced at the constructor's shipyard in Skagen, Denmark, and a fifth vessel (i.e. the first of the second generation) was delivered to operator Odfjell Wind last summer (2014).

As Danish Yachts digested feedback from in-service experience with the first four 25m Cat/SWATH craft ('Cat' because they can also be operated as catamarans, see side bar), which have relied on their light carbon/epoxy structures to enhance performance and running economy at sea, it engaged Gurit to take a fresh look at the structural design to see if it could be lightened further. Thanks to this re-optimisation, a further 15% weight saving has been achieved for the fifth and subsequent craft. As David Olsen, a Gurit structural engineer, explains,

''By developing a more optimal structural arrangement, we succeeded in safely reducing the skin and core thickness of many panels. A finite element model of the structure enabled us to identify crucial primary load paths and place appropriate support structure there, while identifying less critical elements that could be made thinner or, in some cases, eliminated altogether.''

Also involved was a re-styling of the wheelhouse, both to reduce its weight – thereby lowering the vessel's centre of gravity and rolling moment – and to enhance all-round vision from the bridge.

Wave action nullified

A SWATH minimises the disturbing effects of wave action by placing the vessel's buoyancy, i.e. its hulls, below the sea surface and therefore beyond the reach of wave-induced surface agitation. The twin hulls are connected via sidewall struts to a deck/superstructure that is held above the sea surface clear of the waves. Thus, both the superstructure and the hulls ride clear of the waves, respectively above and below the sea surface. Because waves act mainly upon the cross-section of any vessel that is in the same plane as the sea surface, and because this waterplane area is relatively small in a SWATH, viz. the cross-section area of the narrow sidewalls, the effect of wave action is minimised in these vessels. Consequently a big advantage of SWATHs for wind farm work is their steadiness when on station and their consequent ability to safely transfer personnel and equipment to and from turbines in higher sea states than conventional vessels can manage. (Up to 2.5 m significant wave height.)

A further advantage of the Danish Yachts SWATHs in particular is that they can also be operated in catamaran mode by de-ballasting the hulls so that their increased buoyancy brings them to the surface. In this configuration, the vessel can achieve the high transit speeds that conventional catamarans are known for, albeit with the relatively large waterplane area that is inherent in surface-tracking hulls. This dual mode ability enables the craft to reach wind farms at high service speeds travelling as a catamaran, then transition quickly to SWATH mode to provide a stable working platform from which to access turbines. On the Danish Yachts craft, hull buoyancy is adjusted with a compression operated active trim system.

SWATH mode can also smooth the ride in rough sea conditions so that personnel arrive on task ready for work rather than seasick and exhausted. Progress is slower than in catamaran mode (c 15 kts as against 22 kts, typically, for Danish Yachts' first-generation craft), but the speed reduction can be worthwhile in terms of delivering technicians in fit condition to work.

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Gurit had already supplied a full materials package for the hulls and superstructures of the earlier craft. Materials for the infused sandwich structures included Prime™ 20LV epoxy resin together with pre-cut, pre-kitted pieces of Gurit Corecell™ structural foam in a variety of formats. To minimise resin uptake around the cuts where the foam panels join, Gurit supplied knife double-cut Corecell M foam. Pre-kitting greatly assisted the process of building all the 2D elements of the structure as well as the more complex 3D sections of the vessel's submersible pontoon hulls, the latter requiring a particularly thick layer of the structural foam.

The primary hull materials were laid up in female moulds and vacuum-infused with resin in a single step that bonded, not only the skins to the core, but also the edges of the core panels together. A number of separate items were subsequently bonded to the infused shell using Gurit Spabond 340LV, while Ampreg 22 was chosen for secondary bonding and wet lamination.

Michael Nielsen, composite technical manager at Danish Yachts, told *RP* that each vessel's deck/superstructure is formed chiefly from flat panels laid up on vacuum tables, subsequently trimmed to shape and bonded together. Each hull, however, with its complex curvature, is infused in two female moulds, one for the lower portion of the hull and the second for the upper 'deck' portion. Emphasising the scrupulous care taken over the infusion process, he explained,

''It can take two to three weeks to prepare everything - the pumps, vacuum lines, sealing etc - and then the critical infusion step itself takes eight to ten hours. Initial cure takes place at around room temperature, typically 20 deg C, and this is followed by a post cure profile that takes the temperature up to 65 deg C and lasts another seven to ten hours. Heating is by convection, hot air being pumped into a large tented volume that contains the mould. Precise zonal control, with extensive thermocouple monitoring of temperatures, ensures that every part of the lay-up is fully infused and cured.''

Included in every hull lay-up is a fine outer glassfibre 'grinding layer'. This can be selectively ground and polished after the hull is demoulded so that a final protective paint coating can be applied directly. This avoids a requirement for a gel coat.

Satisfied with the working partnership enjoyed with Gurit over the first-generation craft, Danish Yachts' CEO Patrick Von Sydow once again appointed the composite engineering group to provide structural engineering services and a full materials package for a second-generation 32m Cat/SWATH intended for the oil and gas and other industries as well as wind farm service. All the vessels are designed to the International Maritime Organisation's High Speed Craft Code and comply with passenger carrying regulations under classification societies Det Norske Veritas for the original four craft and Germanischer Lloyd for the second generation. They are engineered for a 25 year service life.

Yachting roots

As its name suggests, Danish Yachts' experience with carbonfibre is rooted in the construction of high-end yachts, including superyachts. Although superyacht owners can afford to indulge themselves with the latest fashionable technologies almost irrespective of economics, Danish Yachts has found that they do appreciate the lower fuel and maintenance costs that durable, weight saving CFRP structures provide, as well as lower emissions from the smaller, less powerful engines that can be fitted – especially important where local environmental limits apply, such as in the EU's Emissions Control Areas (ECAs).

Commercial vessel operators have even greater need of these benefits and some have shown themselves willing to pay extra for the advantages that carbon composite construction confers. There is a limit to this, however, and it is interesting to note that Danish Yachts' adoption of the infusion process for its Cat/SWATHs, rather than the prepreg manufacturing technique with which it produces premium yachts, has been made largely because of the relative affordability of infusion.