

## Application of Composite Sandwich Panels in the Shipbuilding Industry

# Rationalized Manufacturing thanks to Standardised Design

Large-size GRP-sandwich panels allow the economic and high-quality production of ships which need only half of the fuel of traditional models. This example of the construction of catamaran describes impressively the possibilities such standardised panels open up.

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The application of lightweight construction technologies opens a huge energy-saving potential in the production of fast ships. Today's constructions are practicable with the considerable fuel savings that can be achieved. The Baltec shipyard in Lübeck produces high-strength sandwich ships by innovative lightweight construction. By comparison to conventionally made models with the same water lines length they are half the weight and also see as much as 50 % reduction in fuel usage (Picture 1).

### THE SHIPS

Baltec shipyard in Lübeck builds light weight composite vessels for different purposes, but has specialised particularly in the construction of fuel-efficient catamarans for professional use. The newly developed "Ocean Runner" design is tuned and specifically tailored to meet requirements, which come from the lightweight construction. The design of the ships also reflects optimised forms which are necessary to be able to build in panel construction method. To do justice to the final intended purpose, layout and specific requirements for the ship must be worked out in detailed collaboration with the customer and be integrated into the design. The potential saving

in comparison to other new custom built ships is shown on a pilot's catamaran (picture 2) which is under development. The P240: With 2 x 368 kW the consumption of fuel at 20 knots service speed is only about 6 litres/nm (sea mile). In the individual cases the fuel economy can cover the leasing rate of the ship.

### THE TECHNOLOGY

The production of the large-size GRP (fibreglass-reinforced plastic)-sandwich panels occurs in 12 x 2.4-metre-heatable vacuum press (picture 3). The core and deck layer materials can be assembled according to the intended purpose of the panel (picture 4). The deck laminates are made of pre-cast, pre-impregnated laminates (Epoxy-Prepreg) which can be pre-defined depending on the required structural properties, fibre specification and direction. This guarantees consistent structural properties producing quality, standardised panels. To ensure the panel's unlimited use during the building process, they are sanded on both sides after the post cure process. This ensures that there are no defects within the epoxy surface of the panels.

For the construction of ships, the big sandwich panels are cut precisely to size according to CAD drawings of the outside skin of the

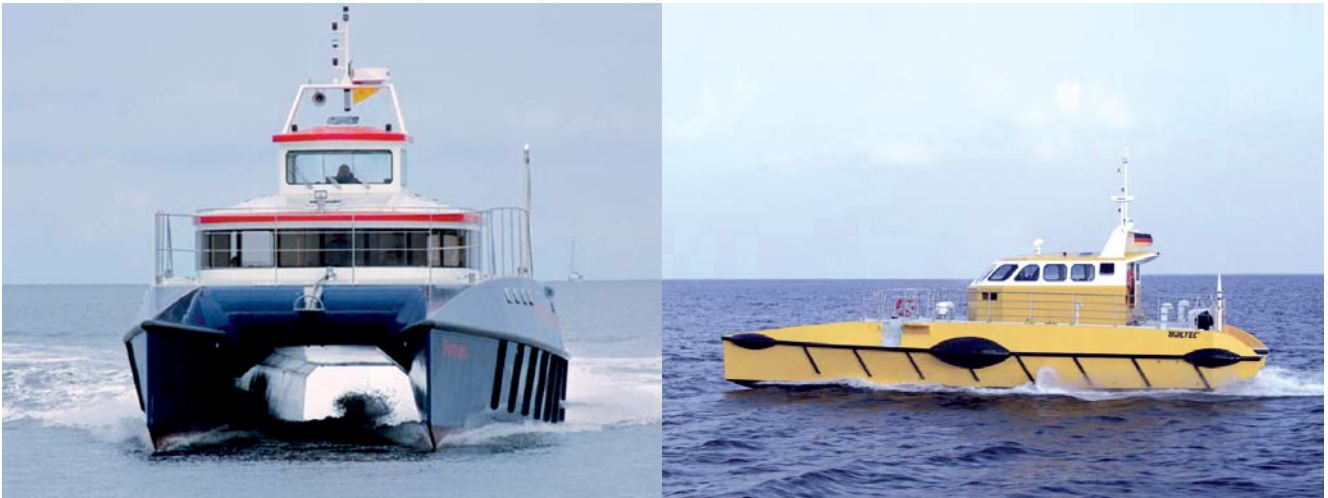


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»In comparison to models made conventionally today, the modern GRP ships use only half the fuel. «

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**FIGURE 1** Thanks to logical lightweight construction Baltec have succeeded in producing ships which use half the fuel of a contemporary model of the same water line length. Above on the left: A200 Workboat with a consumption of 5 litres per sea mile with 20 knots service speed, on the right: P200 pilot boat with a consumption of 5 litres per sea mile with 20 knots service speed

respective ship, its frames and other individual parts. Due to the method of construction used spherical and formed surfaces are only available over long sections. Panel manufacturing and cutting is carried out in different workshop areas and can be prepared as separate working processes, this optimises time and man hours. In the manufacturing hall the pre-cut components are arranged and positioned ready for assembly. Ships are constructed in the same way as shipbuilding is commonly carried out- from "inside out" (picture 5). Yachts and moulded vessels start with the out skin and then construct the internals. Epoxy resin and Hardener is mixed in exact ratios by machine and delivered to the joints by hose delivery to join the panels with fillet joints that do not require finishing by hand. The nozzle delivers the correct mixture of resin and hardener under pressure to the joints creating a uniform structural fillet joint to join panels together.

Building the vessel in this manner reduces the amount of liquid resins and hand laminates within the construction process. The pre-formed panels are already cured thus reducing the exposure of employees to touching the resins or breathing in the gasses hand lay up causes. Reducing hand contact to resins helps in the reduction of sensitisation to the resins and stops skin irritation. Hand lay up is only used where additional strengthening is required, mainly on the outer skin of the vessel too increase stiffness and rigidity. Composing the ships occurs in a clean sphere with only little amounts of liquid resins and hand laminates. Thus thanks to the dry panel construction method none of the boat builders is exposed to much to liquid resins and their gases, the contact of resin to skin as well as working clothes is minimised and the accident and allergy risk is strongly reduced. The use of liquid resins by hand is limited to strengthening laminates, for example, in the outer hull area or in constructive stiffening.

**FIGURE 2** By modern lightweight construction draughts developed pilot's catamaran



**Saving potential, covered to 20 years of service:**

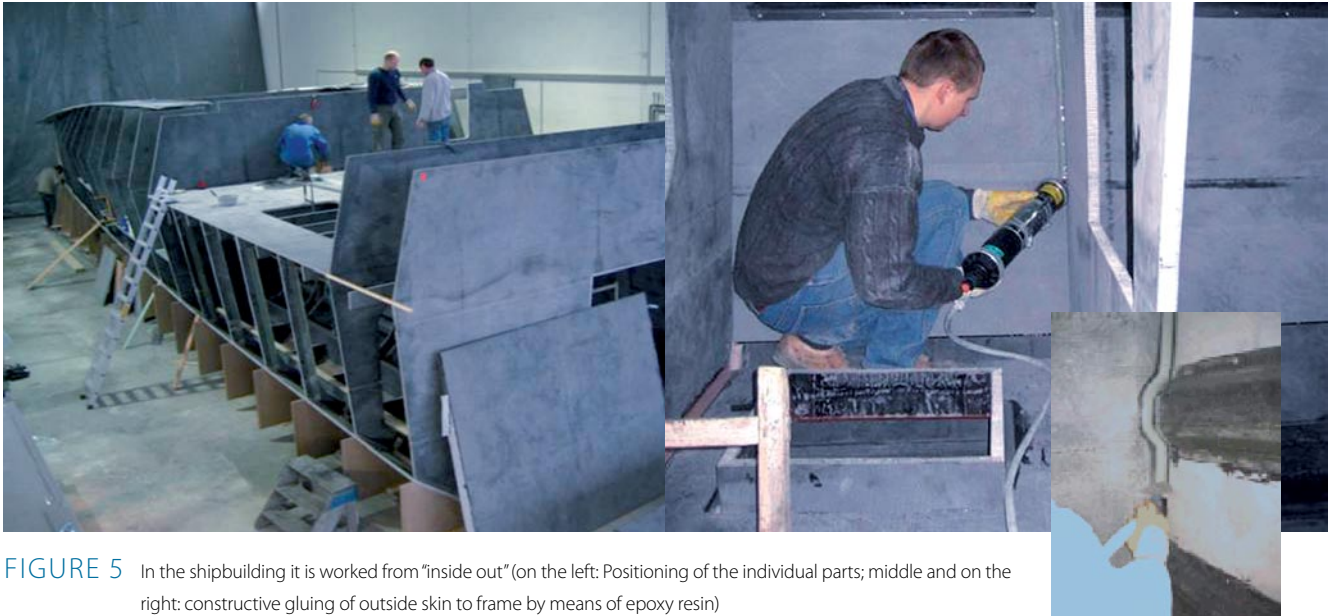
- app. 5.500 tons less CO<sub>2</sub> emission
- app. 2.000.000 litre less fuel
- min. 2.000.000 € less operating costs

**FIGURE 3** The production of large-size GRP (fibreglass-reinforced plastic) sandwich panels occurs in a 12 x 2.4-metre heatable vacuum press.



**FIGURE 4** core materials and deck laminate materials can be manufactured according to the requirements of the panel and its intended use.

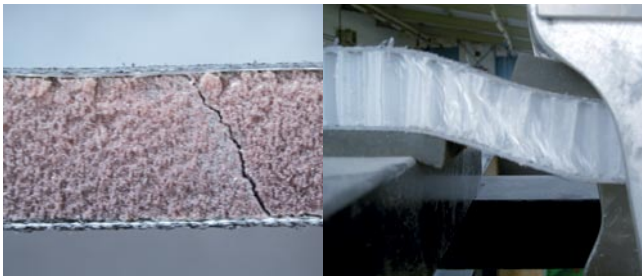




**FIGURE 5** In the shipbuilding it is worked from "inside out" (on the left: Positioning of the individual parts; middle and on the right: constructive gluing of outside skin to frame by means of epoxy resin)

### THE QUALITY ASSURANCE

Das The most frequent failure of the GRP core panel is – as in the picture 6 shown – core failure due to shear stresses



**FIGURE 6** Typical failure due to area compression demand (on the left: Foam sandwich PVC; on the right: Polypropylene-honeycomb core sandwich).

To determine the safety factor between the ship's hull (outer body skin) when it is hitting the waves and the shear strength of the hulls panel, suitable values were measured in a water pressure frame and saved by computer. In addition, a pressure sensor in the keel of the ships body determined maximum water stresses during a test run. On evaluating the results we proved that for the P200 pilot's catamaran more than 20-fold safety margin was obtained for the construction material GRP-foam sandwich panel – a result which still lies 4-fold above the required build values of the classification of craft.

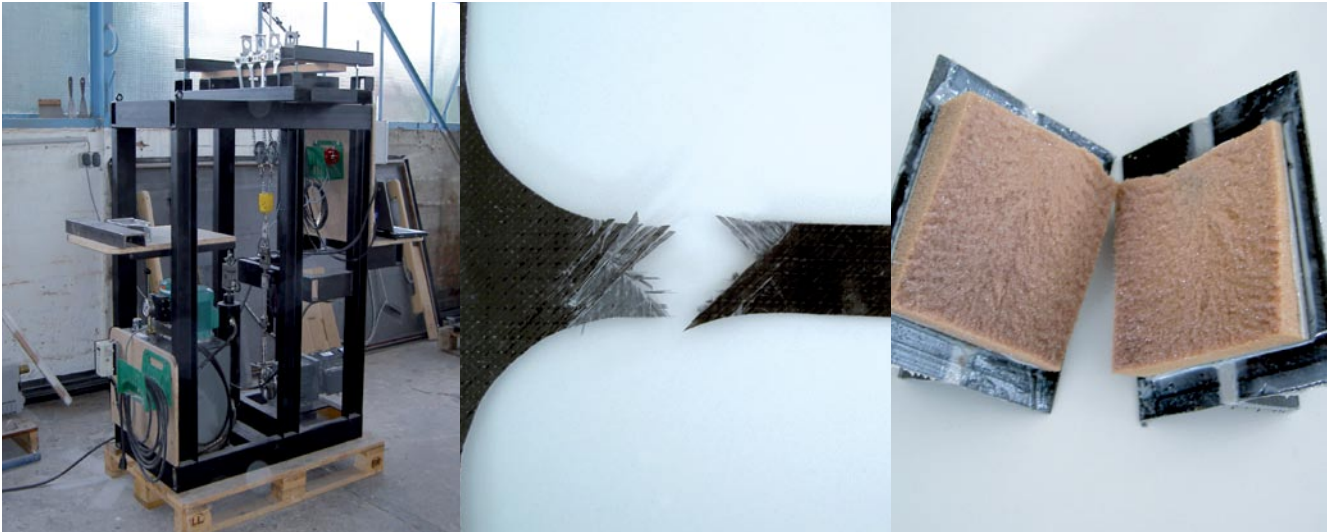
To be able to analyze the behaviour of the GRP and to record its behaviour in everyday long-term applications over the demands

of a 20 years service period, GRP sandwich strips were put out in to a test bed and 10 million dynamic load changes were exerted over a 2-month period. At the end of the test cycle (equivalent to 20 years service) no fatigue symptoms were visible on the external deck laminates, nor in the core material. Also no remaining distortion was recognizable; the material still retained its original shape. A final comparison bending test was also carried out at the end showing only about 10 % less strength, which given the fact the material was 4 times stronger than originally required is insignificant in the scale of longevity of the products life.

Beside usual 3-and 4 point-bending tests the companies universal test machine is used to check strengths of laminates, gluing of deck laminate to core material, effect of point loads etc.

### GRP-MODULE CONSTRUCTION

The application possibilities of sandwich panels are not limited exclusively to the ship hull construction. The panel construction method offers opportunities to make, single modules, whole cabins, superstructures, deck furniture or even stairs separately or to integrate them into the construction (picture 8). On this occasion, especially the water resistant, weatherproof qualities, as well as the stability of the panel at different temperatures makes the GRP panels an ideal choice of material. The use of sandwich elements is already being used in big luxury liners to reduce weights at the higher deck levels. The panels can also be veneered, melamine coated or painted depending on what is required for the application.. This makes the GRP-sandwich panel to a multi-functional and robust material. The same technique can be applied to moulded parts which can also easily be integrated into the construction.



**FIGURE 7** To be able to give statements for the life span of the GRP panels, sandwich stripes were submitted to fatigue testing attempts and afterwards were checked (on the left: universal test machine; middle: Result of a tensile test vertically to the deck laminate; on the right: Result of a tensile test of the laminates).

**FIGURE 8** Sandwich panels are suited not only for the hull construction, but are recommended in particular to make single modules, whole cabins, superstructures, deck furniture and even stairs separately and to integrate into the construction (on the left: Module construction of the hulls and the cabin of the P200 of pilot's catamaran; middle: Stairway steps and deck projection; on the right: Inside elements from GRP-sandwich panels in a houseboat).



#### CONCLUDING REMARK

The use of panel materials – for example particle boards, but also lightweight construction panels with paper honeycombs cores and decks from medium density fibre board (MDF) – today is not just limited to the furniture industry any more. GRP Core material is a suitable building material with various procedure technologies which are being developed and which can be adapted, By changing the processing of the GRP-sandwich panel and to suit the applications. The modular GRP-construction industry is a growing with new application coming from wide and varied industries.

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