CASE STUDY

LIGHTWEIGHT CONSTRUCTION IS KEY TO THE OCEAN EAGLE 43'S RAPID ACCELERATION AND LONG-RANGE FUEL EFFICIENCY

Commissioned by the Mozambique Government, the Ocean Eagle 43 is an innovation in maritime surveillance. The 3 trimaran vessels will conduct multiple missions throughout the Indian Ocean including anti-piracy operations and the safeguarding of fisheries, oil, gas and other maritime resources.

Sicomin played an integral part in this challenging project and supplied a range of advanced resin systems during the build programme that was secured by renowned French shipbuilder, CMN. The trimaran shells were produced at Chantier Naval H2X's facility in La Ciotat, France. All parties worked closely to achieve a truly outstanding result and the project has now received the accolade of the largest ever infusion of an epoxy hull in a single shot.

The Trimaran Design

In order to undertake its patrol duties effectively, The Ocean Eagle 43 must be able to cruise for many hours and then accelerate quickly and pursue. Legendary naval architect Nigel Irens was enlisted to produce a sleek and fast design. "It's taken many years for the world to warm up to this design for an efficient surveillance vessel," notes Irens, "but it is a perfect application for a trimaran." The long, slender main hull and diminutive outer hulls (called amas) provide exceptional stability, yet are lightweight and experience a reduced amount of drag than other hull forms of comparable displacement, including twin hulled catamarans.

The laminate design mainly consists of a glass fibre and epoxy sandwich construction - a well proven composite structure according to Pierre Lallemand, Head of Composites at H2X. "Everything is cored

and infused, except for the monolithic areas near the bottom of the hull at the front of the boat. Carbon fibre was used in the high load areas such as the stringer caps and the arms that connect the amas to the main hull."

The challenge of Dark Hulls

Destined for naval duty, the Ocean Eagle 43's hulls must be painted grey to reduce visibility on the horizon but unfortunately this means the hulls will also absorb significant heat from sunlight. This made the glass transition temperature (Tg) of the resin a key concern for H2X. To achieve a sound solution to this potential problem, they drew on their 20 year relationship with Sicomin to identify an appropriate matrix.

Sicomin has extensive experience with other multiple dark coloured, epoxy infused boat projects. Marc Denjean, Sicomin's Export Manager comments, "The original Tg specified for the Ocean Eagle 43 was 120°C to140°C, a carry-over from the initial design that called for prepreg. However that would of doubled the cost of the resin and also increased the cost of tooling and post-cure requirements."

Fortunately, the H2X design and build teams converted to a more economical resin infusion process and this allowed Sicomin to specify a system with a lower Tg of 90°C.

"Infusion epoxies with a Tg of 80°C are available but in our experience this is too low for dark hulls, risking not only print-through but a loss of mechanical properties over time that could result in laminate or structural failure", states Denjean.

To support this evidence, Sicomin gathered scanning calorimetry (DSC) and dynamic mechanical analysis (DMA) test data.

With time, the Tg will decrease a little (as the laminate is exposed to high temperatures and humidity levels) and this is referred to as the 'wet Tg' – however, it must remain above 80°C. Sicomin requested H2X make small samples, for every batch of mixed resin, during the actual infusion which was then cured with the same history as the boat. These samples were subsequently tested using DSC and DMA to verify the Tg and ensure the mix ratio was respected. This process also provided complete traceability for the moulding process.

Preparing to Infuse

Remarkably, despite the main hull's size, H2X did not conduct any flow modelling of the structure. However, to ensure the infusion process was as efficient and successful as possible, Sicomin assisted with a series of infusion tests completed on a large glass table to ensure all the cored laminates would infuse completely without issue. "The glass table allowed us to see the outside skin wet out and how the resin moved as well as the flow speed. This is a vital part of the resin mixing and feed-line arrangements calculations", comments Denjean.

These laminate schedule tests provided invaluable results. With the designer and naval architect's approval, Sicomin and H2X subsequently made numerous changes to maximise the infusion process such as altering the laminate plan and switching the direction of the fibre to achieve the best flow and wet out possible.

Sicomin also developed 150mm and 300mm wide unidirectional tape for the infusion of the critical arm structures. Stitching was designed to leave open paths to encourage resin flow but was balanced to achieve sufficient fibre volume for the required mechanical parts. H2X used 10 layers of these tapes in the arms.

SR8100 specified for Large Scale Infusions

Sicomin recommended SR8100, a two-component epoxy system, for the Ocean Eagle's hull infusions.

This product has been specifically formulated for large scale resin infusion projects and offered H2X a robust and cost effective solution. The product delivers reduced viscosity at ambient temperatures and is compatible with a selection of hardeners making it versatile and easy to work with.

With Sicomin's support, H2X ran numerous tests to ensure they had the precise viscosity levels and gel times to ensure the SR8100 resin flowed through the reinforcements quickly without leaving dry spots. " You don't want a gel time so long that there is too much time between completion of wet out and beginning of gel", Pierre Lallemand of H2X remarks. "This wastes time and money and increases risk."

To achieve full mechanical properties, the epoxy infused structures also had to be post-cured. Based on the testing procedures previously conducted, a post-cure of 60°C was selected as the most effective.

Throughout these crucial trials, the French classification society, Bureau Veritas (BV) visited H2X on a weekly basis to inspect the construction quality of the laminates and the work being undertaken.

Infusing in One Shot

To keep construction time to a minimum, the hull, amas, arms and deck parts were laid and up and infused in parallel. This was a technical and logistical challenge but one that H2X and Sicomin were fully prepared for.

The main hull took 5 hours in total to infuse and a vacuum was maintained for a further 4 until gel was completed. This was followed by a 16 hour post-cure in a 43 m long oven at 60°C. The 11 metre amas were infused in two halves and then joined along the centreline. The additional large structures included the main deck, the 6m x 9m helicopter deck, the pilothouse and the 5m wide x 15m long arms that connect the amas.

Assembling the Lightweight Superstructure

Following the infusion and cure of the first boat, the assembly of the Ocean Eagle's 106 parts could commence. It took several weeks to build the structure inside the main hull; this included the stringers, bulk heads, floors and decks. Parts were joined by conventional wet lay up tabbing using glass reinforcements supplied by Sicomin and their SR8500 hand laminating resin. Sicomin's Isobond SR1170 was used for enhanced bonding strength in high stress areas.

The first fully assembled boat took 3 months in total to complete and Sicomin and H2X's overall attention to process control and material selection paid dividends. "The weights of the first and second boats' main hulls differed by less than 5kg – impressive for such a large structure," comments Lallemand of H2X.

CMN is so pleased with the design concept of the Ocean Eagle 43 that the company is developing a mine-hunter version. Sicomin continues to work collaboratively with H2X on the remaining 2 boats.

KEY FACTS

- 4000kg of Sicomin's SR8100 resin was needed to infuse each main hull
- The Ocean Eagle 43 is capable of a top speed of 30 knots yet can also maintain an economical 20-knot cruise for a 4,828 km range
- Each trimaran composite structure weighs less than 30 MT

Sicomin, 31 avenue de la Lardière, 13220 Châteauneuf les Martigues, France
T: +33 (0)4 42 42 30 20 / E: info@sicomin.com / www.sicomin.com