Infusing quality at Discovery Yachts

Freelance journalist George Marsh determines why composite boat builders such as Discovery Yachts are moving from wet lay-up to the resin infusion process.

Many builders of reinforced plastic boats keen to transition from traditional manual wet lay-up techniques to a more controllable and environmentally-friendly process find resin infusion an attractive option. The alternative of going down the prepreg route (or a ‘semi-prepreg’ such as SPRINT/Zpreg), is a somewhat higher-tech approach that requires greater capital investment, not least for heated tooling or ovens.

One boat builder that has been stepping up to infusion is Discovery Yachts of Marchwood, Southampton, UK. Latest in a range of performance cruising yachts produced by this firm is the Discovery 57, which debuted at last year’s Southampton Boat Show. This impressive Ron Holland and Ken Freivokh-designed 17.5 m (57 ft) long yacht is extensively resin infused.

As managing director Nigel Stuart told Reinforced Plastics during a recent visit, one of the drivers for the change was the need to constrain structural weight.

“Performance is a key attribute of our yachts,” says Stuart, “so weight is important. We calculated that infusion would save us half a tonne of weight compared with standard lay-up.”

Other calculations suggested that the level of initial investment needed for a change to infusion would be a manageable £20,000, somewhat less than would have been required for prepreg. Manufacture was already taking place in a suitable benign environment – clean, dry factory conditions with temperatures of between 16 and 25°C – and building the steel-framed glass reinforced plastic (GRP) primary moulds would be easier and less costly than producing the heated tooling or large ovens that prepregging requires.

Another consideration was that Discovery wanted to continue to incorporate a gel-coat into the lay-up so that every yacht has a high quality surface finish. This is as easy to arrange with the infusion method as it is with manual wet lay-up. Also wanted was a process that is compatible both with the vinyl ester resin that is used for the hull and other key parts, and the polyester that is used in selected areas such as the window surrounds.

Explaining the preference for vinyl ester, Stuart declares: “Polyester is not as strong; therefore for a given laminate strength
you need more reinforcing glass. This leads to a thicker laminate, causing you to risk exotherm issues as well as increasing weight. We did consider epoxy but discounted it at this stage on grounds of cost and processability.”

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Another plus for infusion was the ability of the process to infuse multi-layer laminates incorporating very different materials, in a single hit. For the Discovery 57, the laminate choice was a mainly E-glass reinforced vinyl ester, but also including a layer of Kevlar aramid in forward sections for extra impact resistance, and some carbon for local strengthening. The structure, being of sandwich form, also includes a structural foam core.

Production timetable

Arguably, a downside to infusion is the amount of care that has to be taken to ensure that the dry laminate lay-up becomes totally infused. Having to scrap a large part because it has significant voids is a painful and expensive experience. To avoid this possibility the team carried out many trials, culminating in one on a quarter-scale hull section. Various meshes and material arrangements were tried, together with different configurations of resin feed tubes and injection points.

Having ‘nailed’ the process configuration and variables, the next step was to lay up a hull, following a carefully pre-determined timetable. A modus operandi was developed whereby cycle time for the full lay-up and moulding of a production hull is five days, i.e. a working week. This time is adequate for the small serial production volumes required.

Day 1 is dedicated to hand-laying into the female composite mould the gel-coat followed by the initial outer skin layer.

On the second day the remaining outer skin dry cloth layers are laid.

Day 3 sees the pre-kitted foam core sections laid, the foam incorporating channels for resin distribution.

Inner skin lay-up takes place on Day 4, followed by the vacuum bagging operation with its associated consumables. Resin tubes are laid with ports typically at 400 mm intervals, though closer together at critical points such as edges and angled sheer lines that could be natural void traps.
The fifth day, normally a Friday, sees the infusion step itself taking place, using pre-warmed resin. Air is evacuated from the lay-up, a large vacuum pump being used for bulk air removal initially, with a more conventional vacuum pump taking over for the latter stages of evacuation. Thanks to all the development trials and modelling that have taken place, the resin front normally advances evenly and progressively until the entire hull is fully infused. Great care is taken to ensure that resin condition is optimum. Resin is contained in tanks enclosed in heated jackets, and is delivered to the lay-up by resin pump. Advanced resin injectors ensure that the resin delivered to the distribution network is injected smoothly into the lay-up.

Following this central week-long production operation, there is no rush to demould the infused hull. In fact it remains in the mould for four to five weeks more while most of the internal structure — stringers, frames, bulkheads, keel bearers, floors, engine beds etc. — are laminated and bonded in, followed by certain accommodation modules that have been prefabricated on site. All internal joinery plus mechanical and electrical items up to the sheer line are fitted.

Meanwhile, the deck, which is of foam and balsa core sandwich construction, is moulded and deck hardware is fitted to the cured moulding. The deck is then lifted by overhead beam crane and lowered into the cured moulding. The deck is then lifted moulded and deck hardware is fitted and balsa core sandwich construction, is Meanwhile, the deck, which is of foam fitted.

Most of the composite materials, including resin, fibre mat, gel-coat, bonding adhesive etc., are sourced from Scott Bader. Cystic series resin, skin coat and Permabright gel-coat are used for the hull while extensive use of woven mat reinforcement helps secure high strength-to-weight. Crestomer bonding products are used for bonded joints including the critical hull-to-deck join, which comprises two mating flanges. Gurit provides the Corecell structural foam core. Consumables are supplied by distributor Marineware Ltd.

In-house

As much work as possible, most of it in fact, is kept in-house. This enables Discovery Yachts to retain full control of production timing issues, quality and costs. Nigel Stuart holds that these advantages outweigh the higher expense of manufacturing in the UK as compared with off-shoring to lower labour cost economies.

As he maintains: "We have huge technical resources in the UK and great depth of skill in many of the manual trades needed. There is a great background in marine engineering and boat building here in the south. As a result we can do most things ourselves; as well as lay-up and laminating this includes joinery, tooling, plug and mould making, mechanical, electrical and so on. We believe that these factors, along with our investment in an efficient composite manufacturing process and our attention to quality, keep us competitive in world markets."

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Two coats of isophthalic gel-coat are used for the hull, that below the -waterline being non-pigmented, both as an anti-osmosis measure and to afford visibility of the underlying laminate. As further protection against osmosis, the hull below the waterline is epoxy coated. Finally, two coats of anti-fouling are applied prior to launching.

Gurit (formerly SP High Modulus) was entrusted with engineering the structure. Marine engineering consultancy director Alex Shimell at Gurit’s Hamble office says that much attention was paid to weight minimisation and standardisation of production procedures. In terms of weight, for instance, balsa core that was originally considered made way for Corecell which would absorb less resin so that the laminate could be thinner and lighter for the same strength. Initial work with ISA standards proved unrewarding, resulting in too many laminate layers, so instead the approach and codes supported by Italian classification society RINA were adopted.

Considerable time was also spent optimising internal stiffening structure so that there are fewer disruptive interfaces with accommodation modules and furniture. Discovery’s own in-house design department, which employs CAD with Solid Works software, also contributed.

Still in transition

At the time of our visit to Discovery Yachts, the transition to infusion was not yet complete. Some decks (for a number of models as well as the Discovery 57) were still being wet laid, as well as certain interior modules such as galleys and shower units. Structural beams are also laid up by hand. The Discovery 55, a sister to the Discovery 57 which the company was producing before the latter was introduced, was still being made using manual wet lay-up, but this model is due to transition also.

Overall, the company has aimed for incremental progress rather than a total ‘big bang’ revolution, so that it can learn and refine processes as it goes.

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As Stuart points out by way of example: “One of the issues is achieving close control of the process so that laminate thicknesses are consistent. We work to quite tight tolerances so that, for instance, when the half dozen or so pre-fabricated interior modules are bonded into position and the deck is put on, everything fits and there is no need for extensive trimming and gap filling.”

He is in no doubt as to the final destination, however, saying: “We’re pragmatic about how quickly we change things. We are happy to still use wet lay-up where
appropriate, but on the whole we are moving towards infusion for practically everything.”

Reaction of the workforce of just under 100 (a tenth of whom are apprentices) to the new process has been highly positive. Shop floor operatives appreciate the lack of contact with wet resin and the liberation that infusion brings them from the ‘resin clock’ constraint under which, with traditional hand lay-up, there is a race against time to use a batch of mixed resin before the pot life is exceeded and it starts to gel and set. Infusion is inherently cleaner than the process it replaces and workers operate in contemporary premises that are not only clean but also well ventilated, heated and lit. The factory includes a composites engineering shop, a joinery shop and a machine shop equipped with, for example, an advanced CNC five-side wood cutter. A modern climate controlled laminating facility includes vacuum tables on which bulkheads are laid up and cured. A hydraulic press enables the company to produce its own teak-faced plywood used on the visible sides of interior bulkheads and furniture.

Nigel Stuart and his team are convinced that their adoption of vacuum infusion has resulted in a structure that is lighter, stiffer and of more consistent high quality than could have been produced by wet lay-up, thanks largely to the close control of fibre volume fraction that the infusion method affords. This helps attract customers in what is a highly competitive market and, by now, several of the company’s advanced infused composite Discovery 57 yachts, constructed to the European Union’s Ocean Category A standard, have been built and are ready to sail the world’s oceans.

6000-litre infusion

Discovery Yachts specialises in high-quality, high performance sailing cruisers. Further along the UK’s south coast is a noted luxury motor yacht producing company that has been applying infusion on a grand scale. Princess Yachts of Plymouth uses 6000 litres of resin to infuse the latest model in its ‘M’ range, the 132 ft long P40M the first of which, Imperial Princess, was launched last year. Princess had been using the process for some time for smaller vessels but faced a significant challenge in scaling it up for the P40M. Infusing the hull takes seven hours and is the culmination of a process that has been planned in great detail. Injection of pre-warmed resin is touch-screen computer controlled and a pressure feedback system helps ensure close adherence to the required process parameters.

Unlike Discovery Yachts, Princess uses fluid-heated moulds to effect a post-cure. Head of composites Julian Spooner says the infusion process developed by the company results in a tough laminate having a high fibre-to-resin ratio and less than 2% void content. The hull, he asserts, weighs a fifth less than a traditionally hand-laid hull of the same size. Many planar parts for the yacht are made using a 100 m² heated vacuum table. Spooner adds that among the important benefits of the closed mould infusion process are very low emissions, a key factor in the achievement of ISO 140001 certification for the purpose-built manufacturing facility.

Other builders of fast cruising yachts, both sail and power, have sought similar benefits by adopting vacuum resin infusion. Germany’s Hanse Yachts, which has a reputation for employing efficient modern production methods, infuses the sandwich glass/epoxy skinned Corecell foam cored sandwich structure of its 630e fast sail cruiser, for example. Significantly, Hanse now owns Dehler Yachts and the Dehler 41 is similarly infused, though the resin used in this case is vinyl ester.

Infused foam cored sandwich is also the basis for X-Yachts’ Xp 38 sailboat (the ‘p’ signifies performance) in which the resin is epoxy, although an earlier infused model, the Xp 33 has vinyl ester as the resin. The roll call of infused performance cruisers also includes the latest C72CS sailboat from Dutch builder Contest Yachts, the Solaris One-60 from e-Yachts, the J-111 from J-Boats and the Tartan 4700 from Tartan Yachts in the USA (the last-named also has carbon composite mast and boom). Croatia-based AD Yachts offers infusion as an option for its ‘performance optimised’ Salona 38. Oyster Yachts, known for its quality sail craft, made a foray into the infusion of superyachts at its RMK subsidiary in Turkey where three vessels up to 125 ft long were built before recession struck.

These are all examples of a growing trend. Hand lay-up, though still widely used, is clearly on the way out as the predominant boat manufacturing technology, as it becomes replaced by closed-mould processes. In this arena ‘straight’ resin infusion has to compete with resin film infusion (using ‘semi-preg’ materials such as SPRINT™ and Zpreg™) and prepreg methods that are also making headway in the yacht and boat sector. But as a logical medium-tech step up from traditional methods, resin infusion is widely favoured for its ability to deliver superior laminate quality and consistency, reduced emissions, reduced resin usage and faster ply lay-up – all within an affordable transition budget and with the minimum of disruption to existing factory provision.

Further information

Discovery Yachts; www.discoveryyachts.com
Princess Yachts; www.princessyachts.com
Hanse Yachts; www.hanseyachts.com
Dehler Yachts; www.dehler.com
X-Yachts; www.x-yachts.dk
Contest Yachts; www.contestyachts.com
e-Yachts; www.e-yachts.com.au
J-Boats; www.jboats.com
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