

# Cutting edge

By using one of the world's largest CNC five-axis machining centres, Dencam can cut plugs and direct moulds out of polyurethane or epoxy modelling paste for hulls of more than 45m (148ft) at higher speeds, lower cost and with greater accuracy. **BOB GREENWOOD** reports.



**O**n the grass outside the federal Chancellery in Berlin is a pair of 12m (39ft) Adidas soccer boots looking as though they've been casually flung down. They're part of Germany's World Cup festival and they were produced at Faaborg on the Danish island of Fynnen using Dencam's five-axis machining centre. Built by EEW Maschinenbau of Germany, measuring 52m x 8m x 4m, this is said to be the largest CNC machining centre of its kind in Europe.

The giant football boots were a one-off. The machine's more regular production is moulds and plugs for composite boats and wind turbine blades. Dencam has also been used by car manufacturers to make prototype car-body designs.

Regarding the wind turbines, Dencam produces the plugs that make a large proportion of the world's turbine blades. These

**1** Measuring 52m x 8m x 4m, Dencam's five-axis CNC machining centre is said to be the biggest in Europe. Here it's cutting the port half of the direct mould for the 32m (105ft) Royal Denship 105, a trideck motoryacht.

**2** The milling head of the large CNC machining centre fine cuts in the PU paste at 20m-30m per minute.

**3** Moulds for smaller components are cut on the smaller of Dencam's two CNC machining centres.





So too are Royal Denship's 8m (26ft) and 9m (30ft) Limo tenders, although these are tailored to fit the space requirements of individual superyachts.

"A major advantage of CNC milling for the client is speed to market with new models, especially if customers provide 3D drawings," says Schneider. "It could save half to a full year — six months instead of 12-18 — in the moulding of a large yacht. The cost is the same as by hand, but the cutting is speedier... CNC milling can cope with virtually any shape and handle almost any complexity. That's not a problem. And it helps in the design phase, where you can add in manufacturing details such as flanges in the design of production tooling."

Dencam's CNC moulding tool-making system is particularly well suited to large, custom or semi-series projects where tool-making would normally be a costly and time-consuming element of building in FRP.

A prime example of this application is the Royal Denship powercruiser range. This range of Bill Dixon-designed boats comprises the 82 Open express cruiser, the 85 Flybridge and the 105 Open and Trideck motoryachts.

The 32m (105ft) trideck is the latest of the Royal Denship semi-production yachts to use Dencam tooling and is also remarkable in being one of the largest boats anywhere to be direct-moulded. "Some have done direct moulding on smaller boats," says Schneider. "This is a natural development, but with a significant jump in size."

In April this year two halves of a female hull mould were cut on Dencam's large CNC machine for direct lamination. Like most hull plugs they were constructed on a wooden frame. However, it was the convex inner sides of the half-moulds that were then lined with DIAB rigid PVC foam planks stuck down

**4** The mould for a superstructure side panel for the Royal Denship 105 awaits final grinding and polishing. **5** The 30kW milling head on the small CNC machining centre can cut aluminium, epoxy and carbonfibre panels, as well as polyurethane paste. **6** The portside of the Royal Denship 105 mould substructure is pieced together in preparation for PU foam to be applied. Once that is rough milled, it will be coated in PU paste for fine milling.

plugs produce the moulds for 15 types of blade in the country that generates over 20 per cent of its electricity from wind power — more than any other nation in Europe.

As far as boats are concerned, the company is able to produce the tooling for boats of over 45m (150ft).

The longest plugs it has made to date were, in fact, 47m (154ft). These were for the Skjold Class motor-torpedo boats being built by Umoe Mandal for the Norwegian navy. Because the MTBs are very high-speed, surface-piercing catamarans, absolute symmetry between the two hulls is essential. This is one area where CNC tool making clearly comes into its own. "The milling machine's accuracy is  $\pm 0.5\text{mm}$  over the total length of the machine, but locally it can be accurate down to  $0.1\text{mm}$ ," says Ole Eriksen, sales manager for Dencam.

Dencam was started in April 2003 by Danish entrepreneur Peter Johansen as a production

company within his Royal Denship boat and megayacht building group to "bring in an intelligent approach to series yacht building with a vast investment in technology," he says.

Hans Schneider, Royal Denship's managing director, expands: "Dencam grew out of innovation. No machine could do what we wanted on the scale we wanted, so we started the company to bring industrial production to big boats."

Since then Dencam has produced tooling for a diversity of composite craft, large and small. Among these are plugs for the International Dragon, the classic Johan Anker-designed 8.8m (29ft) ex-Olympic class one-design keelboat, of which 24 will be moulded this year by subcontractors working for the Denship group.

Another project saw it cutting the plug for the X-35 one-design performance cruiser for Danish company X-Yachts. Both the Dragon and the X-35 are relatively small, series-built boats.



**7** The liquid resin and hardener components of Sika's M72 polyurethane paste are combined in an E Tartler mixing unit. **8** Every other day PU paste shavings have to be cleared away from the mill. They can be safely disposed of by burning. **9** Hans Schneider, managing director of Royal Denship (left), and Ole Eriksen, Dencam sales manager. "A major advantage of the system to clients is speed to market with new models," says Schneider. **10** The Royal Denship 105 — the hull is arguably the largest that has been infused using a female direct-mould.

into place with polyester glue.

This substructure was coated with polyurethane foam which was rough milled to take a final coating of Sika PU paste to provide a surface that would then be fine milled, ground and polished ready for lamination by one of the Royal Denship partner shipyards.

The process of producing the finished direct-moulds for the two halves of the Royal Denship 105 hull was scheduled to take about six weeks in total. "We'll spend four weeks in preparation of the mould tools before they go into milling and finishing," Ole Eriksen told *EB* when we saw the 105 mould-making operation in April. "That's quick compared with traditional mould making, which could take months."

The robotic milling machine head, which is guided by 3D computer files containing the exact contours of the hull design, moves briskly along the length of the hull mould. Suspended from a moving gantry that runs on rails atop concrete pillars, it makes a first rough cut of the PU foam at the rate of 100m-130m per minute. After the final modelling-paste layer has been applied, fine milling is carried out at a rate of 20m-30m per minute.

As well as cutting hull moulds and plugs, Dencam's giant CNC machining centre also shapes other large mouldings such as decks and structures. Tooling for smaller moulded components is cut on a smaller CNC machining

centre also built by EEW. This unit, whose dimensions are 15,5mx4.7mx2m, has stiffer rail guidance compared with the large machine and a powerful 30kW spindle (compared with 12kW on its bigger counterpart) that's capable of milling aluminium and carbon as well as PU or epoxy modelling paste.

Dencam can not only produce extremely accurate moulding tools, it can do so with minimal manpower. The company employs just eight people, including three administration staff, yet it runs the two CNC machines for two shifts a day and at weekends. All they need is a copious supply of modelling paste.

"We use 90,000 litres (or 80 tonnes) of polyurethane paste a year," says Ole Eriksen. "That's approximately one third of the world market... We use several paste systems — polyurethane for marine and industrial, and epoxy paste for windmills, although we started using epoxy in the hull moulds of our Limo tenders. Altogether, we're using 120-130 tonnes of model paste a year."

Dencam's principal supplier of PU paste is Sika Tooling, part of Sika Deutschland and an 80-strong autonomous business unit within the Sika group developing tooling products in its own laboratories.

More than just supplying products, Sika Tooling has worked closely with Dencam to develop modelling-paste solutions tailored to

Dencam's applications. In volume terms, the main product supplied by Sika is its Biresin M72 polyurethane paste — the one which, according to the company, particularly suits large-scale modelling with CAD-CAM.

Biresin M72 is a two-component product, where both resin and catalyst are liquid until they're combined to produce a workable paste. Dencam uses an E Tartler mixer to blend the components to the output rate that it requires to produce the right degree of stiffness for the angles and surface shapes of the job in hand.

The advantages of two liquid components, says Peter Soff, market development manager for Sika Tooling, are that they can be pumped through quite long lengths of pipe before mixing, although for continuous working, large drums of resin and hardener can also stand directly beside the mixer. "It is simple to adapt the paste machine to the milling head and use it for an optimised non-stop dispensing process without extra investments in tandem dispensing equipment," he says.

Once hardened, the paste can be milled after eight hours without any post curing, again saving time and processing work, adds Soff, while allowing high-speed milling with almost no dust.

Looking ahead at the prospects for direct moulding using CNC-milled PU paste, Eriksen says: "This will hopefully evolve into a good business... We've had requests for tooling up to 43m (140ft) in GRP by this method... To make large direct-moulds in paste is still unusual. If you wanted a mould to last you would expect to use glassfibre moulds. But our aim is to get 10, maybe even as many as 20, impressions from one direct-mould by our system." 