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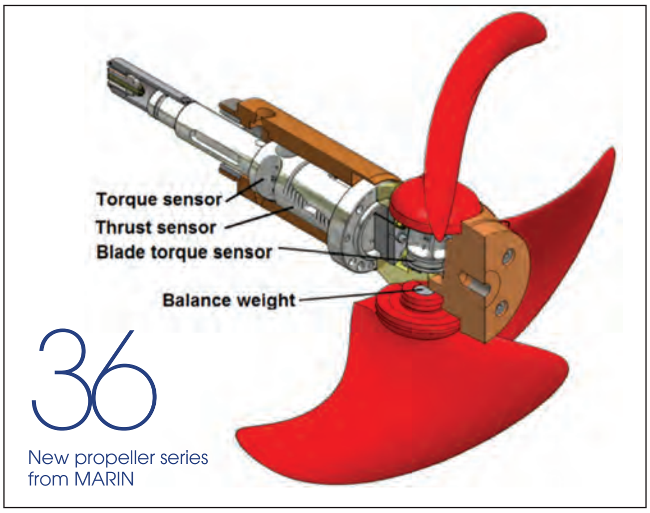
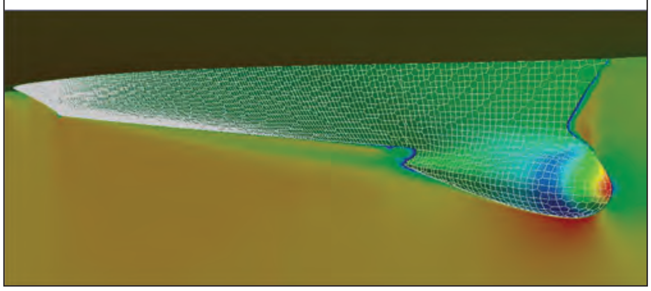
25-62 Features



36
New propeller series from MARIN

42
The development of the automation of welding

58
fast multi-objective design optimi-sation explained

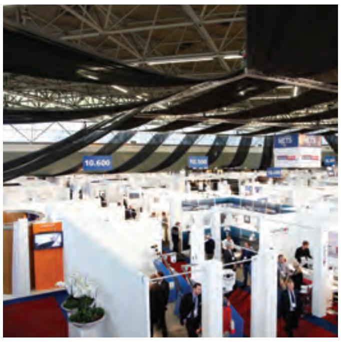


On-line Edition

The Royal Institution of Naval Architects is proud to announce that as of January 2008, *Naval Architect* journal has gone digital. We are very pleased to inform the maritime industry that each issue will be published online, on the RINA website. Visit www.rina.org.uk/tna and click on the issue cover you wish to view. This means that the entire publication, including all editorials and advertisements in the printed edition, can be seen in digital format and viewed by members, subscribers, and (for a limited time) any other interested individuals worldwide.

THE SUPERYACHT PAVILION IN AMSTERDAM

At the heart of the 25th METS

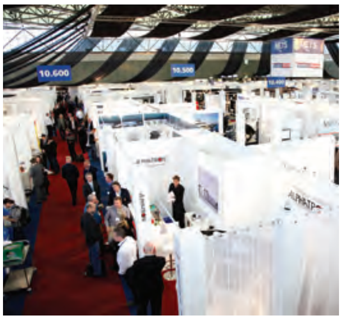


What is the SYP?

The SuperYacht Pavilion (SYP) has grown into a vibrant show-within-a-show at the heart of METS, the world's biggest and best attended leisure marine trade show. Since its launch in 2006, the SYP has expanded to comprise over 175 exhibitors and now has its own dedicated hall and independent catering and conference facilities.

Just for business

METS is a strictly trade-only event and this ensures that the genuine superyacht industry related exhibitors welcome only relevant industry professionals. The SYP is of interest to a significant part of the nearly 20,000 professionals who visit METS each year and attendance is boosted by the speakers and delegates who take part in the associated social and conference events.



Knowledge exchange

The SYP runs in association with the Global Superyacht Forum (GSF), one of the world's leading summits for superyacht captains, designers, builders, project managers, brokers and owners. The GSF programme covers up-to-the-minute topics, and interaction between speakers and delegates is excellent. The GSF is organised and presented by The Superyacht Report Group in association with METS organiser, Amsterdam RAI.

METS at 25

METS celebrates its 25th anniversary in 2012 so expect a festive atmosphere! METS started back in 1988 with just over 100 exhibitors and in 2011 it had a staggering 1,331. For the superyacht professional it's a unique combination. At no other trade-only event can you visit a thriving superyacht equipment exhibition and also have access to well over 1,000 other marine trade exhibitors, some of whom also cater to the superyacht sector.

- 19,000+ visitors from 100+ countries
- 1,300+ exhibitors (incl. 150+ in the SYP)
- 15 national pavilions
- 3 specialist pavilions including the SYP
- Strictly professional, strictly trade-only
- Meet & Greet areas for excellent networking

Where is METS?

METS/SYP is held in the Amsterdam RAI exhibition halls just 15 minutes from Amsterdam's International Airport and 10 minutes from the historic city centre. To help with your planning, Amsterdam RAI can book hotel rooms for you and assist with other travel requirements.

The Elicium, Amsterdam RAI.

Be part of the SYP 2012 – part of the METS!

SYP official magazine: The Superyacht Report

SuperYacht Pavilion

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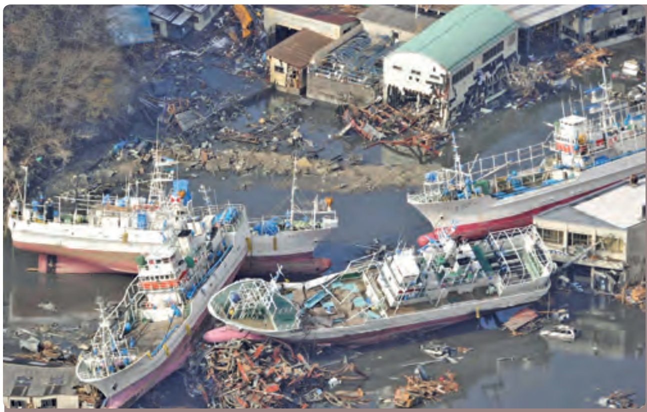

Maritime prognosis takes a turn for the worse

High and dry; casualty numbers could still rise as the maritime indusrty makes a slow recovery

If ever chickens have come home to roost it is within the shipowning and operating community, that the full force of an avian return is being felt is not news to many. But, the intensity and extent of the sickness that has accompanied said homecoming remains unclear.

Of course the sickness - whether unsustainable consumer demand or new ship orders - currently afflicting the shipowners does not remain quarantined, but spreads rather rapidly across the entire maritime community, most notably in this case to the ship building sector.

After the collapse of Lehman Brothers bank in 2008 the repercussions on shipping were swift. First came the collapse in demand in both Europe and the US for consumer goods, a factor that had been driving growth, particularly in the container sector, at an outrageous and unsustainable rate. Then came the supply side debacle. Owners, again particularly in the container sector, were used to planning for growth in excess of 15% a year. Unlike most businesses when there is little demand factories slow production, in shipping the two-year lead time meant that ships have just kept rolling off the production line. Post Lehman the new ships intensified greatly the collapse in demand.

A slight improvement in the global economy in 2010 saw owners once again ready to order new tonnage. Dodo's are creatures of instinct apparently, or rather were creatures of instinct. And that is not necessarily a good thing.

Owners have been used to the cyclical nature of shipping for many years, and as many are prone to saying, "we build ships for 25 years operation, not for next year's profits". In the past the economic slumps have come and gone with monotonous regularity and there is some expectation that this will happen again with the latest slump.

However, there are some good reasons why this latest recession is a game-changer and is more an explosion of the historic kind, think Krakatoa rather than Eyjafjallajökull. In the first place this is the first recession since globalisation really took hold and the maxim that when America sneezes Europe catches a cold has gained significantly in credence and scope with Asia and the rest of the world also getting the snuffles.

In addition the banking crash and post-Lehman landscape has been followed by a European currency crisis which, is showing no signs of abating. Growth has become the aspiration, but growth based on consumerism grounded on debt that is money leant on the strength of a notional increase in the value of property is not a solid foundation on which to build ships for 25 years trading; as the industry has found out to its detriment and cost.

In all the financial tsunami that has swept through the quiet, leafy maritime suburbia will change the vista forever. The question is how? It seems certain that there will be a less fragmented ownership structure and that growth will be real rather than notional and, therefore, of considerably smaller proportions to the 15% that became the norm in the first decade of this millennium.

Lower growth will mean that the over-capacity that currently exists in almost all the shipping sectors will be sustained for some years to come. Over-capacity of ships will in turn ensure that the orderbook remains subdued and that means that there is already too much yard capacity.

Some yard casualties have already been seen, Shina SB in South Korea for example, more are on the way, STX has had its entire European operation up for sale for some time and Spanish yards which last year managed just one new order between 23 private yards. This year may be pivotal for Spanish yards as the contracted work finally dries up, yards will have to close.

This not a sickness, however, that is just affecting Europe and Korea as this month's China Ship News story highlights the global nature of the economic catastrophe that is being visited on the maritime industry and that catastrophe has some way to run yet.

Jean Richards of Quantum Shipping Services, a maritime financial institution, outlines the difficulties; Some banks are happy to lend to existing customers, but that lending often comes with strings attached, that is 'you take this repossessed ship off my hands and I'll lend you money for your gas ship'.

Financial restructuring is gathering pace and payment and covenant breaches are becoming more common as owners are increasingly faced with third party trade creditors as well as banking debt. And with the flood of new ships still to arrive on the scene, rates and therefore income will remain low.

This is a bleak homecoming for any bird, in the short to medium term. One ray of sunshine amid the chaos and gloom might just be 'regulation', which could see the early scrapping of inefficient and costly ships, but that is a faint hope for jam tomorrow rather than anticipation of a turkey dinner. *NA*

Finance

Fanning the flames

Ship finance experts are warning of the second wave of ship financing difficulties set to swamp the industry. Harald Serck-Hanssen, DNB's global head of shipping, told the audience at Tradewinds' Posidonia conference last month that new orders are down and the ship finance markets are shrinking. He went on to say that as refinancing dates approach significant new problems will arise as ships are worth less and so refinancing will take place at significantly lower levels.

As a result a number of owners are turning to the bond markets to finance new buildings, but as George Elliot, CEO of Maista Naftilia Asset Management pointed out, "Shipping is an old business, but it is new to the capital markets," and while institutional investors are interested "many [shipping] companies are theoretically bankrupt."

Elliot believes that post the Lehman Brothers bank collapse there are two types of owners, proactive and reactive. Reactive owners edge through a process that starts with denial of the stark financial realities that they are facing, leading them to do nothing. Denial gives way to protest where owners attempt to "play hard-ball with the banks". Failure to gain investment gives way to the third phase, acceptance of their fate.

"No-one wants to invest in other peoples' problems," says Elliot, so proactive owners were those that sought an early solution to the financial storm heading their way. Companies such as Dryships, Navios and OSG raised money through the bond and equity markets.

However, Jean Richards, director at Quantum Shipping Services told Naftiliaki's Posidonia conference that the bond and equity markets were open only to the larger companies who knew how to access this finance. Times are tough and will get tougher for small to medium sized players, says Richards.

"There is a lot of restructuring [of debt], a deferral of principles outstanding and as operating expenses are only just covered by rates, interest remains unpaid, this leads to increasing defaults and no new lending," says Richards.

Ultimately that means the newbuilding market will stagnate until owners are able to access capital. Already there is evidence of significant yard over-capacity as the new orders shrink, she added.

Lubricants

Cyltech oils slow steamers

Castrol says its latest Cyltech lubricant, which is rated as a BN80 oil, is designed for vessels that are slow steaming with reduced sulphur fuels.

The company has argued in recent months that a single universal lubricant cannot provide adequate protection for the range of operational demands that will include slow steaming and the use of low sulphur fuels as well as standard fuels when a vessel is not operating in an emissions control area (ECA).

As a result of the changes in pollution control regulations it was understood that Castrol was advising clients to store and use up to three different BN rated oils onboard their vessels. However, Castrol clarified its stance at the recent Posidonia exhibition where company executives said that it would be unlikely that ships would need to carry more than one type of oil.

Paul Harrold, Castrol's marine and energy technology manager says: "Any imbalance between cylinder oil feed rate, BN and power compromises engine efficiency, slow steaming may bring lower lubricant feed rates and, when higher sulphur fuels are used, a higher lubricant BN protects the engine against potential damage. It also limits the amount of burnt cylinder oil in exhaust gases, thereby cutting emissions."

Castrol says however, that carrying more than one oil type is not necessary. "As a result of research, field trials and engine inspections, Castrol believes that each vessel should use a single cylinder lubricant based on that vessel's predominant operating conditions. Where 40 BN cylinder oils may suit vessels permanently operating in Emissions Control Areas, the supplier has concluded that those of 70 - 80 BN are better suited to vessels regularly slow steaming and on international trade, even those involved in frequent ECA transits."

This subtle change to Castrol's position brings the company closer to the position taken by a number of other competing companies, most notably Total which is the only oil company to be currently marketing a universal marine lubricant, Talusia Universal, but also Shell and Exxon who have both announced that they will soon offer a universal lubricant of their own.

Even though Castrol has said that its customers are concerned about wear rates and lube oil costs attached to slow steaming, it appears that many owners do not share these concerns. MAN Primeserv surveyed 149 owners that had employed slow steaming.

The results of this survey showed, among other things, that given the opportunity to save lubricating oil by adapting a lube oil dosage system to the engine load, slightly more than 20% of respondents were considering engine upgrades and only around 16% of those that had upgraded their engines were "seriously considering cylinder oil optimisation as a means of saving costs and optimising cylinder lubrication for low-load operation."

Engines

Finns flex low-speed unit

Wärtsilä's latest engine, the low speed two stroke RT-Flex version D, which has a turbocharger on the driving end side of the engine, has been announced by the company.

The company says the RT-Flex is suitable for smaller vessels and offers reduced operating costs and reduced emissions.

"Due to its narrow design, the new engine version will be used for ship designs with slim stern sections where the current standard execution, with turbochargers mounted on the exhaust engine side, does not fit. The RT-flex50 version D can now be used instead of other engine types featuring a smaller cylinder bore and higher speed. In many cases the higher performance of the cylinders allows the use of one less cylinder and can, for example, reduce maintenance costs. Thanks to the low speed of the engine and propeller, the total fuel consumption of the vessel is considerably reduced," said the company.

Energy efficiency

Rickmers greens its MPVs

German ship operator Rickmers has opted to fit ABB dynamic trim and fleet management systems to five nine-year old multi-purpose vessels (MPV).

Rickmers will fit ABB's Energy Management system to the five MPVs by the end of the year and will monitor the vessels' efficiency before deciding on whether to fit the remainder of its fleet, more than 100 other ships, with the technology.

ABB will supply dynamic trim optimisation, energy management systems and fleet management solutions to the owner from what it calls its "newly developed Advisory Suite" of software.

According to ABB the payback time for the systems, calculated using the current cost of bunker fuel, will be less than one year. The system will reduce the vessels' fuel consumption by 5% annually, not only saving fuel but also reducing emissions.

A Rickmers Group statement says that the company is starting with a group of five ships that are operated by Rickmers-Linie which provides breakbulk, heavylift and project cargoes services, and deliveries for large-scale projects. "The installation of the system will be done ship by ship and the first system is expected to be commissioned in the third quarter of 2012. The complete system for five ships is expected to be fully operational by the end of year."

The first five ships to be equipped with the ABB systems will be *Rickmers Singapore, Rickmers New Orleans, Rickmers Jakarta, Rickmers Antwerp and Rickmers Tokyo*.

Correction

In the May issue of *The Naval Architect* we ran a story entitled 'Korean's top-up BWTS market', in which we incorrectly stated that the Techcross BWTS was a UV based system. The Techcross system, however, cleans ballast water using electrolysis. *The Naval Architect* would like to apologise to Techcross and our readers for the error and for any inconvenience caused.

One of the first Rickmers vessels to implement ABB's Energy Management system is *Rickmers Singapore*, which operates on Rickmers-Linie's scheduled Pearl String round-the-world service. It is seen here navigating the Houston Ship Channel

Bankers keep new designs afloat

Pure economics is behind the growing interest in ship design as banks and ship financiers focus on a vessel's operating costs in an era of pricey bunkers, *writes Julian Macqueen*.

"Fuel-efficient ships make a very compelling case for all financiers," independent investment banker Michel Bourgery told *The Naval Architect*. Bourgery illustrates his point with some notional numbers.

A charterer could be paying US$15,000 a day to hire a ship and nearly double that – around US$25,000 at current prices – to make up the fuel bill. A new, fuel efficient ship, burning less fuel, say five tonnes a day, could furnish the charterer with savings of US$1 million or more annually. In this scenario, the argument for fuel efficiency is both simple and compelling.

But, there is a secondary consideration: and that is how lower operating costs will affect the market for used ships. Second-hand values are primarily a function of the prevailing freight rates, but they are also determined by operating costs.

"Second-hand values of existing traditional tonnage will probably go down sharply when the new tonnage hits the water," says the financier, whose views are echoed elsewhere in the ship finance community.

"Banks are taking the question of design seriously," agrees a senior executive with a major German ship finance institution. As in any asset-based financing, the value of the asset determines the structure of the funding. To issue a mortgage on a ship, the ship finance bank will take a keen interest in its resale value.

"The vessel is the major collateral in any ship finance deal," says the financier, which means that where the ship might stand in any efficiency index will affect its future value.

The focus on fuel efficiency and eco-ship design also has the potential to influence sources of funding for ships.

Since the end of the shipping boom in 2008 and the onset of the credit squeeze, traditional sources of ship finance have all but dried up. This has led to private equity funds taking an interest in the market. Until now, these funds have tended to be active in the second-hand market only. However, according to reports in the trade press, newbuildings are becoming more attractive to this type of private investor.

US investment bank JP Morgan will be German shipping company Bernard Schulte's partner on five 5,100TEU container vessels being built at Hanjin Heavy Industries' Subic Bay facility in the Philippines. Delivery of these ships is set for 2014.

The fuel consumption of the Hanjin ships will amount to 35tonnes per day less than older Panamax designs — or 50tonnes less at a sailing speed of 18knots. This equates to a saving of US$20,000 per day, according to a report carried by the shipping weekly, *Tradewinds*.

In addition, newbuilding prices have fallen considerably. Vessel prices on the Hanjin deal have been reported to be as low as US$45 million each, or US$225 million in total. The deal includes options for five ships.

Connecticut-based Alterna Capital Partners is another US private-equity player said to be eyeing newbuilding investments. Alterna is understood to have been involved in talks Schulte had for a series of 2,200TEU ships at Jiangnan Chanxing Shipyard and Yangfang Group.

To date, private-equity fund interest in boxships has been on the second-hand market. Alterna, which has been looking at the sector for at least two years, is understood to have made offers on second-hand ships. But, a combination of historically low prices for newbuildings and the move towards designing fuel efficient ships could herald change.

Tradewinds cites an unnamed US-based financier as saying that attractive newbuilding prices and eco-friendly designs are proving a draw for private equity.

"Private equity has hitherto always stayed away from newbuildings. They always wanted ships in the water. They didn't want the carrying costs," according to the source.

Funds invested in newbuildings could lend support to fuel efficient design by accelerating the development of a new class of ship capable of generating significant savings.

Indeed, shipping magnate John Fredriksen, who has recently entered into a spending spree, has signalled a willingness to invest in newbuildings. The tanker owner is branching out into dry bulk and liquefied petroleum gas carriers. Market reports on the Fredriksen move cite low newbuilding prices and the prospect of achieving considerable fuel efficiency as driving the shipowner's expansionist ambitions forward. The owner calculates that a new vessel could save as much as US$7,000 a day compared to a five-year-old medium range tanker, based on a fuel cost of US$700 per tonne. *NA*

Communication

Marlink upgrades portfolio

Marlink has re-developed its WaveCall standardised VSAT offering to the worldwide shipping community.

The expanded WaveCall portfolio consists of two service propositions. WaveCall will offer users standard connectivity up to 1.5Mbps and starts from US$1,000 per month. WaveCall Premium, which in addition to offering up to 3Mbps broadband connectivity, also offers flexible committed CIR to enable multiple voice lines and the capability for business critical applications such as VPN, remote monitoring and telemetry services.

"WaveCall gives us highly competitive maritime connectivity with fixed, low monthly expenditure based on bandwidth and performance required across our fleet," says Gunnar E Eide, surveyor maritime ICT & automation, Odfjell Ship Management. "Our WaveCall services from Marlink will enable us to benefit from an easier to use, smarter and more flexible VSAT network. We have worked closely with Marlink to ensure we have the right configuration for our fleet and the deployment process has been straightforward. We are able to interact directly with Marlink for service and support and they ensure the service runs to our satisfaction," adds Eide.

www.marlink.com

CAM

PEMA delivers to Baku Shipyard

Pemamek Oy Ltd has agreed on design, construction and delivery of a flat panel line for Baku Shipyard LLC from Azerbaijan. After its commissioning that will start from early 2013, Baku Shipyard will operate a flat panel line for ship panel fabrication in their new facility.

The scope of the delivery is a complete 12m flat panel line with PEMA OSW one-side welding station with magnet clamping, PEMA PTU panel rotating system, lifting boom arrangement for panel turning for two-sided welding, PEMA SMP stiffener mounting and tack welding station, PEMA SWP stiffener welding portal, PEMA WMP web mounting and tack-welding station, four PEMA SP service portals for finalising the welds, PEMA TS transportation trains, PEMA LOS load-out station and necessary conveyor lines.

The panel line utilises high-tech welding power sources from Lincoln Electric Corporation - Pemamek's strategic global partner for providing world-leading welding equipment, technology and consumables.

Multiple stiffener welding in a PEMA SWP stiffener welding portal

"We consider this a major breakthrough in our effort on the Caspian Sea shipbuilding market together with our agent, Caspian Engineering Technology (CET) of Azerbaijan", says Jukka Rantala of PEMA. "We are really looking forward to work with SOCAR and Keppel Offshore and Marine, and see this project as an opportunity to forge good co-operation into long-term partnerships with them."

A joint venture company formed by the State Oil Company of Azerbaijan Republic (SOCAR), Keppel Offshore and Marine (KOM), and Azerbaijan Investment Company (AIC), Baku Shipyard is expected to be ready by the end of 2013. Operated by KOM, Baku Shipyard will carry out general marine engineering, shipbuilding and repair of vessels for clients operating on the Caspian Sea.

www.pemamek.com

Cranes & cargo equipment

BGD awarded Brazil contract

Bergen Group Dreggen has been awarded a new contract with the engineering, procurements and construction (EPC) contractor Techint Engenharia e Construção SA in Brazil. The contract has an estimated value of NOK60-70 million (US$10 million), and comprises delivery of a total of four offshore lattice boom cranes for two fixed wellhead platforms being constructed for OSX.

The contract will generate activity from Q3 2012 and throughout most of 2013, with deliveries to the customer scheduled to Q2 and Q4 2013.

www.bergen-group.no


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Tug "Elyah",
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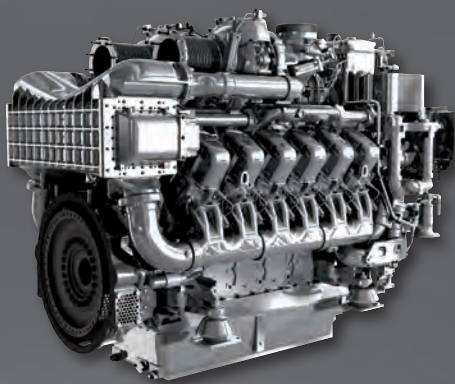

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Engines

Wärtsilä X35 gets thumbs up

Wärtsilä's new electronically controlled low speed engine, the Wärtsilä X35, has successfully passed its Factory Acceptance Tests (FAT). The tests of the two engines took place in earlier this year at both the 3.MAJ Engines & Cranes company facilities in Croatia, and the Yuchai Marine Power Co., Ltd. (YCMP) factory in China.

Wärtsilä gets good results from its X35

The 6-cylinder Wärtsilä X35 has undergone a series of tests as part of a comprehensive testing and validation programme. The engine performance of the first two engines fully met all expectations and predictions. All the measured results were in keeping with the calculated values, and well within accepted limits. The measured parameters included stresses, strains, temperatures and vibrations in the engine structure, running gears and combustion chamber components, together with pressures and temperatures in the engine processes, as well as fuel consumption, exhaust gas emissions and smoke. The tests, furthermore, confirmed the predicted brake specific fuel consumption (BSFC) of 176g/kWh, within the usual 5% margin under IMO Tier II conditions.

The first 6-cylinder Wärtsilä X35 engine to be produced and tested in Europe, it is the first of four such engines scheduled for manufacturing and testing at 3.MAJ during 2012. The second of the tested engines was produced at YCMP, a Wärtsilä licensee since 2009.

"The successful Factory Acceptance Tests are an important step forward in the development of the Wärtsilä two-stroke engine portfolio, as these represent the first engines of the new X-engines family. The Wärtsilä X35 engine is now available for market introduction at a time when the marine sector has a clear need for electronically controlled, low speed, high efficiency two-stroke engines," says Martin Wernli, president, Wärtsilä Switzerland and vice president, Product Centre 2-stroke.

www.wartsila.com

Ancillary equipment

Colfax Fluid Handling announces All-Optiflow

Colfax Fluid Handling has introduced the Allweiler All-Optiflow series of progressing cavity pumps.

All-Optiflow progressing cavity pumps will offer up to twice the flow of standard pumps for applications up to 6bar (87psi) and move virtually any type of liquid, including fibrous and solid materials efficiently and reliably, says the company.

This Allweiler pump series is designed to optimise the standardisation of structural components, such as a patented stub shaft connection and a lifetime-lubricated joint, allowing operators to move most liquids economically. The stator surface is honeycombed and works in tandem with the patented "sharkskin" rotor surface. Providing a lower starting and operating torque, allowing the pump to operate at higher efficiency than normal and providing stable performance curves throughout operation. "The advanced design of the All-Optiflow lowers total costs of ownership (TCO) over that of comparable systems," said Stefan Kleinmann, senior director marketing & business development.

Allweiler launches latest series of pumps.

The pumps feature high power density to help reduce energy consumption by up to 15% when compared to standard progressive cavity pumps. Shaft diameters are approximately 30% smaller than those found in standard progressing cavity pumps, reducing friction by nearly 50%. This, combined with the application of low-wear materials, provides the potential for reduced maintenance costs.

www.allweiler.com

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SHIP ECONOMY & TRADE

Survival of the fittest

After a financial crisis, while shipping enterprises are emerging and reorganising, Jiangsu maritime companies will open another gate to industrial resource integration and bring opportunities for further increasing the industrial concentration and strengthening the shipbuilding industry, writes Wu Xiu Xia

Under the 800tonne gantry crane, a 320,000dwt VLCC lies, at work there is also an international-grade panel block assembly line. On the production floor of Jiangsu New Century Shipbuilding Co., the shipowner, the ship surveyor and workmen are busy making rounds between the dock and the sub-section production area, the completed skeleton of an 82,000dwt bulk carrier stands, there are vessels at berth and others returning from test-sailing crisscrossing on the Yangtze, all bearing witness to the formidable strengths of the ship builder.

New Century and Jiangsu New Yangzijiang Shipbuilding are pivotal shipping enterprises in Jiangsu province, with works progressing as planned in firm and steady strides with 10 and 13 vessels delivered in April respectively.

It's a different story though for the small and medium ship enterprises along the Yangtze visited by the reporter. Under the stand-alone gantry crane are but a couple of vessels being built, steel materials are scattered on the production floor, vessel subsections left outdoors are rusting. Some small ship enterprises new to the industry are "in at the deep end".

The financial crisis has thrown ship enterprises into a struggle for survival with some landing on green pastures while others land on barren ground. That's a wake-up call for ship enterprises to the urgent need to stop and think about their path of development after the blind rush to expand in the last industrial boom and how to make sure they have the strength to counter market risks.

This process will see mergers and acquisitions as well as restructuring of ship enterprises, ousting the weak and incompetent, will open the door to resources integration and industry consolidation, and hence give the ship building industry in Jiangsu the opportunity to grow.

The Berth at the COSCO Nantong Shipyard Co

Line drawn between the strong and the weak

In the first quarter of the year, ship enterprises in Jiangsu completed 87 vessels with loading capacity totalling 3.463 million tonnes. Heeding the gloomy prospects of the international shipping scene and the ship building industry, Jiangsu has trimmed the output targets for all vessel types. Despite that, [newbuilding output] records show that major ship enterprises in the province including Jiangsu New Century Shipbuilding Yangzijiang Shipbuilding, Nantong COSCO KHI Ship Engineering, Taizhou Kouan Shipbuilding, Taizhou Sanfu Ship Engineering and Ming De Heavy Industry were all able to meet their annual output targets and deliveries were made on time.

These pillars of industry managed to thrive in choppy waters mainly because they have kept honing their strengths in recent years. They have come a long way, be it in their management systems, production efficiency, technological expertise or the ability to assess international market situations. Their management has helped boost production efficiency, allowing most of them to shorten the production cycle of their core vessel models.

For example, the docking period of 50,000dwt bulk carriers is maintained at 36 days and outfitting at berth turnover has been kept steady within 70 days with the fastest managed in 58, and the [berth cycle] for 4,250TEU container carriers is 45 days. They boast production efficiencies matching those of their Japanese and Korean counterparts and labour productivity consistently higher than the national average. Furthermore, these ship builders have deep pockets and high risk resistance.

A New Yangzijiang Shipbuilding spokesperson said unlike the small and medium ship builders, the major ship enterprises were all well prepared before the advent of the financial crisis. Apart from benefiting from an efficiency boost achieved through handling large orders of certain vessel types, listed ship enterprises have abundant capital to back

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their requirements. Moreover, major ship enterprises on average deliver more than 30 vessels a year, whereas the small ones often manage only three to four. Major players are maintaining the same production momentum as before.

The small and medium ship builders in Jiangsu are on the other hand rather susceptible to risks. The smallest glitch in the market leading to a funding problem for but one ship would shake their business and affect funding of contracts to follow, creating a vicious cycle. Jiangsu Soho International Group, for one, had to close its business because of poor management. It invested RMB700 million (US$110.7 million) in its business and five years later had to put its building berth on lease. The local government tried to arrange a merger and acquisition, however, with the company in heavy debts, CSC Jiangsu Jinling Shipping Co. decided to only lease the building berth and equipment. Yang Zhou Wan Long Shipbuilding Co. is also in trouble. Other than its current undertaking, which is a 2,000tonne floating crane, it has no new contracts in hand. And, it had made no delivery in the first five months of this year. A company source, who declined to be named, said the company is basically in a semi-idle state. The fact is many small and medium ship enterprises along The Yangtze River are in that same quandary. Plagued by poor management, with an order drought and funding difficulties, many of them are having problems in keeping production going.

Jiangsu SOHO Marine Co. and Wan Long Shipbuilding are not the only small and medium ship builders in Jiangsu province along the Yangtze and coastal areas, who are in trouble because their orderbooks are empty. After the financial crisis, some ship enterprises in the Guanhe estuary, Yizheng and Zhejiang areas have basically stopped production and their businesses have come to a standstill.

Zhang Jun, director of the shipping office at Yizheng, Jiangsu, said with more than half of the resources along the shoreline now in the hands of small ship enterprises, a reshuffling of the cards to oust some of them will be, to a certain extent, good for industry consolidation and restructuring of resources, as well as pooling industry professionals and capital, and ultimately help foster cohesion and the overall clout of the industry.

Orders lifeline

With respect to securing orders large ship enterprises enjoy a stronger risk resistance than their small and medium peers. This is clearly indicated in the new order statistics for the first quarter of the year in Jiangsu. In the quarter, the province booked orders for 41 new vessels with a total loading capacity of 1.276 million tonnes and the majority of them are in the hands of major ship enterprises and so are the high value-added contracts. COSCO (Nantong) Shipyard Co. has orders for a wind turbine installation vessel, a semi-submersible stable platform and the T18, which is an automatic jack-up drilling rig, for the Norwegian offshore oil drilling company Seadrill.

At the moment, after talking to the heads of different ship enterprises, big and small, it is obvious the topic they would rather avoid is the orderbook and those who do talk about it are cautious. They did not want to mention it because it's meagre. Many ship enterprises included state-runs have not received any new orders past springtime and those in hand for some of them will last only till the end of the year. Furthermore, ship enterprises would shy away from confirming tentative orders before pocketing the first tranche of payment.

Orders are the lifeline for ship enterprises; it is what puts bread on the table for the hundreds or even thousands of their employees and go as far as to decide the future – the life or death – of the enterprise. The scramble for orders has become a focus of ship enterprises. For, no doubt, ship enterprises would be dealt a fatal blow should orders dry up.

Compared with the large shipping enterprises, the small and medium ones have few orders. Most of them are actually "dragged under" by their orders and some are facing bankruptcy with no new orders in sight. According to sources close to Wan Long Shipbuilding, the company, after completing and delivering its current undertaking – a 2,000 tonne floating crane - will take over repair works for two vessels from a folded ship enterprise in Wuhan.

Two vessels will have follow up repairs and their engines tuned and tested by the company. Based in the same area as Wan Long Shipbuilding, Zhejiang Jiuzhou

New ships built by Jiangsu shipbuilding companies


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Bulk carrier built by Taizhou Kouan Shipbuilding Co.

Shipbuilding Co. is a small to medium private shipping enterprise which entered the industry in 2007. Its management said the company has not received any new orders since the beginning of the year and landed only four last year and is now working on just two 700tonne refuelling vessels. With few orders in hand, the company has to let go of many contract workers. The company, which is among the top 10 shipping enterprises in Yizheng, Jiangsu, had more than 900 contract workers when business was booming and now it has fewer than 300.

With market demand down, price competition getting fierce, funding tight and glitches in newbuilding deliveries, shipping enterprises making river boats at the lower end of the market are facing added pressure. The 13 riverboat builders in Yizheng completed new boats valued at RMB580 million (US$91.72 million) in all translating into sales revenue of RMB310 million (US$49.02 million) and profit of RMB1.11 million (US$1.76 million), a year-on-year drop of 11.2%, 13.5% and 8.3% respectively.

Together they have on staff 631 workmen, only 49.3% of the total in the same period last year, and most of them have been operating only one-fifth of the time with more than two-thirds of the building berths idle. Shareholding rows, debts, works halted because of lack of funds and labour disputes are all on the rise.

To date, three ship enterprises including Yangzhou Jinniu Shipping Industry Co., Ltd. and Yangzhou Changrun Shipbuilding Co. had gone bankrupt and four small ones have lost control of their businesses. Market sources said should orders dry up, the phenomenon of shipyards becoming idle for extended periods will spread, and with testing market conditions expected to continue next year and the year after, more and more shipping enterprises will close or halt production.

Breakthrough going with the tide

However severe the market situation is and whatever are the chances they have to make it through the tough times; shipping enterprises in Jiangsu are not throwing in the towel, but are taking the initiative to strive for breakthroughs.

Amidst order shortages and a drop in profitability, some shipping enterprises have chosen to shift their focus onto developing marine engineering businesses and specialised vessels, while others are looking at research and development and fine tuning company structure, and others have been working closely with vessel owners to optimise vessel functionality, hull form designs, structural layouts, engine performance and coatings, daring to use new technologies and materials.

These efforts have helped vessels stand out in fuel efficiency, emissions standards, dynamic sailing performance, harnessing the power of currents at the stern and low maintenance rates. More and more shipping enterprises have adapted to the new emphasis on energy efficiency, transforming themselves into green, low emission enterprises sharing the direction of development at large of the shipping industry.

Li Wei, director of the ship division at the Nantong Economic and Trade Commission, said some ship enterprises in the city have shifted their focus on to marine engineering

You Tong built by CSC Jiangsu Jinling Shipping Co.

and building specialised vessels, for example, with excess production capacity, DaoDa Heavy Industry (Group) Co. moved into finer market segments. Last October, working with IHC from The Netherlands, it built two 12,000m^3 self-propelled trailing suction dredgers. Taizhou Kouan Shipbuilding Co, while continuing to put out traditional products, has expanded its portfolio of specialised engineering vessels, and stepped up development and application of security, environmental protection, energy saving and anti-fouling technologies.

It has also been developing low carbon emission and energy efficient vessels to meet market demands as well as taking orders of marine engineering auxiliary service vessels and marine engineering service vessels. Through adjusting its product mix, the company has enhanced its core competitiveness.

Furthermore, another ship builder Yangzhou Guoyu Shipbuilding has kept perfecting its skills. It managed a breakthrough in addressing the problem brought about by a large hatch over the hold and shortened the time required to close the hatch. This achievement has given terminal operators greater convenience and added to the competitiveness of shipping companies.

Wang Shuai, general manager of Guoyu Shipbuilding Co., said ship enterprises should not just build according to design, but incorporate shipping operational concepts into production, in other words, optimise vessel models keeping in mind their practical applications as expected by their owners. Only ship builders who could do that would thrive and have competitiveness that lasts.

Qin Yan deputy director, Jiangsu Economic and Information Commission, said Jiangsu has topped list of provinces with the most vessel output in the country for eight consecutive years. Currently, it has a ship building sector with a pretty comprehensive industrial setup and enjoys integrated competitiveness in areas including raw material supplies, quality labour and having a complete production system.

Jiangsu has become an influential ship building region in the world. The 12th Five Year Plan period is critical for China to rise to become a shipbuilding power in the world and the province to grow to become the ship building powerhouse of the country.

In the current year, in particular, ship enterprises in Jiangsu have been able to remove hurdles to their business and make their best efforts to expand in the market while honouring delivery promises. The province plans to deliver vessels totalling more than 25 million tonnes this year. This latest shuffle of the cards will see Jiangsu advance at an accelerated pace towards the goal of becoming a major ship building province of the nation, the nation's ship building powerhouse. *NA*

Breathing easy

In an extract from a paper delivered at RINA's Environmentally Friendly Ship conference in February; Jasper Lavertu, assistant knowledge development, and Sabine van Nieuwenhoven, naval architect, both at Feadship (De Voogt Naval Architects), outline the intelligent propulsion system of Future Concept Breathe

Reducing the level of emissions and the operational costs go hand in hand and so efficient vessel designs are critical in today's market.

Feadship, a partnership of Royal De Vries Shipyard, Royal Van Lent Shipyard and design and engineering bureau De Voogt Naval Architects since 1949, offers fully customised yachts with, what the company believes is, innovative styling, technology and usability.

Innovations are the result of direct customer demands, but also from research and development within Feadship itself. The results are presented each year at a concept design. Future Concept Feadship inspires customers and provides insight into future trends in yacht building.

Feadship's naval architects were behind the revolutionary Breathe concept (figure 1), which reduces fuel consumption by 20 to 40% at cruising speed. The system is remarkably simple and deploys a minimum of components. The hull shape is extraordinary and designed to provide a minimum of resistance, with the centre of buoyancy far aft. The Wave Damping Aft body creates negligible stern waves and reduces resistance. The propulsion system has only one main propeller, making the most of the very latest innovations.

The propulsion arrangement (figure 2) features an electrically driven contra-rotating azimuth sternthruster (azipod) in line with a single shaft main propeller at the centreline. One medium speed diesel engine is mounted in the engine room. Furthermore, a power take-off/power take-in (PTO/PTI) is installed to convert hydraulic power to electric power and the other way round. Two rudders are installed for steering.

The single shaft propulsion concept provides less appendage-related drag. Propulsive efficiency is maximised by applying a large diameter main propeller, a contra-rotating azimuth sternthruster, and a medium speed main engine. The combined effect results in a reduction in fuel consumption of about 40% at a cruising speed of 14knots and approximately 20% at a top speed of 16knots.

Reliability is ensured by the azimuth sternthruster providing sufficient speed for getting home should the main engine malfunction. The main engine and generators are separated in distinct watertight compartments, guaranteeing constant propulsion in case of a fire or damage to one of the compartments. Should the main engine, gearbox, shaft line or main propeller fail, the azimuth sternthruster and rudders can be used for sailing and steering. In case of failure of

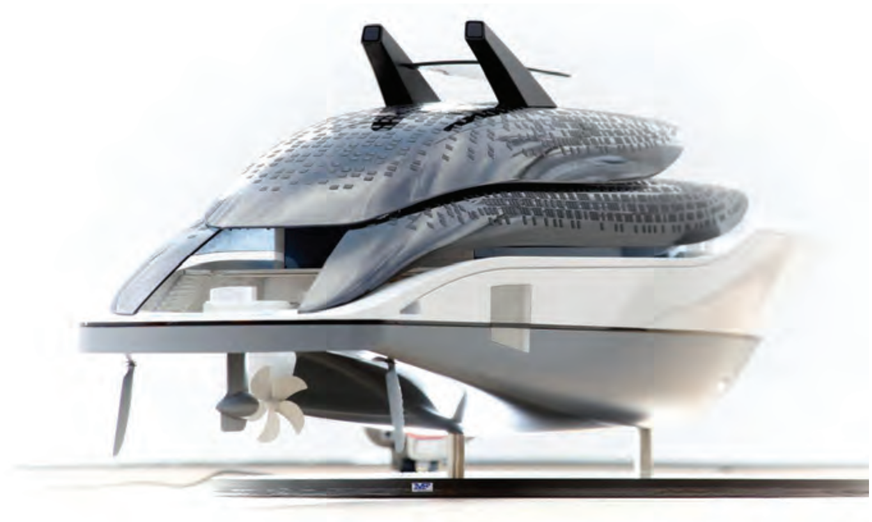
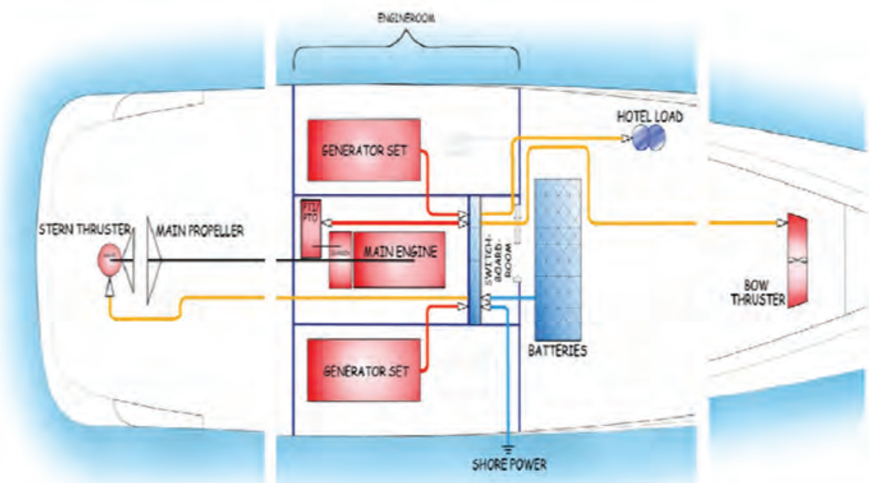


Figure 1: The Breathe concept

Figure 2: Propulsion arrangement



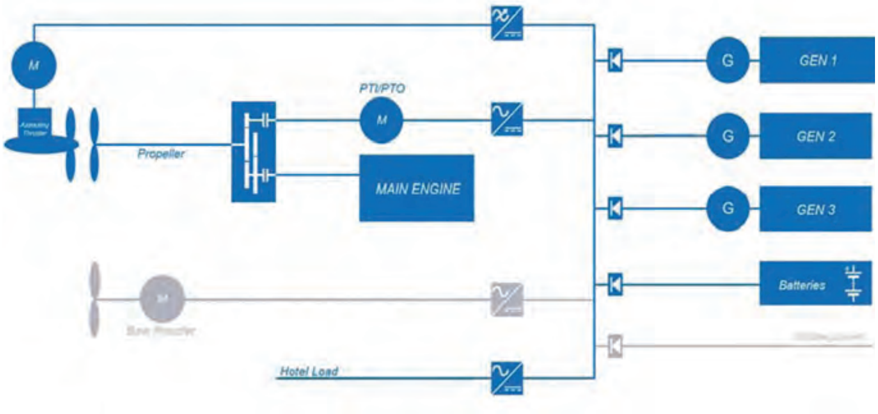


Figure 3: Basic propulsion principle

the azipod or electric drive, sailing and steering will be achieved with the main propeller and rudders.

Operational modes

Several propulsion and manoeuvring modes are identified. The basic propulsion principle is shown in figure 3.

The system is designed for diesel electric manoeuvring and sailing up to a cruising speed of 14knots. This means the yacht can leave port and sail without having to start the main engine. Diesel electric power is quieter and much cleaner than diesel power alone. In this mode the forward main propeller is driven by the PTI on the gearbox, whereas the aft contra-rotating propeller is driven by the generators.

In range mode, the forward propeller is driven by the main engine. A diesel-direct-powered main propeller results in lower electrical losses compared to a diesel electric powered main propeller. The aft propeller is driven electrically by the PTO, which is controlled by the main engine.

In maximum speed mode, the combination of the main engine and the generators provide the power for both propellers to reach a speed of 16knots. In speed sprint mode, the batteries are also engaged to provide additional propulsive power.

As the large sternthruster can be rotated 360degs, it provides excellent manoeuvrability in port or at slow speeds. Manoeuvring is possible with the azipod alone or with the azipod and main propeller. In the latter case the azipod can be fixed at an angle of 90degs to provide sideward thrust in both directions and the main propeller used for forward and reverse thrusting.

During normal sailing the yacht will steer using only the two rudders. The azipod will be fixed at centre position to avoid any disturbance to the flow and reduce the risk of cavitation and vibrations.

In rough seas where higher steering forces are required, the azipod will assist the rudders. In this steering mode the steering angle of the azipod is restricted to 5degs to avoid major disturbances of the flow. In even more extreme conditions the power on the main propeller could be reduced and the power on the azipod increased. Larger steering angles on the azipod could be acceptable with this power distribution. Maximum speed will be reduced in this mode.

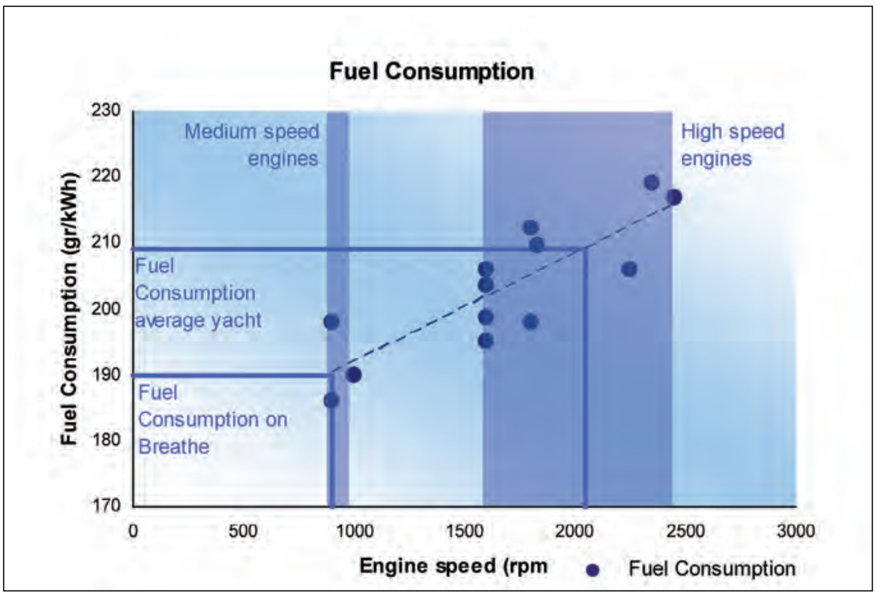
Main engine

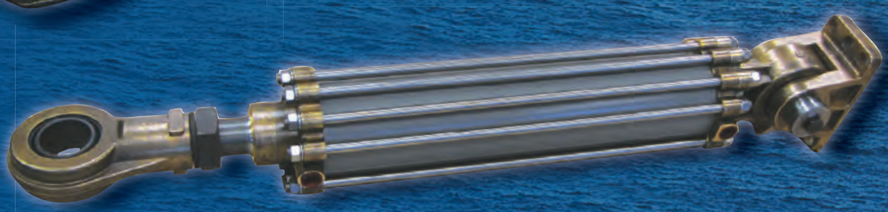
Power is produced by a single larger, heavier yet also more efficient medium speed diesel engine. Medium speed engines consume about 9% less fuel compared to their high speed equivalent (see graph 1). The main engine is not only used for direct propulsive power, but also to supply electrical power to the sternthruster and hotel load via the PTO. The main propeller is therefore driven by the main engine or electrically via the PTI, or by a combination of the two. The power supply for the electrically driven azimuth sternthruster is provided either by the generator sets or by the PTO, or by a combination of the two. Additional electrical power can also be provided by the batteries.

Hull efficiency

The hull has a slender foreship combined with a remarkably shaped aft. The stern is wide, with a small bilge radius, and with the centre of buoyancy located far aft. This hull shape creates a smaller deep wave trough, smaller transom waves and negligible aft shoulder crest waves. This so-called Wave Damping Aft body, as previously published by Hämäläinen [1], is better for the environment and

Graph 1: Engine speed versus fuel consumption





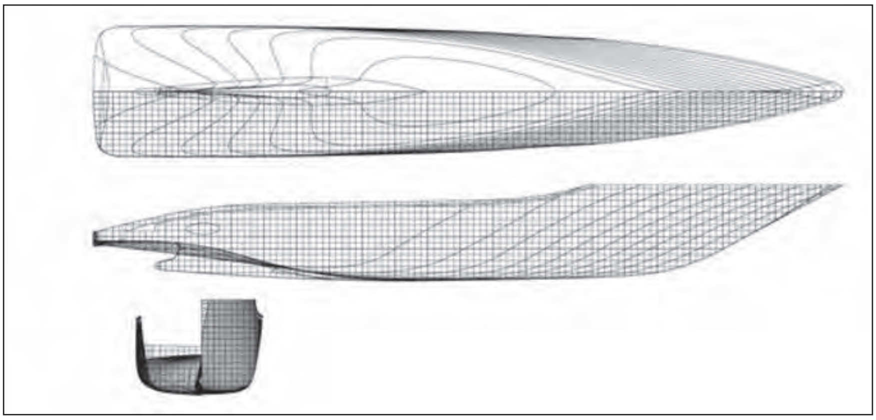
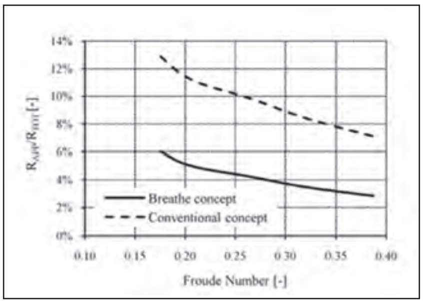
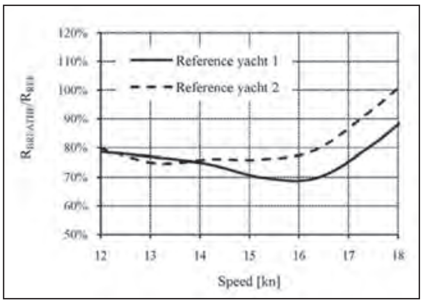


Figure 4: Breathe's hull lines



Graph 2: Appendage drag reduction



Graph 3: Total resistance gain

generates less resistance. See figure 4 for the hull lines.

The propulsion arrangement is characterised by a single shaft main propeller. The single shaft line is protected in a hydrodynamic gondola. The use of a single shaft and the absence of exposed shaft lines and brackets results in far less appendage drag compared to a conventional twin shaft configuration. The estimated reduction in appendage related drag is derived from a comparison made between the Breathe concept and a conventional propulsion concept at equal Froude numbers. Graph 2 shows that the appendage drag is reduced by approximately 50%.

The total resistance of the Breathe concept, calculated with designated computer software, is compared with two reference yachts at equal Froude number range. Moreover, the reference yachts are scaled to a corresponding displacement. Graph 3 illustrates that due to the reduced appendage drag and the improvement of the hull shape, a reduction in resistance of approximately 20-25% is possible up to a speed of 16knots.

Contra-rotating propellers

The hull has a tunnel-shaped aft ship to accommodate the hybrid propulsion, consisting of a main screw with large propeller diameter and an azimuth contra-rotating sternthruster. The bigger main propeller diameter is capable of transmitting the same power at lower shaft speed and lower propeller loading, and is therefore more efficient. Sufficient hull-propeller clearances are maintained to minimise the effects of propeller-induced pressure fluctuations. Normally Feadship maintains a clearance of about 25%-30% of the propeller diameter. However, due to the lower rotational speed of the propeller, a reduced clearance of 20% seemed reasonable without negative impact on noise and vibrations.

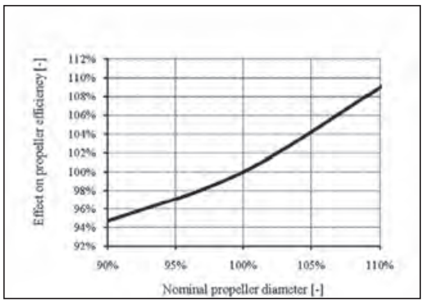
The effect of the propeller diameter on the propeller efficiency is shown in graph 4. The propeller diameter of the Breathe concept is roughly 5% larger than a conventional design; hence an increase in efficiency of 4% is expected.

In line with the main propeller, a contra-rotating azimuth sternthruster is installed. To take into account the convergent wake of the main propeller, the propeller of the azimuth sternthruster is slightly smaller. The principle of contra-rotating propellers is described in depth by Holtrop [2]. The gain in propulsive power of contra-rotating propellers must be found in a cumulative favourable effect from a reduced viscous loss and a recovery of the rotational losses of the forward propeller.

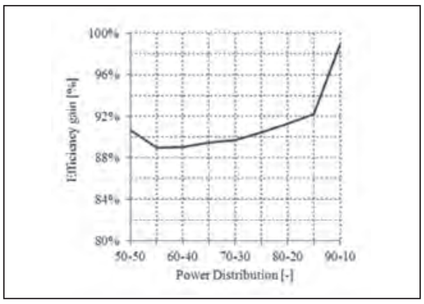
The viscous losses occur due to frictional drag of the propeller blades. A reduced viscous loss can be obtained by a lower rotational speed of the main forward propeller, hence a higher pitch. This results in an increase in the rotational losses. Rotational loss arises due to the rotating motion in the wake of the main propeller. Since the contra-rotating aft propeller is capable of cancelling almost the full rotational losses, the reduction of the rotational speed offers an increase in efficiency.

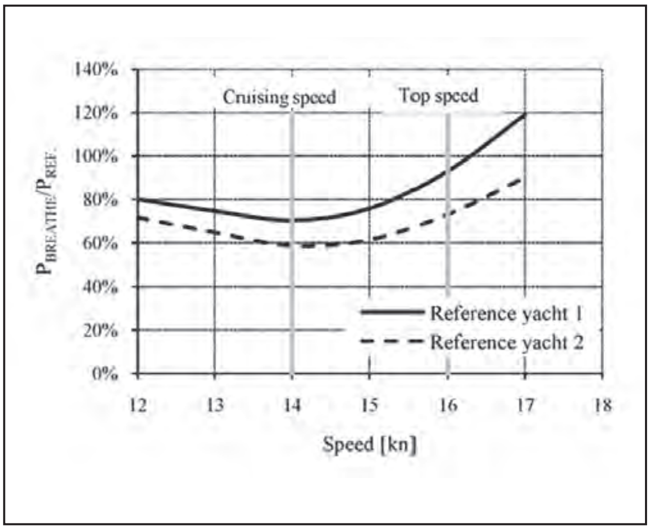
Due to the higher electrical losses of the electrically driven contra-rotating sternthruster, the total efficiency of the contra-rotating propellers depends on the power distribution between the two propellers. In graph 5 the efficiency is calculated for several power distribution combinations. As the contra-rotating propeller pair, a total increase in propulsive efficiency of approximately

Graph 4: Propeller diameter versus efficiency



Graph 5: Total propulsive efficiency





Graph 6: Total power gain

10% is to be expected with the Breathe concept compared to a more conventional design.

Total power gain

The total gain in power due to hull efficiency and contra-rotating propellers is compared with two reference yachts. The expected fuel consumption of the Breathe concept at various speeds is derived from results of model tests performed in the deep water tank at MARIN. These figures are compared with actual data from the sea trials of two reference yachts. For the differences in displacement of the two reference yachts, the fuel consumption is corrected using the Admiralty coefficient method. Graph 6 indicates that the total gain in power is approximately 30-35% at a cruising speed of 14knots. At a top speed of 16knots the gain in power is approximately 10-15%.

Conclusions

The hull of Future Concept Breathe is designed to provide a minimum of resistance. Moreover the single shaft propulsion concept provides less appendage related drag. Propulsive efficiency is maximised by applying a large diameter main propeller, a contra-rotating azimuth sternthruster, and a medium speed main engine. The combined effect results in a reduction in fuel consumption of about 40% at a cruising speed of 14knots and approximately 20% at a top speed of 16knots. Reliability is ensured by the azimuth sternthruster providing sufficient speed for getting home, and the separation in distinct watertight compartments of the generators and the main engine to guarantee constant propulsion. *NA*

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Going green for yachts

Future IMO exhaust emission regulations will not just affect commercial vessels, but will also impact smaller markets such as the yacht market. However, the yacht industry is preparing itself for the green challenges that lay ahead

The biggest challenge faced by today's yachts is the IMO's MARPOL Annex VI 2008 Amendments. The dual approach chosen will introduce new sulphur requirements in fuels; moreover, its Tier III regulation will see a tight cap on emissions from nitrogen oxides (NOx) for vessels that will operate in emission control areas (ECA's) from 2016. Less stringent Tier II regulations will still apply for vessels operating outside the NOx ECA's.

Udo Kleinitz, technical manager, International Council of Marine Industry Associations (ICOMIA) says that to meet the regulation owners and manufacturers are looking at four different factors to make sure a vessel meets the standard. "It is a very complex standard being a combination of fuel requirements and exhaust emission limits, applicable globally and locally in ECA's."

The particular emission limits for NOx in ECAs as set through Tier III come into effect in 2016, but Kleinitz believes there is still a lot of development work to be done by manufacturers for products to be able to meet this requirement easily. "Technical feasibility of meeting the new requirements is not the issue. From today's perspective Tier III is possible to meet likely through engine exhaust gas after treatment. The applicable process is called selective catalytic reduction (SCR). However, this option will require much more space in the engine room with unknown implications in the operation of these systems. This could put the commercial viability of these vessels at risk (since most of them include being operated in charter).

Further, Kleinitz notes that the US presents the only NOx area so far, whereas other ECA's such as the North Sea/Baltic/English Channel region are SOx emission control areas (SECA's). The MARPOL Annex VI regulation also includes the reduction of SOx emissions, which by 2015 will need to be reduced to 0.1% in ECAs and from 2020 0.5% globally. Anything that is operating outside of the US ECA will need to comply with Tier II requirements, but will need to meet with the SOx requirement by burning low sulphur fuels, he explains. Currently it is unclear to what extent areas in Europe are envisaged as future ECAs for NOx.

ICOMIA along with David Elson of the British Marine Federation (BMF) has run a study looking into how yacht owners and designers can make their vessels comply with the standards for reducing both NOx and SOx emissions and what technology is on offer. Kleinitz says that for this it has consulted engine manufacturers on how best to prepare for Tier III. He believes that the most cost effective solution is to install integrated systems which, at least provide a certified combination of engine and aftertreatment under warranty of the engine manufacturer. "This appears to give more flexibility in reducing size by optimising the correlation between after-treatment and engine. Options to look at are e.g. backpressure increase, installing SCR between turbochargers, combining with in-engine solutions, SCR-silencer combinations … etc. It also removes the burden to certify individually purchased engine/aftertreatment system components by the yard and is cheaper if done by the engine manufacturer on type approval basis."

There are other options under discussion, but it is unclear whether they will be fully developed and reliable by 2016. "We have to assume the worst case scenario from a space demand perspective and this will be SCRs installed in yachts."

However, the study by ICOMIA and BMF points out that the engine and catalyst manufacturers need to understand in more detail the specific restrictions that yacht arrangements cause. There is potentially considerable flexibility in the design of these systems and there may be options to change catalyst shape, size, lengths etc. and there are many variables that influence this design. "But there are also a number of questions still to be answered. A main contributor to the SCR size is the quality of fuels used. If a propulsion system could be run on low sulphur fuels (such as used in road applications in the US and EU) the catalyst size would be significantly smaller. A possible solution to keep SCRs small could be yards, together with engine manufacturers, agreeing a maximum sulphur content guaranteeing the operation of the SCR."

Further, the design of an SCR system is not straightforward and over-simplifying the process to provide generic installation guidance can risk missing key parameters. Factors such as flow rate, NO_2 content, temperature, pressure drop etc. all have a significant impact on the configuration. From initial studies and SCR implementation projects it also appears installing an SCR in an already tight engine room is one issue, servicing and maintaining it could actually become a real challenge for designers and operators. Many of the available installations will not suit the requirements of the yacht industry. SCR developers and engine manufacturers need to understand the size of the market and the specific issues that the industry faces (an articulation of needs), and decide if the sectoral demand is large enough to justify specific yacht type catalysts.

In 2009 BMT Nigel Gee started a broad literature search looking at different types of emission treatment on the market such as SCR's, NOx scrubber systems, and lean NOx catalysts to name a few. BMT also engaged engine manufacturers to understand the likelihood of Tier III compliant engine solutions being developed. Through this process BMT concluded that it wasn't prudent to rely on the manufacturers to deliver a solution and that SCR's were the only robust technology that could be relied on to achieve Tier III requirements. BMT continue to maintain that position with the way that the market is positioned in 2012.

BMT Nigel Gee spoke to high-speed engine manufactures: "We spoke to engine manufactures but they didn't really want to discuss anything in detail, apart from one, MTU, who were quite open. The others were quite guarded and manufacturers are playing their cards close to their chests. But, manufacturer's not talking about potential systems for the future is not helpful for yacht designers and builders planning for the future", says Shallcross.

The industry is looking at other solutions such as gas based/dual fuel engines which will help reduce NOx emissions, but unlike a ferry which travels between two destinations a yacht has a wider area of travel and so would need global bunkering facilities. Additionally there are only a few high speed engines on the market that can run on dual fuel installations.

He adds that prudent yacht designers who are designing vessels now that will be built from 2016 on need to leave space for extra equipment that may need to be installed. Shallcross highlights that SCR technology is there with a proven land based record (some modern family Diesel Cars are even fitted with them) and the list of marine installations is increasing. "It's important to recognise that the solution has to be customised to the engine, factors such as back pressure limits, lube oil consumption and ash generation need to be considered when selecting the equipment", says Shallcross. It's also important to define the fuel grades that the vessel will bunker with. Higher sulphur levels have a direct impact on the catalyst chemistry.

The wider systems issues also need to be considered, these installations consume significant quantities of compressed air which are likely to drive changes in the vessels systems. Tank volume and systems will need to be provided to store and deliver the reductant, typically an aqueous urea solution, which doesn't mix well with carbon steels. It should also be noted that these systems add little attenuation to the vessel and designers will still need to incorporate traditional silencing methods.

However, even with the technology at hand the main challenge for designers will be to create the space inside of the yacht to install it. "The reductant mixer pipe (used to introduce and mix the reductant into the exhaust gas stream) on an SCR unit is usually longer than an engine, but long engine rooms adjacent to large tender compartments (a typical arrangement on yachts) are challenging from a damage stability perspective", says Shallcross. The dual challenges of long reductant pipes and maintaining serviceability of SCR's makes the arrangement of equipment within engine rooms challenging.

Shallcross says that the regulations will be problematic for both the larger and smaller yacht market and there is unlikely to be any delay to the scheduled introduction in 2016 as proven technology is already in the field. ***NA***

SeaKing enters yachts market

UK-based SeaKing electrical engineering firm has fitted out two yachts

SeaKing has moved into the yacht market after working on projects for Svitzer. Neil Mellenchip, group business development manager, SeaKing says that the yacht market has appeared less affected than other markets by the recession and is an interesting market, particularly for upgrades.

The company was involved in *Kogo*, a four month drydock project where SeaKing worked onboard the vessel. "This was a terrific contract to work on which really showcased the range of services we offer to the super yacht sector, which is a key growth sector for us," says Mellenchip.

The company sent six marine technicians to work on the *Kogo* upgrade which was a complex and demanding job. Work included the installation of helicopter landing lights, Earth monitoring systems as well as CCTV, WiFi and alarm networks. Other new equipment installed included an advanced DALI lighting system and a Bridge Navigational Watch Alarm System.

"We were also responsible for upgrading the onboard Crestron control, media distribution and entertainment network with a brand new KNX system. Further work saw modifications to guest cabins, bridge wings, air compressors, the air handling plant and the ships lift. In addition SeaKing was responsible for the calibration of the ships combinators," he says.

SeaKing has also carried out work on the yacht, *Solemar*, which involved a refit of its fire detection system.

Mellenchip highlights that work within the yacht industry is done very much by personal recommendation and believes that in the future this market will hold a lot of potential for the company. SeaKing's main service is that of system integration, which includes lighting power, telecoms/sat comms/radar.

"The complexity of super yacht equipment is increasing each year," he says. "It is vital that any electrical technicians involved with this sort of work have a thorough and complete understanding of product application and the installation process." ***NA***

RINa grasps the environmental challenge

More stringent environmental regulations lay ahead for the shipping industry that will also present challenges for the affluent mega yacht industry

In 2009 Registro Italiano Navale (RINa) launched its GREEN PLUS notation which is granted to new vessels that make a significant investment in design solutions. Those solutions include onboard equipment and operational procedures which contribute to an improvement in environmental performance beyond the minimum levels required by international regulations on environmental protection.

The goal-based voluntary notation is based on an environmental performance index which covers all aspects of the vessel's impact on the environment, including carbon emissions.

At the time Ugo Salerno, CEO of RINa said: "Yacht owners seek the ultimate in performance using the most modern materials and technological innovations, and they are prepared to invest in the most innovative green technologies to ensure their yachts achieve the highest levels of efficiency and the lowest possible environmental impact." He added: "This will encourage the introduction of new technologies, which RINa experts will evaluate on a case by case basis. That is where RINa's GREEN PLUS standards come in."

Today the notation is becoming a popular goal for yacht owners and makers with two yachts being constructed at Italian shipyards being awarded the notation this year. Paolo Moretti, general manager marine, RINa commented: "The 50m yacht *Better Place,* constructed by Wally is the biggest carbon fibre hull and is the first of its type to be awarded for green classification. This is because it has the possibility to sail without engines [using sails], but also has electric propulsion." The second yacht being constructed at Rossi Navi shipyard has been awarded the GREEN PLUS Notation due to the environment systems and design features that have been installed onboard, such as lube oil spillage prevention and optimised hull form.

Moretti says that the market is seeing interest in yachts being more fuel efficient. "The fuel cost is something to think about. When you consider larger yachts, it's for the designer and shipyard to make a sustainable design." He also says that with regulations not impacting hard until 2015, many designers are not thinking this far ahead at the moment for yachts. This he noted is due to yachts not using heavy fuel oil and using different fuels, so that the yacht industry will need to comply, but further down the line.

Paolo Moretti, general manager marine, RINa highlights how green regulations will impact the mega yacht market

"We are seeing that certain nationalities are more concerned about the environment. It is different for a yard that makes a series of yachts as they take charge of the design. It is larger specialist yachts, where you see the designer/owner have more control over what is being installed", he added.

Safety

Developments of the passenger yacht code, has seen the code being revised. Moretti says that the base limit of 2000gt was already "out of fashion" almost when it came into effect, due to some of the large yachts that are being constructed today. The industry is pressing on regulators to keep rules up to date. "It's a good counterpart to create new rules and create a big change, which now will make them pretty much in line with passenger ships", he said. Shipyards and designers now have to involve classification societies more in large yacht designs.

What he has also highlighted is that this change has also brought about interest from suppliers, which are now getting involved in the process and are getting their products tested to IMO standards. Also, suppliers are challenged by creating not just safe but aesthetically pleasing equipment for mega yachts, Moretti highlights that if you are paying a large sum of money for a yacht you want things to look nice on it. However, he points out that: "You start putting pressure on manufacturers then they can come up with solutions and what we see now is that those ideas are starting to come through."

Future developments

The market has seen a slight increase in yachts over 30m and there is currently a good market for the 40-50m range. However, the segment of work vessels and pleasure yachts under 30m is stagnant. "We are in a period where contracts are being signed, but not much is being signed at the moment. It has been almost three years [since the recession hit the market] and now it's even worse. It is going to be a crucial year as shipyard order books are drying up and it will be a case that either contracts will be signed or the yards will close."

The challenge for the superyacht and mega yacht industry in the future is whether it will be capable of meeting the Tier III emission reduction regulations by January 2016. Moretti says that if manufactures cannot meet this limit then it will impact on yachts of 400gt plus, which is a threat." He added that: "The industry is really having to follow the regulations now and not just consider them. Some designers and yards are preparing, moving well in advance of the deadline." *NA*

Rooted in Victoriana the FSP21 is a ship for Elizabethans

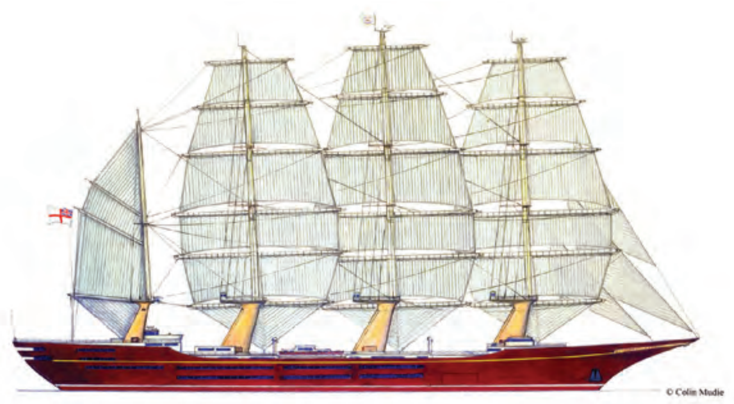
Last month saw the Diamond Jubilee of Queen Elizabeth II and with that a new Royal flagship design, Future Ship Project for the 21st century (FSP21comes), which is claimed to be the largest and most modern square-rigged education and adventure training and research sailing ship in the world

When HMY *Britannia* was decommissioned a body called the Cadland Trust, now named The Future Ship Project for the Twenty First Century (FSP21), was established to promote a vessel to succeed it with a national sail training ship. Naval architect Colin Mudie, helped the trust design a concept which over the years has developed into the 198m barque rigged national flagship.

The basic requirements specified a recognisable sailing ship suitable for worldwide operation in a non-confrontational role. The vessel will be able to accommodate 220 students with onboard facilities for training and research to University levels. This they will do in addition to their crewing duties in sailing the ship. Mudie highlights the advantages that it will give to the trainees: "It will bring intercommunication between communities. We have heard and seen some wonderful experiences from trainees that have taken part in previous foreign exchanges."

As the ship is the biggest sail vessel that will have ever been constructed there were some difficulties to overcome, as Mudie mentions: "The size of the vessel was a challenge as it is so big. However, we do have some advantages over the previous Victorian style. The Victorians were marvellous designers, but were restricted by their tools. Today we have both [designers and tools]."

An important factor in the design of the vessel is how to make the ship sail windward in light winds. The development of the necessary side force at low hull speeds by the hull form is an essential factor which, kept something of a limit on ship length. The vessels speed is not designed to compete with other modern fast ships, but the sail plan is an important part of the vessel's performance. Combining this with the need for reliable harbour and close quarter handling, with the possibility of azimuth thrusters as the power propulsion.



FSP21 could be a replacement for HMY *Britannia*

Another interesting feature of the vessel is the development of photo-voltaics (solar cells) woven into the sail canvas. Mudie says that the power could then be stored in batteries or hydrogen as a fuel for the diesel generators. "The vessel will have twin azimuth thrusters, nine diesel-electric engines, with nine generators and probably a battery pack to store the solar energy, which can supply over a day's needs to power the hotel loads and a sailing speed of 24knots in neutral winds", said Mudie. He also highlights that the battery bank is also natural sailing ballast.

The interior of the vessel will be made up of a box construction that is planned to form an internal structure with a cladded skin. This will also allow easier refitting of the vessel later on. There will also be a structural cohesion from the mast plinths down to the battery area with a major factor being the use of the Jeffery's tubes through the accommodation area. The tubes will contain all the ship's systems engineering and will be maintained from within. Individual cabins and other units will be able to "plug in" to the Jeffery's tube allowing more space for the layout of the decks. "The sail drop has been reduced to 45ft, which has allowed more space to be used on deck as well", added Mudie.

Adding to the green technology that has been included in the design Mudie also noted that the trust has also spoken to the UK's Maritime Coastguard Agency (MCA) with regard to the design. He has said that the MCA has shown a lot of interest in the design as it may help them to improve their own regulations. "One area is that of bulkheads, we may not use them, but instead use watertight boxes", he said.

As yet the project is in the preliminary stages, still waiting for further financial backing to get the go ahead. It is hoped that the vessel will be constructed in the UK, although tenders for the construction should it go ahead will be open to all. For this the trust has identified three places where the assembly may take place. It is expected that it will take in the region of 18 months to construct the vessel.

The vessel's role would be to provide the nation with a ship that will set standards, for technical and environmental research. The vessel will also be used by heads of state, Mudie says that this may not be just for UK heads of state. He also comments that the vessel will be suitable for disaster relief and could even be used as a mobile hospital. *NA*

For Queen and Commonwealth

Ideas for the replacement of the 'Royal Yacht' have not been lacking, as another vessel design is laid down on the table by advertising entrepreneur Ian Maiden and designed by Jon Bannenberg

The latest proposal is for a 127m motor yacht that would be crewed 80 Commonwealth members and designed to sail as a Commonwealth flagship. Maiden believes that a Commonwealth flagship would bring huge benefits to Commonwealth countries, in helping trade and to exhibit their exports, and for training and education. He says that the usage of the ship by the royal family would add prestige but, would take second place to the ship's main focus.

"The principal objective for the new yacht is that it should be used primarily as a touring 'Flagship' for Commonwealth member states in the promotion of trade and enterprise. The brief for the ship was to design a vessel with *Britannia* 'DNA', that didn't have a chopped off stern like you see on some vessels today and would be leaner and fitter, by that I mean have less crew onboard and have more working space", says Maiden.

The ship itself will be a showcase for the latest technical innovations coupled with imaginative aesthetic and artistic contributions drawn from Commonwealth countries. Maiden highlights that times have changed and that a new royal yacht as such is no longer in keeping with the mood of the country, particularly in these difficult economic days.

Having said that, he still believes that it is right and proper that The Queen as head of the Commonwealth and also head of state should have access to a secure vessel for state and other official needs in home waters and overseas.

The design for the vessel was originally drawn up in 1999, the idea at the time was that it was to replace *Britannia* and to be a motor yacht. Jonathan Strachan, deputy managing director, Burness Corlett Three Quays (BCTQ), says that: "The yacht is more like a passenger vessel and one of the challenges is trying to get a yacht to work as a passenger ship." The vessel will also have azipod propulsion to give it better manoeuvrability.

Rendering of Commonwealth Flagship

Since the design of the vessel there has been a flurry of environmental regulations to make vessels more environmentally friendly. Strachan notes that at the time of the vessel's design it was not envisaged that there would be new environmental regulations coming into play. Also, when it comes to the energy efficiency design index (EEDI) the vessel will not score as high as a cruise vessel, that has the capacity for more people, but Strachan comments that the commonwealth vessel has a different purpose. "We can look at alternate fuels and environmental systems onboard, as we are quite willing and capable and the regulations are pushing us further in that direction", he says.

The design of the vessel is still in its early stage with a general arrangement (GA) plan and hull form that has so far been designed. Strachan says that the next step: "Is for someone to instruct us to get the design priced up. Then it's down to whether the price fits with the funding available." Tenders would go out to UK shipyards as well as overseas yards, but Strachan highlights that it would be good if the vessel could be constructed in the UK.

The build cost of the Commonwealth Flagship is budgeted at £100 million including a contingency allowance of £15 million; while the useful life of the vessel will be 60 years. Maiden says that the cost would not fall on the British taxpayer. The major proportion of the build cost would be offset by Commonwealth members.

He adds that each Commonwealth state has its own particular national resource and by contributing 'in kind' they would each be identified in a tangible manner with the objectives of the programme. Examples of this is steel and component assembly from India, timber from Ghana, aluminium from Canada, electronics from Singapore, fabrics from African states, and hull assembly from Britain. *NA*

TECHNICAL PARTICULARS	
Commonwealth Flagship	
Length oa:	127m
Length bp:	107m
Breadth mld:	18m
Depth	
Main deck:	7.80m
Upper deck:	10.60m
Design draft:	5m
Crew:	80
Passengers:	50

MARIN develops new propeller series

Dr. Ir. Jie Dang, senior project manager, Ships Department, MARIN explains the development of the latest propeller series from Marin, the Wageningen *C* and *D* Series

Different from fixed pitch propellers (FPPs), controllable pitch propellers (CPPs) are well-known for their advantages when utilised at full power in any circumstances: accelerating and stopping; rapid manoeuvring; dynamic positioning (DP); etc. For these reasons, CPPs are widely used for multi-purpose vessels where their propulsors are often used in off-design conditions.

In order to predict the performance of a CPP in off-design conditions, people have to either carry out dedicated and expensive measurements for a specific propeller design, such as is often done for navy vessels, or rely on the estimated values from the existing four-quadrant open water data from the *B*-series, which were primarily designed for merchant ships with FPP blade forms.

Scarce information is available in the public domain for the complete two-quadrant open water characteristics of CPPs, especially when the propeller blades are deflected away from its design pitch (Yazaki 1962, Chu et al 1979). In the Wageningen series book (Kuiper 1992), off-design information is only available for two CPPs in ahead and astern conditions, one with a design pitch ratio of zero and the other of one.

With the booming business in oil exploration in recent years, accurate prediction of the off-design performance of a propulsor becomes more important than ever, especially in the requirements for DP operations. Dedicated tests for each propeller design is unaffordable for most of the projects, while the existing limited information is far less than enough. There is a strong demand for developing a new contemporary CPP series with complete information of their off-design performance.

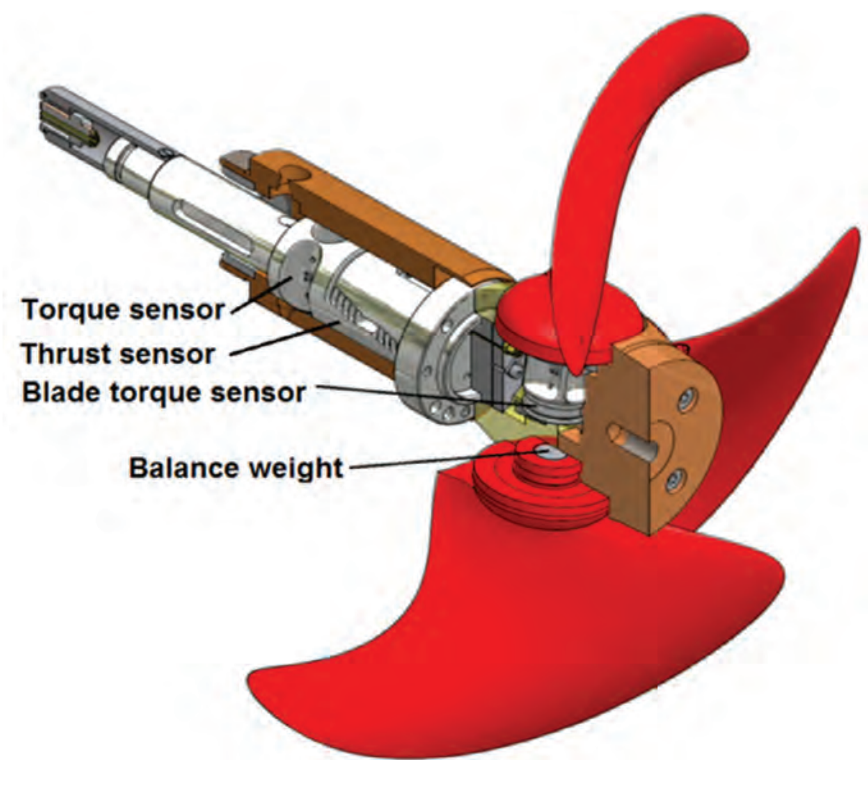
In addition to these, a CPP blade has a completely different blade form compared to an FPP. This is because more practical issues need to be considered for a CPP, such as the blades must be able to pass each other from positive pitch to negative pitch; the blade must sit on the blade foot between bolt holes; that the blade overhang at the blade root is not preferable to prevent stress concentration; that the blade tip must not touch the inner side of a duct at any deflected pitch angles for the ducted CPPs; etc.

Within all of these, one important and unique thing is the blade spindle torque of CPPs (Pronk 1980), where very limited information can be found (Chu et al 1979, Ito et al 1984). To the knowledge of the authors, there is also no CPP series with systematic information on the propeller blade spindle torque at all possible blade pitch settings (from full positive pitch to full negative pitch and over the complete two quadrants).

With the strong demands from the industries and by taking into account the fact that CFD calculations are not yet accurate enough and needs still to be validated against model test results, from the beginning of 2011 MARIN started to consider, together with the universities and the industry, the possibilities of developing a new CPP series. In September 2011, a Joint Industry Project (JIP) was officially launched, which is called the Wageningen Propeller *C*- and *D*-series for both open and ducted CPPs. Here the *C* stands for controllable and the *D* stands for ducted.

Dedicated sensors have been designed and manufactured to measure the propeller thrust, the torque on the shaft and also the blade spindle torque on one blade – the key blade. The blade transducer is special designed and capable to measure the spindle torque on the key blade with a negligible disturbance of the thrust and torque forces which, provide

Figure 1: Propeller shaft thrust and torque sensors and the blade spindle torque sensor



bending moments on the transducer at the same time. All the sensors are shown in Figure 1.

Conducting propeller series tests for the complete two quadrants, especially at different pitch settings for CPPs (typically more than 10 pitch settings are needed between full positive and full negative pitch), is not affordable in the present economic situation.

New test technology needs to be developed in order to reduce the cost significantly. This has been made possible by the rapid development of sensor technology in the past decades, which makes dynamic measurement possible at higher frequencies with rapid response. This leads to the idea of a quasi-steady test technique for propeller open water characteristics.

Quasi-steady test techniques have already been used for the propulsion tests in the towing tank of MARIN for some years (Holtrop and Hooijmans 2002). However, quasi-steady propeller open water tests have never been explored in the past. Under support of the Wageningen *C*- and *D*-series JIP, a pilot study has been successfully carried out, which proves that the quasi-steady test results are as accurate as the conventional steady test results, while reducing the test time by a factor of eight to 10.

A quasi-steady open water test is, in principle, an unsteady model test by continuously varying the advance speed and/or the rotational rate in order to obtain the steady state performance of a propeller. For the present study, we have proposed the following four test runs in order to cover the complete two quadrants, as numbered in Table A.

This proposal makes it possible to test the complete two-quadrant open water characteristics of a propeller in only four test runs, using two runs by varying the towing speed of the carriage and two runs by varying the shaft rotational rate where sinusoidal variations are used.

Three hysteresis effects have been identified during a quasi-steady test. They are the hysteresis effect due to the mass and mass moment of inertia of the propeller, including also the added mass effects; the hysteresis effect due to the unsteady hydrodynamic flow around the propeller, mainly the vortex shedding to the propeller wake, both spanwise and also chordwise; and the hysteresis effect due to flow separation and re-attachment.

With light material for the propeller blades – aluminium and well-control of the speed variations, those hysteresis effects are either cancelled by averaging the sampled values during the increasing and decreasing speed, or small and negligible.

An example of the quasi-steady test results by using a MARIN stock aluminium propeller at design pitch is shown in Figure 2 where a comparison has been made between the quasi-steady test results (the solid lines) and the conventional steady test results (the dots) with their 95% occurrence intervals (the +'s above and below the dots).

At present, 24 participants have joined the JIP and the JIP remains open for participation. The budget made available from the new participants will be used for extension of the series or for the post-process of the data. At this moment the series consists of the following 32 propellers with contemporary CP

Table A: Quasi-steady test runs for the complete 2-quadrant open water characteristics of a controllable pitch propeller

run	shaft rotational rate	advance speed	β range
1	constant +nmax	0 to +Va max to 0	0 o to ~+30o to 0 o
2	0 to +nmax to 0	constant +Va max	+90o to ~+30o to +90o
3	constant +nmax	0 to -Va max to 0	0 o to ~-30o to 0 o
4	0 to +nmax to 0	constant -Va max	-90o to ~ -30o to -90o

History of the B-series

The Maritime Research Institute Netherlands (MARIN), former Netherlands Ship Model Basin (N.S.M.B.), started to develop the well-known Wageningen Propeller *B*-series right from the establishment of this institute in 1932 (Kuiper 1992).

The first series was published by van Lammeren (1936) and Troost (1938 and 1940), followed by a long period of further developments and expansions of the series over more than 40 years. A major review of the available data was given by van Lammeren et al (1969 and 1970).

The *B*-series had been further extended to six and seven bladed propellers in the 1970s. A total of 20 series with more than 120 propellers were tested over that period. Systematic series have also been developed for ducted propellers since 1954 (van Manen 1954). A major amount of data of the K_a-series was published by Oosterveld (1970).

In the meantime, other systematic propeller series were also developed worldwide. However, none of these series is as extensive as the *B*-series, which have found widespread applications.

Besides that the propeller characteristics (the thrust and the torque) of the series in design operation conditions have been made available by model tests between J=0 and K_T=0, four-quadrant open water characteristics of some of the propellers in the *B*-series and in the K_a ducted propellers series were also made available in the 1980s (MARIN report 1984) for off-design conditions. Table B provides an overview of the propellers in the B-series where their 4-quadrant open water characteristics are available. For the K_a-series, only K_a4-70 propellers in 19A and 37 ducts have been published.

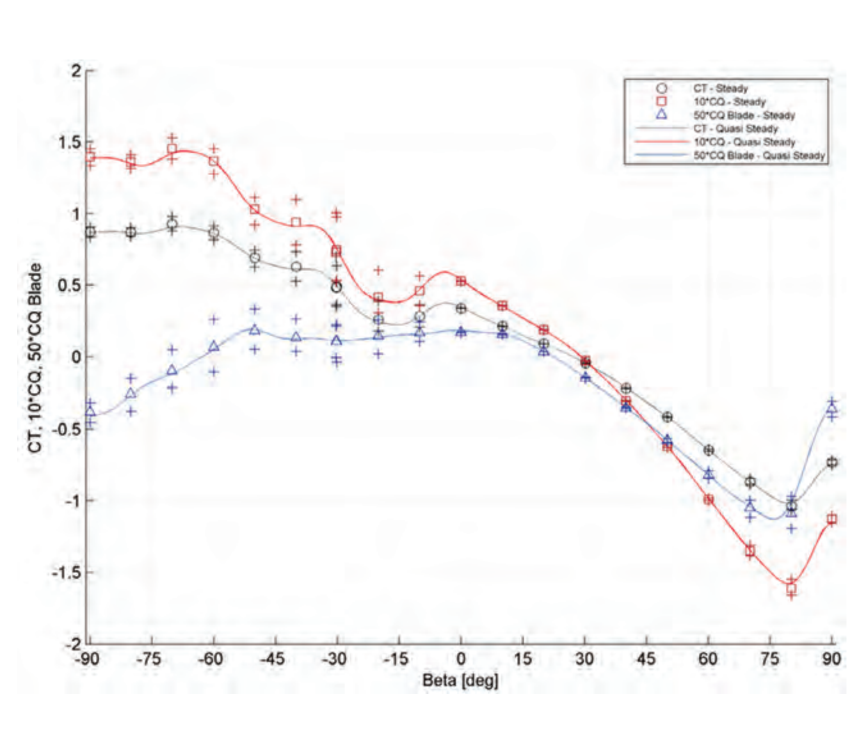


Figure 2: Comparison of Fourier series fitted curves to steady test results with their 95% occurrence intervals, sinusoidal variations, at design pitch

blade designs and two standard ducts, tested at 12 pitch settings over complete two-quadrant for each propeller:

C4-40 P/D=0.8; 1.0; 1.2; 1.4
C4-55 P/D=0.8; 1.0; 1.2; 1.4
C4-70 P/D=0.8; 1.0; 1.2; 1.4
C5-75 P/D=1.0; 1.2; 1.4; 1.6
C5-60 P/D=1.0; 1.2; 1.4; 1.6
D4-40 P/D=0.8; 1.0; 1.2; 1.4 in both 19A and 37 ducts
D4-55 P/D=0.8; 1.0; 1.2; 1.4 in both 19A and 37 ducts
D4-70 P/D=0.8; 1.0; 1.2; 1.4 in both 19A and 37 ducts

In addition to the propeller thrust and torque, the propeller blade spindle torque is also provided as systematic data in propeller series for the first time. *NA*

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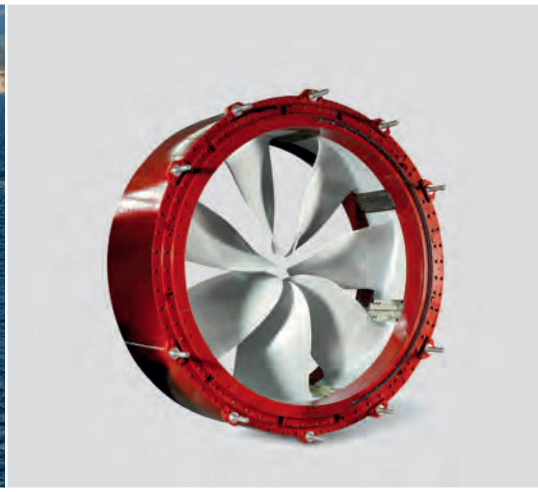
Table B: Overview of B-series with four-quadrant open water characteristics (pitch ratio P/D of the propellers are listed in the table)

AE/A0 [%]	40	55	65	70	75	80	85	100
Z=3			1.0					
Z=4	1.0	1.0		0.5, 0.6, 0.8 1.0, 1.2, 1.4			1.0	1.0
Z=5					1.0			
Z=6						1.0		
Z=7							1.0	



A weld of difference

The practical application of welding robots in Japanese shipbuilding started in the 1980s and it has greatly improved productivity. More than 60 sets of welding robots now operate at Universal Shipbuilding. But, there is room for improvement write T.Shinohara and Y.Saitoh of Universal Shipbuilding

Automation of welding in enclosed spaces, such as double hull blocks, has been delayed when compared the use of robots on open blocks, resulting in low usage of the robotic system. Furthermore, there is room for improvement of welding quality and operability in the existing robot welding systems.

Various robot welding systems have been applied to shipbuilding to improve productivity in particular, at indoor stages of production such as sub-assembly and block-assembly [1]. So far, most of the welding robot systems weld fillet joints of the flat panels or the open blocks.

The applications of welding robots to the closed double hull block or outdoor stages are still rare cases. In order to further improve the productivity in shipbuilding, the application of a welding robot to narrow or closed double hull blocks is required and further improvements to existing robotic welding systems are also necessary.

With this in mind we are developing robotic welding systems based on a new concept. The robot welding systems of the sub-assembly stage and the block-assembly stage have been continuously updated, and a portable robot welding system with a unique concept was developed for the butt joints of longitudinal frames in a closed double hull in dock.

The development of software, including a CAM system, is important for the robot welding system. Using a simulation on the CAM system, the improvement of function and interference avoidance of the robot is possible and welding of curved joints are also possible by using off-line operational capability in the CAM system.

Various types of robot welding system have been used based on the characteristics of each construction stage. Figure 1 & Figure 2 show the typical types of welding robot used at the sub-assembly stage and the block-assembly stage.

Figure 1: Welding robot system with twin torch for sub-assembly (Gantry-type)

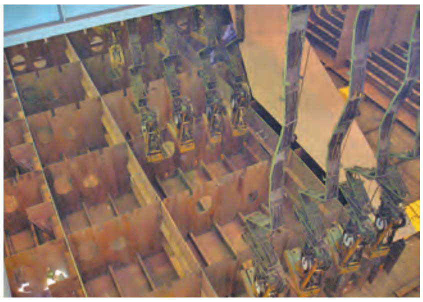


Figure 2: Welding robot system for block-assembly (Hanging-type)

These systems were introduced in Japan in the 1980s and they have contributed to a remarkable improvement in productivity. Still utilised as the main automation facility in our shipyards a recent an application technology of a welding robot for curved blocks has also been developed, whose welding sequence is optimised by genetic algorithms [2]. Furthermore, a robot welding system applicable to the double hull block has been developed [3].

Indoor welding

At the sub-assembly stage, gravity welding with the use of a stick electrode is preferred in Japan because it fits the

Figure 3: New type multi-robot welding system

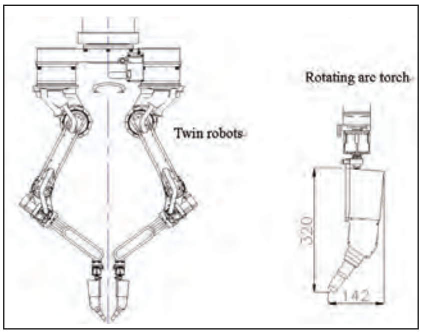


Figure 4: Twin robots unit and the Rotating arc torch

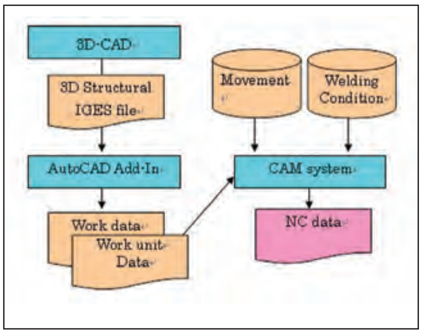


Figure 5: Data flow of the CAM for the welding robot for Sub-assembly

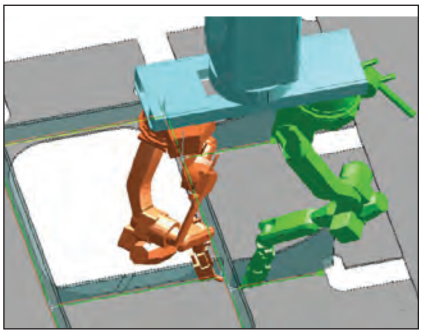


Figure 6: Different behaviour between twin robots

characteristics of welding activity during sub-assembly and increases productivity.

More recently, the application of CO_2 arc welding processes has increased at this production stage. At this stage, the application of a robot welding system started at Ariake Shipyard in 1989 and at the TSU yard in 1995. Figure 1 shows Gantry-type welding robot systems installed at Ariake.

The target work of this robot is to weld the stiffeners to web-plates. At this stage, vertical welding is less than 5% of the total weld length and almost all joints are fillet welding in a horizontal-flat position. Therefore, this welding robot has been developed with a twin-torch system in order to keep the perfect weld-quality of end-corner welding.

Alternatively, the application of multi-robot welding systems started in 1995 at TSU. This system consists of 10 sets of welding robots (manipulator). Each robot has six degrees of freedom and moves with the sliding equipment (external axis). This welding robot adopts a rotating arc process for high speed welding. The rotating arc sensor moves at 50Hz and achieves high speed welding at 70cpm [4] [5].

Recently, TSU updated its multi- robot welding system (Figure 3) because the previous system had an interference problem between robots. The arc time ratio of this system is reduced by collision occurrences. Therefore, the newly developed system has been designed to reduce interference. Significant features of this multi-robot welding system are as follows:

- Consists of 8 robots (4 pairs)
- Twin robot type
- Miniaturisation of the rotating arc torch.

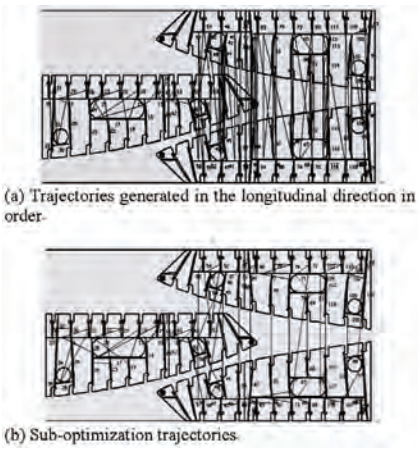


Figure 7: The trajectory generated by the CAM system

This welding system has the same capacity to weld as a conventional system with eight robots. These welding robots are paired with two manipulators as shown in Figure 4. Each robot is hung by the moving equipment with three prismatic joints and one rotary joint. Therefore, they can weld fillet joints using a twin welding process without interfering with one another. This system has adopted the high-speed rotating arc torch which is miniaturised, making it possible to weld small fillet weld joints. The dimensions of the rotating arc torch are 142mm in width by 320mm in length as shown in Figure 4.

This system generates operational data based on the placement of the hull panel planned in advance. An add-on for the general-purpose CAD creates a hull panel layout at the sub-assembly stage. The newly developed CAM system reads the information in the IGES format for the hull panel layout to create the NC data automatically as shown in Figure 5.

This CAM system is capable of simulation of the off-line operation for interference check. Even if one robot stops through interference, the other robot is able to weld continuously for about 300mm as shown in Figure 6. Figure 7 shows the example output of the trajectories generated by the CAM system.

The thin lines in the Figure 7 show the trajectory of the tip of the rotating arc torch. Figure 7 (a) is the trajectories generated in the longitudinal direction in order. Figure 7 (b) is the trajectories sub-optimised to minimise the travel distance. In this case, the running time is reduced by 8.5% for this optimisation.

Block Assembly

A welding robot system has been applied at the block-assembly stage since the 1980s in Japan. The concept of the robot system is the cooperation with human instead of full automation unlike the multi-robot welding system. After setting up the welding robot with a grid of the hull block by the operator, the robot welds automatically as shown in Figure 2.

Robotic welding for block-assembly is more difficult compared with that of sub-assembly, because fitting accuracy deteriorates at post-process. Furthermore, in some cases, conventional welding robots can not control torch position in a narrow space. Figure 8 shows the typical application structure of welding robots in the block-assembly stage. The dotted lines show the weld line. The authors developed a new robot welding system equipped with the following:

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The Institution also believes that it has a role to play in recognising achievement of engineers' in improving safety at sea and the protection of the maritime environment. Such recognition serves to raise awareness and promote further improvements.

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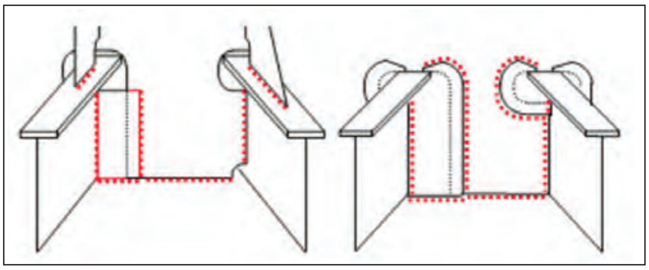

Figure 8: Typical application structure of welding robot in block-assembly stage

Figure 9: Welding robot system for block-assembly

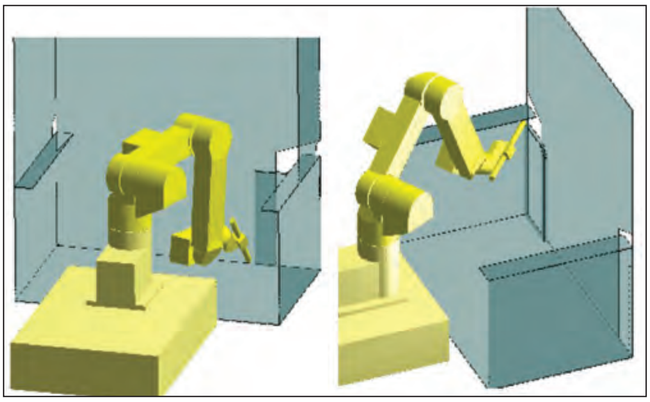

Figure 10: Off-line simulation for block-assembly robot

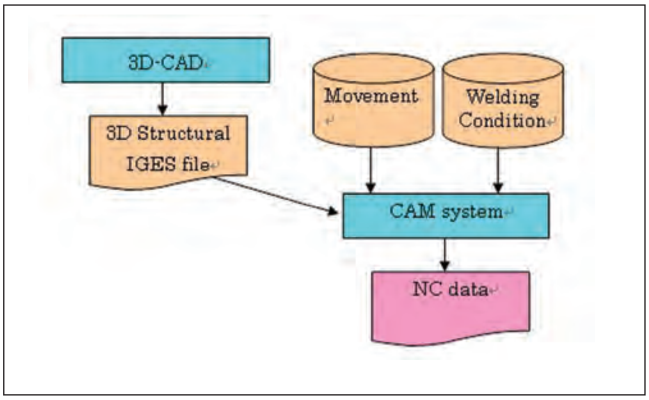

Figure 11: Data flow of the CAM for the welding robot for block-assembly

Figure 12: Welding result in the block-assembly

- Optimisation of link parameters
- Correspondence to gap-variation
- Off-line simulation.

The welding robot has five degrees of freedom and moves with the mobile unit that has an ultrasonic sensor to follow the longitudinal member as shown in Figure 9. The arm length of the welding robot was optimised at 700mm by the off-line simulation. The welding robot can control a proper welding position by this optimisation.

Figure 10 shows the off-line simulation for confirming the welding position in the work space. In addition, the welding robot can adapt to the gap-variation by inputting the root gap by operator before the operation. The welding conditions for the gap-variation are incorporated into a CAM system.

Figure 11 shows the CAM system for the welding robot system at the block-assembly. The CAM system generates the NC data based on the structural data at the block-assembly. This CAM system is capable of simulation of the off-line operation as shown in Figure 10. The movement database corresponding to the curved weld joint was constructed by this simulation facility. Figure 12 shows an example of welding result including the curved weld joint at the block-assembly stage.

Double hull welding

In recent years there has been an increased need for more efficient welding in double hull spaces. However, a conventional welding robot is too big to be carried into the confines of a closed structure. Automatic welding for butt joints of longitudinal frames in double hull tanks in dock are a particular problem. These joints require high grade welding skills to adapt to the root gap-variation. Therefore, the authors developed a new type robot welding system with the following features:

- Miniaturised robot
- Generating the optimal welding conditions
- Adaptive control for gap-variation.

This system consists of a robot welding manipulator, rails on which to travel, an

International Conference on the Education and Professional Development of Engineers in the Maritime Industry

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As the global maritime industry emerges from the downturn it has been experiencing in recent years, the key to its future success will be innovation in all aspects and sectors of the industry, whether it be in research, design, construction or operations. And in an industry which is technologically led, such innovation will be provided by engineers who have the professional skills to meet the future demands of the industry. Such engineers will need to have achieved the knowledge and understanding which underpins those professional skills while at university, and to have developed them through training and experience after graduation. But what are those skills which the maritime industry of the future requires, how are universities and colleges to provide the graduates who are able to develop them, and what is the role of industry in enabling those skills to be developed? What are the particular skills required by different sectors of the maritime industry – commercial, naval, recreational, offshore, renewable energy? What are the interpersonal skills which engineers of the future will require to complement their technical skills?

This 2nd International Conference on the Education and Professional Development of Engineers in the Maritime Industry will build on the success of the first conference in 2011, and again bring together representatives of both industry and academia to present and discuss how those engineers of the future who will be the key to the future success of industry will achieve the knowledge, understanding and professional skills which industry needs, both today and in the future. The conference will compare the differences in the requirement and delivery of education, training and professional development in different sectors of the industry and in different countries, seeking to both learn and benefit from such differences. Given the lead time to provide professional engineers, the conference will seek to identify the changes needed now to provide the engineers of the future.

Papers are invited on the following topics:

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- Collaborative provision, including experiences of educational and CPD programmes delivered by several institutions on more than one site.
- International developments, including: education's global market; the international student experience; programme delivery on a satellite campus
- E-delivery - successes and failures in delivering programmes remotely, including: web based material, video streaming, and live delivery via video link
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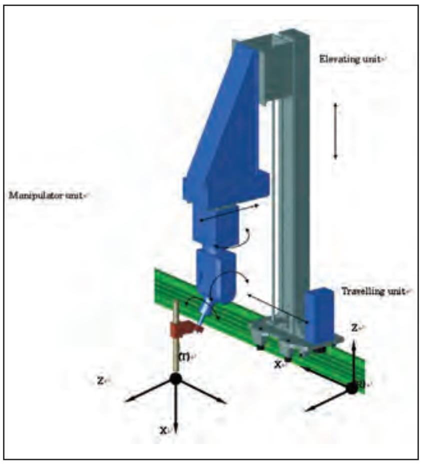

Figure 13: Portable welding robot for double hull in dock

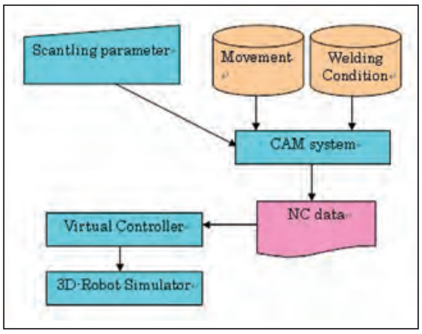

Figure 14: Data flow of the simple CAM for the welding robot for the double hull block

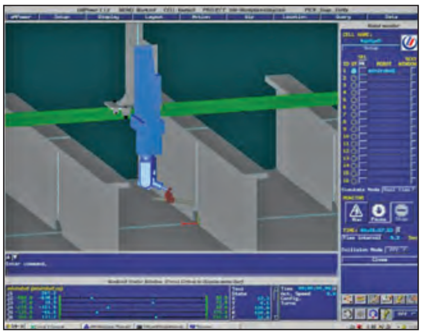

Figure 15: Off-line simulation for the closed double hull

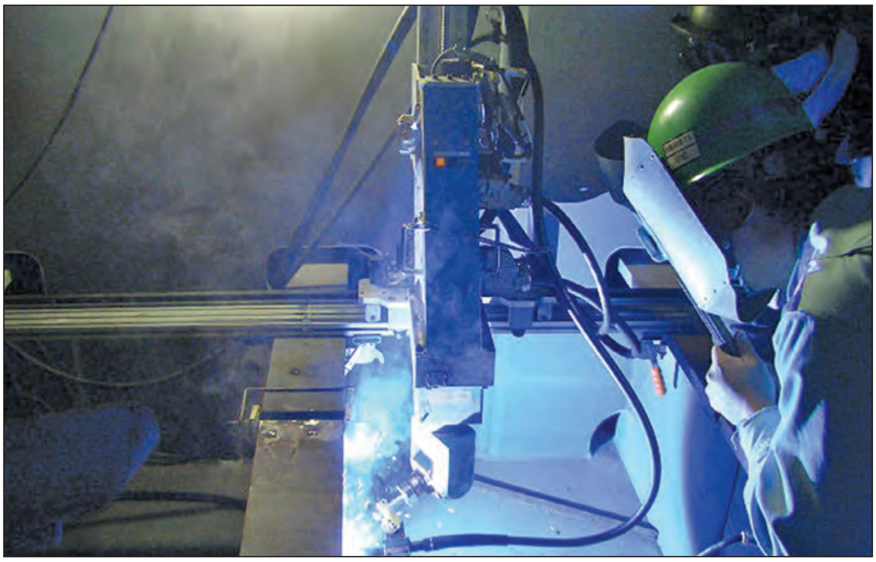

Figure 16: Robot welding in the closed double hull in dock

operating box, a robot controller and welding equipment. Figure 13 shows the welding robot manipulator for longitudinal members in the double hull in dock. The dimensions of the robot are 110mm wide by 435mm long and 1,180mm high. The welding robot manipulator has three prismatic joints and three rotary joints. The robot manipulator is composed of a travelling unit, an elevating unit and manipulator unit. The robot manipulator can be brought into or out of the double hull tanks easily by decomposing into several parts. This welding robot system has the sensing capabilities for automatic recognition of the groove shape and root gap, and it generates the optimal welding conditions for the weld joint.

A simple CAM system for this welding robot system generates operational data based on the input of the dimensional data at the longitudinal space shown in Figure 14.

This simple CAM system is not capable of the simulation for off-line teaching or interference check, unlike the previously discussed CAM system. However, using a commercial 3D simulator customised for this welding robot system, off-line operation of the welding robot can be confirmed at real time shown in Figure 15. The welding robot model on the 3D simulator is controlled by the virtual controller, and is checked for interference.

This welding robot system has been developed for the butt joints of longitudinal faces and longitudinal webs in the double hull in dock and butt joints of the bottom shell plates. Figure 16 shows the application status of the robot welding in the closed double hull tanks in dock. This welding robot system has been successfully applied to more than 10 large tankers and large ore carriers. It is contributing to not only productivity-improvement and product quality stabilisation but, also to improve the working environment and reducing heavy physical workload. *NA*

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MMNCs, the lighter side of shipbuilding

Reducing structural weight is an important way to improve ship performance. One approach is to develop materials that combine relatively low mass (weight) with the requisite strength, flexibility, and other criteria, writes Rajeev Manjunatha, naval architect at Axsys Technologies

The aircraft industry was the first to introduce lightweight materials (e.g., aluminium alloys) on a widespread scale beginning in the 1920s. This continues today with the adoption of lightweight composite materials in other industries as well.

Less weight, consistent with other performance and safety requirements, means more useful work can be extracted from a unit of fuel or other energy source. Weight-reducing technologies are critical to the success of new, highly efficient energy technologies such as hybrid vehicles.

Shipbuilding is the second largest consumer of lightweight materials. There is a growing demand for lightweight metal; aluminium represents the second largest metals market in the world. Light, strong, and corrosion-resistant aluminium is the ideal metal for shipbuilding. Metal matrix nano composites (MMNC) could prove to be the next generation of building materials.

History of aluminium in shipbuilding

It was first used for building a steam passenger boat in 1891. The boat named *Le Migron* was designed in Switzerland and was intended to carry eight passengers. This was the first boat partially made of aluminium, which confirmed that the metal was useful in shipbuilding.

Later, The Scottish shipbuilding yard Yarrow & Co presented a 58m motor torpedo boat made of aluminium. This boat named *Falcon* was manufactured for the navy of the Russian Empire. The boat reached speeds of 32knots, a record for those times.

But, in late the 1890s the cost of aluminium was 35% higher than the cost of steel, which hampered active use of the light metal. Another shortcoming was discovered later, corrosion. Although it sounds strange today, it turned out that the yachts made of aluminium at the beginning of the twentieth century were exposed to severe corrosion in salt water.

The service life of all these vessels turned out to be significantly less than that of similar vessels made of steel. Imperfect manufacturing processes and a lack of understanding of aluminium's properties hampered wide dissemination of this metal in shipbuilding. Engineers faced a complex problem which they managed to solve only a few decades later.

After considerable research from the early 1900s, Aluminium Alloy 5083, considered the base alloy of shipbuilders, was registered by the Aluminium Association in 1954. Alloy 5083 initially won popularity in shipbuilding thanks to such properties as high strength, corrosion resistance, good mouldability, and excellent welding characteristics.

By the 1960s, improvements in the technology, as well as a reduction of the cost of aluminium led to the extensive use of the light metal in shipbuilding. Aluminium was used in manufacturing the shells of yachts, superstructure, masts, and port infrastructure.

In the 1970s, high-speed passenger vessels first appeared in Scandinavia - catamarans made of aluminium. Being light and quick, they proved their profitability and speed advantage, and became standard for passenger transportation for many years.

Aluminium's postive properties

- High Strength to weight ratio
- Density one-third that of steel
- Excellent corrosion resistance
- Weldable
- Ease of forming, bending and machining
- Availability and diversity of functional semi-finished products
- High thermal and electrical conductivity
- Recyclable
- Non-magnetic

The results of which would be the following:

- Fuel Savings
- Increased Range
- Increased Payload
- Higher Speeds
- Manoeuvrability
- Stability
- Less maintenance
- Lower total ownership costs

Table 1

	Countries		
	China	Korea	Japan
Labour	10%	19%	22%
Steel	30%	27%	26%
Equipment	60%	54%	52%

Until recently, alloy 5083 virtually had no competitors among other aluminium alloys until 1995 when aluminium alloy 5383, an improved version of alloy 5083, was registered. Alloy 5383 had improved corrosion resistance and its impact strength and yield point of welded constructions increased by 10% and 15% respectively over 5083. These improvements potentially allow for a considerable reduction in the mass of welded vessels.

In 1999, aluminium-based alloy 5059 was registered with the American Aluminum Association, which was called Alustar. This new alloy proved that aluminium can be stronger than steel. The alloy has the values of ultimate strength and a yield point comparable with the corresponding values of low-alloy steel S235, AlCu4SiMg (AA2014). This alloy developed for the shipbuilding industry also has considerably improved strength characteristics compared to the traditional alloy 5083. The yield point before welding is increased by 26% and by 28% after welding.

Studies continue, and probably, very soon scientists will present us with even lighter and stronger aluminium alloys, which will allow manufacturers to create vessels and structures of the new generation.

New building price breakdowns generally have three major components, labour, steel and equipment, see table 1. The next generation of composites, is however, upon us. Nanotechnology is all about being small. After all, the prefix "nano" means one billionth of something. Nanocomposites are lighter, stiffer, less brittle, and more dent- and scratch-resistant than conventional plastics. Some nanocomposites are also more recyclable, more flame retardant, less porous, better conductors of electricity, and can be painted more easily.

The concept

Use of carbon nanotube reinforced aluminium as a base shipbuilding material could produce a lighter and stronger ship. This paper shall concentrate on how the composite is fabricated and the advantages of its application in shipbuilding.

The reinforcement of metals can have many different objectives. The reinforcement of light metals opens up the possibility of the application of these materials in areas where weight reduction has the first priority. The development objectives for light metal composite materials are to improve those properties that avoid the use of aluminium in commercial shipbuilding.

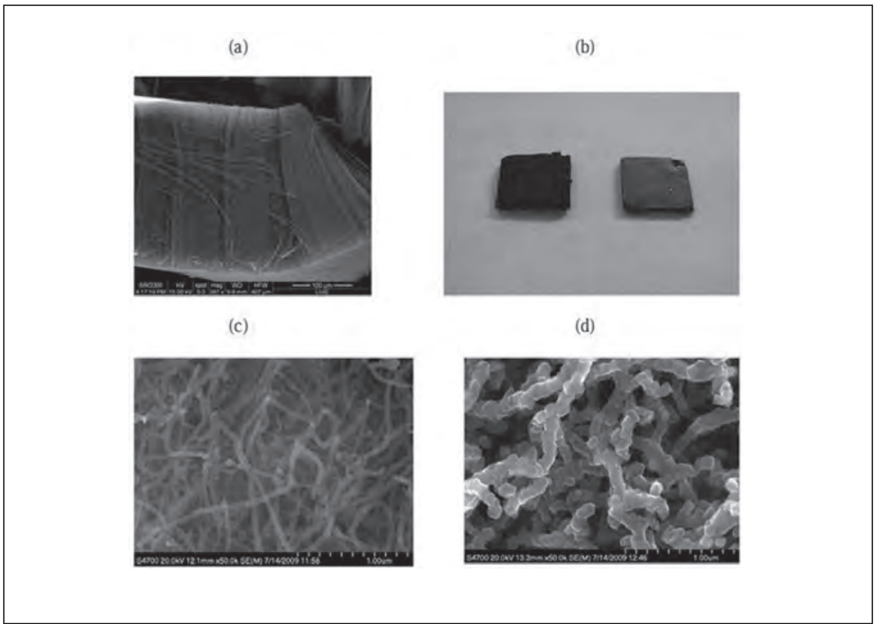
- Increase in yield strength and tensile strength at room temperature and above while maintaining the minimum ductility or toughness
- Increase in fatigue strength, especially at higher temperatures
- Improvement of thermal shock resistance
- Improvement of corrosion resistance,
- Increase in Young's modulus,
- Reduction of thermal elongation
- Improve Resistance Stress corrosion cracking.

Properties of CNTs

- **High Aspect Ratio Structures**
- **High Mechanical Strength: Tensile Strength (60 GPa)**
- **Young Modulus (1 – 5 TPa)**
- **High Electrical Conductivity (typically 10^{-6} ohm m)**
- **High Thermal Conductivity (1750 – 5800 W/mK)**
- **High Current Density (10^{7} – 10^{9} A/cm^{2})**
- **Chemical Stability: (not attacked by strong acids/alkali)**

Carbon nanotubes (CNTs) whose tensile strength and thermal and electrical conductivity along their axis surpass virtually all known materials; it also shows an increase in the mechanical

Figure 1 shows:
(a) The "forests" of CNTs synthesised via chemical vapour deposition (CVD) can be grown to macroscopic lengths on the order of millimetres and
(b) The optical difference between the pristine and aluminium-coated forest.
(c) This SEM image shows that the top of this CNT forest exists as somewhat of a tangled nest and that the CNTs measure between 30–80nm in diameter.
(d) It can be seen that after sputter coating 1μm of aluminium on the CNTs, they are sheathed in 25–30 nm of aluminium. This strongly suggests good interaction (wetting) and is promising for the investigation of impregnation with aluminium to create a continuous CNT metal matrix composite. Additionally, the morphology of the coating is not smooth like the surface of the CNTs. The distinct edges indicate the nucleation of metal crystals on the CNTs, further confirming the mobility of the sputtered aluminium



strength and hardness of metal matrix composites (MMCs).

Though nanocomposite materials exhibit ultra-high-strength, there is often a trade-off that results in decreased ductility. This may be attributed to currently used processing methods that result in the formation of voids and defects, as well as to the inability of nanostructured grains or additives to sustain a high rate of strain hardening.

Raw materials

Metal matrices employed in MMNC are mainly Al, Mg, Pb, Sn,W and Fe. In general, it is the reinforcement that is in the nano-range size in these materials.

Marine grade aluminium –including sheets, plates, extrusions, forgings and castings –are readily available from aluminium mills or distributors around the world.

CNTs consist of graphene cylinders and are available in two varieties, as single walled (SWCNT) and multi walled (MWCNT), with about 70% yield in the case of SWCNT. While SWCNTs are single graphene cylinders, MWCNTs consist of two or more concentric cylindrical sheets of graphene around a central hollow core. Both types exhibit physical characteristics of solids, either metallic or semiconducting in nature, with microcrystallinity and very high aspect ratios of 103.

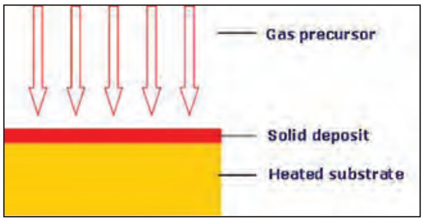
Processing methods

Despite their nano dimensions, most of the processing techniques of the three types of nanocomposite remain almost the same as in microcomposites. This is also true even for CNT-reinforced composites.

MMC manufacturing can be broken into three types: solid, liquid, and vapour.

1. Solid state methods
2. Liquid state methods
3. Vapour deposition.

Among several techniques of CNT synthesis available today, chemical vapour deposition (CVD) is most popular and widely used because of its low set-up cost, high Production yield, and ease of scale-up.



A graphic illustration of carbon nanotube production using chemical vapour deposition technique

Chemical vapour deposition

Chemical vapour deposition or CVD is a generic name for a group of processes that involve depositing a solid material from a gaseous phase.

Precursor gases (often diluted in carrier gases) are delivered into the reaction chamber at approximately ambient temperatures. As they pass over or come into contact with a heated substrate, they react or decompose forming a solid phase and are deposited onto the substrate. The substrate temperature is critical and can influence what reactions will take place.

The CVD processing method has proven to be very economical and can be scaled to bulk production.

The high price of CNTs can be justified by their superior mechanical and electrical properties. In addition the development of synthesis techniques for CNTs has resulted in a substantial reduction in the cost of production of CNTs. According to present market rates, the cheapest price is US$13,000/kg for SWCNT (purity 60%), US$15,000/kg for ARC-MWCNT (purity 30-40%), and US$400/kg for CVD-MWCNT.

Advantages of CVD process:

- **Very simple and inexpensive set up**
- **Can be used for a wide range of metals and ceramics**
- **Can be used for coatings or freestanding structures**
- **Fabricates net or near-net complex shapes**
- **Is self-cleaning—extremely high purity deposits (>99.995% purity)**
- **Conforms homogeneously to contours of substrate surface**
- **Has near-theoretical as-deposited density**
- **Has controllable thickness and morphology**
- **Forms alloys**
- **Infiltrates fibre preforms and foam structures**
- **Coats internal passages with high length-to-diameter ratios**
- **Can simultaneously coat multiple components**
- **Coats powders**

According to many research papers and laboratory tests conducted at various universities and companies around the world it is quite evident that a maximum 2% weight increase is sufficient to increase the characteristics of Aluminium (see Table 2). However, this weight percent can be reduced by improving the quality of CNTs produced and also by

Table 2

Description	Experimental Young's modulus (GPa)	Shear lag Young's modulus (GPa)
Al + 0.5wt% MWCNTs	61.92	71.97
Al + 1.0 wt% MWCNTs	66.15	74.17
Al + 2.0wt% MWCNTs	74.62	81.95

understanding precisely the requirement. The less the use of reinforcing CNT the lower the total expenses in producing the Al nanocomposite.

In shipbuilding normally the requirement of steel will be approximately 2000 -3000tonnes for ship of 10,000dwt depending the design and type of vessel whose particulars will be in the range of: length = 120 – 150m, breadth = 15 -20m and depth = 7 -10m.

As we are assuming aluminium is to be used for the entire vessel, in general because of its low density and elastic modulus, in order to achieve minimal stiffness requirements, a section of aluminium must be three times thicker than its equivalent steel part. i.e. (5mm of steel = 15mm of Al). Based on the fact that Al costs approximately US$3/kg and steel US$0.65/kg, replacing steel with Al in higher strength applications dramatically increases material costs at a minimal reduction in weight.

In case of using this reinforced Al nanocomposite (Al NC), once developed to suit the requirement in shipbuilding, we can make it possible to maintain the same thickness. That is in order to achieve minimal stiffness requirements we can replace the same thickness of Al NC as of steel equivalent.

This dramatically reduces the total weight of the ship to one third, and using Al for shipbuilding has its own advantages. Further advancement in technology can present us with a material where we could substitute perhaps an 8mm plate of Al NC for a 12mm steel plate.

Cost comparisons

Most of the total ownership resides in operations, maintenance and sustainment:

Although the acquisition cost for the Al NC equivalent ship will be currently higher than that for the steel ship, the Al NC equivalent ship will have a lower total ownership cost. This is because of fuel savings and lower maintenance needs. The Aluminium ship does not require painting over its life, except for anti-fouling painting. It also has lower power machinery to repair, and less manning due to decreased onboard maintenance by the ship's crew a significantly higher residual value at end of life scrapping as well. Because the aluminium ship uses less fuel it will have a lower carbon footprint, than the steel vessel.

The material costs of building a ship are only 20-30% of the total cost of the ship. Major costs are associated with the manufacturing of the ship. Today's advancements in technology allow faster and bulk production of CNTs, and also scientists are coming up with novel ways to produce CNTS. Though the current price of CNTs are high there will be a further reduction as demand increases. The same is in case of aluminium.

The increased material and manufacturing costs for the proposed Al NC hull ship structure can be almost counterbalanced by taking advantage of the weight benefit of the Al NC in reducing either the draft or the block coefficient. The reduced displacement reduces the required draft or block coefficient for the same principal dimensions and draft. Less propulsion power is then required for the same speed and less fuel is required for the same endurance. Al NC ships can go faster, carry bigger payloads and travel longer ranges while enjoying increased stability and better fuel efficiency.

Repair

Aluminium is no more difficult and no more expensive to repair than other shipbuilding materials. In fact, the repair of aluminium structures is relatively straightforward. It requires tools and expertise that are similar, if not the same, to those used for repairing steel ships. Repairs are less difficult because aluminium is easier to cut and weld than steel.

There are very few restrictions on what can be repaired on an aluminium ship, and there are numerous repair facilities in the around the world with the expertise to repair aluminium vessels. In addition, increase in usage of Al has resulted in introducing several programmes to train workers on how to effectively repair aluminium naval structures.

Painting

No need to paint. Only anti fouling painting is required in the underwater region of the vessel. This in fact reduces an average of 8 - 10tonnes of weight for a ship of approximately 100 -150m long. It also reduces the total cost. Assuming that the steel ship requires re-painting every five years, savings of US$2 - $5 million/ship are possible over the life of the Al NC vessel.

Recycling

Theoretically Al is 100% recyclable. Aluminium has high residual value at the end of its life. Nearly 75% of the aluminium ever made is still in use today. When an aluminium vessel reaches the end of its life span, it continues to provide tremendous value as a result of its high recycling value.

Crew

As the systems and machinery installed are smaller compared to steel ships, the maintenance required is less and so is the manning. Assuming this for a total operational period of a vessel this significantly contributes in reducing total ownership costs.

Conclusions and recommendations

There is a huge demand in the market for larger ships and this has forced designers to search and come up with an alternative material to reduce weight while maintaining strength. When properly designed Aluminium typically reduces the weight of structures by approximately 50% and or more in some cases.

Technological advances have allowed aluminium to meet or exceed the minimum strength requirement used in the shipbuilding industry.

The only current disadvantage is the capital costs of ships built with aluminium. Although the initial investment for an Al NC ship is three times higher than a conventionally built vessel, a simple theoretical total ownership costs analysis made here shows that at the end of Ship's service life which is normally 25years, the operations and maintenance costs of a steel ship along with the acquisition costs are equal or exceed the initial investment made for ships built of aluminium nanocomposites. *NA*

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CFD-based aft-body optimisation in practical ship design

As CFD-based hull form optimisation gradually makes its way into practical ship design, there is much development on this subject, but in some cases it is still far from being practically applied

A system used by MARIN is described here, which seamlessly fits in with the usual design consultancy. Its basis was laid in the EU-funded VIRTUE project. Since then it has evolved into a system that is frequently applied in practical ship design work, and helps to answer many design questions.

Successful CFD-based ship hull form optimisation in general hinges on a number of issues.

- A complete definition of constraints (e.g. minimum displacement, propeller tip clearance, rotation rate, hard points)
- The definition of the design space; which must be a compromise between giving maximum freedom and keeping the number of parameters limited
- The computational effort, which for hundreds or thousands of detailed RANS computations could easily become unacceptable
- The choice of the objectives. Minimum fuel consumption and minimum vibration and noise are usually primary targets, but need to be translated to object functions that can be computed
- A large numerical accuracy of the evaluation of the object functions; as otherwise the predicted trends are affected by numerical errors.

We consider these aspects below.

Setting up the design space

To keep the dimension of the search space low, it is important that the variations of the hull form can be described by relatively few, physically relevant and case-specific parameters, not by a multitude of general geometric parameters. Moreover, for practical applications this design space needs to be defined quickly and easily. The method used is the GMS-Merge tool (Hoekstra and Raven, 2003). This defines hull form deformations by parametric blending of the original hull form and a number of variants. These are created in the CAD system GMS, using any design experience or insight in the flow characteristics for the original hull. If the basis hull forms satisfy the geometric constraints, often all variations in the design space do so, reducing the need to write out all constraints for every design task.

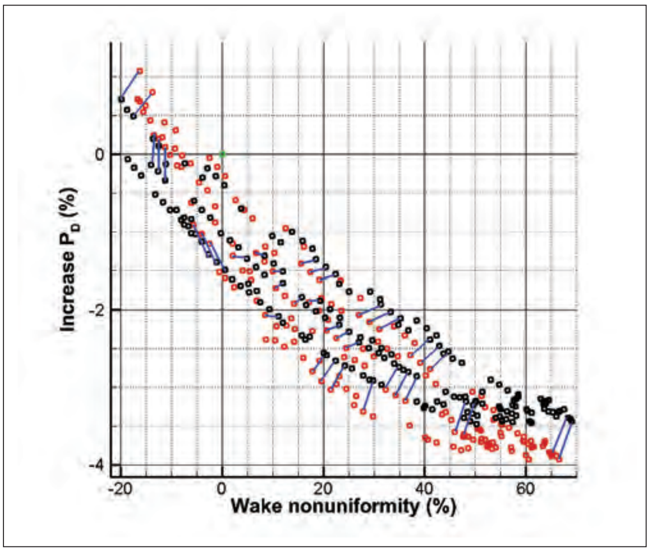

Figure 1: Pareto plot for optimisation of power and wake quality, for the VIRTUE tanker (model scale). Red: coarse grid. Black: fine grid

The RANS code

The CFD tool used is PARNASSOS, one of MARIN's in-house RANS codes. This is a dedicated code for ship resistance and flow computations, which is efficient and numerically accurate. E.g. a double-body flow computation on a grid with 3 million cells takes just about five hours on a single PC-processor. This permits it to run many computations in parallel on idle desktop PC's. In this way, RANS computations for as many as 1000 hull form variations can be run overnight. Grid generation for the design variations is fully automatic (van der Ploeg, 2011).

Minimising required power

It is important not to minimise resistance but to minimise required power, as the results can be different (van der Ploeg and Raven, 2010). The first object function to be minimised is:

$$P_D = \frac{R_T \times (1-w)}{1-t} \times \frac{V_S}{\eta_R \times \eta_0}$$

The resistance R_T is obtained from a first RANS computation, which also provides the nominal wake. However, w is the effective wake fraction. This is currently estimated from the nominal wake using the NOMEFF tool (*van Gent and Hoekstra, 1985*), an approximate method based on solving linearised Euler equations for a given actuator disk.

To compute the thrust deduction *t*, a second RANS computation is done for the same form, with a force distribution representing the propeller with a thrust T_0, reasonably close to that required for self propulsion. t then follows from the resistance increment. The 3D force field that represents the propeller action is here derived from the loading distribution computed for a propeller


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behind the original hull; which is more realistic than using a simple actuator disk model (van der Ploeg, 2012). It is essential to estimate the propeller efficiency in open water, η_o, as this may vary significantly between design variations. This could be evaluated by a coupling with a propeller code or by incorporating the propeller in the RANS computation. However, this would mean that one optimises the hull form for the particular propeller chosen, instead of optimising both in combination. In order to estimate better the achievable performance, η_o is obtained from the B-series of propellers (*Kuiper,1992*). So far, the thrust, wake fraction, number of blades, propeller diameter and revolution rate were fixed, while the blade area ratio and pitch ratio for each hull form were found from the B-series; but other choices are possible. The resulting η_o is used to find P_D.

Propeller inflow

In practical applications, a second objective is often required that has to do with the quality of the propeller inflow. Since scale effects are significant, usually we do the optimisation for full scale. In case of danger of erosive cavitation, one would like to prevent strong variations of the wake in circumferential direction, especially in the top half of the propeller plane. For example, an L2-norm of the circumferential derivative of the inflow velocity can be used. Alternatively, we can use a norm of the variation of the local angle of attack of the flow on the propeller blades.

A large numerical accuracy of the evaluation of these objective functions is required, as otherwise the predicted trends and optima can be affected. Much attention has been given to reduce grid dependence and remove dependence on iterative errors (van der Ploeg and Raven, 2010).

Optimisation

With the components described, evaluation of design variants can be done. The simplest approach is a systematic evaluation of designs evenly spaced in the design space. This gives a good insight in the trends and good clues for further refinement. But, if the number of basis hull forms that span the design space increases this becomes unfeasible. Design of Experiments (DoE) techniques can be used to reduce the number of RANS computations, and still identify trends by determining a Response Surface. Actual multi-objective optimisation can be done by genetic algorithms. All computations within one generation can be computed in parallel. These techniques have already been successfully applied.

Results

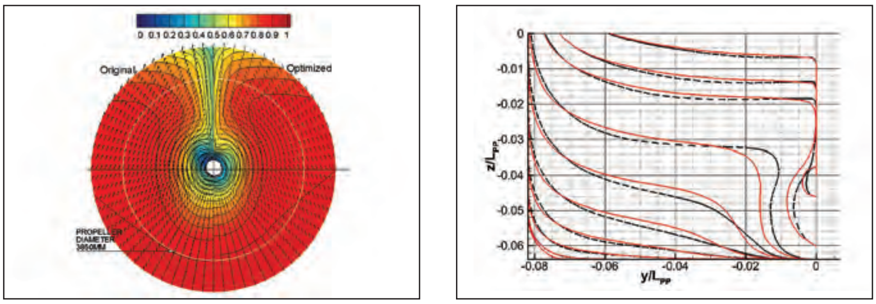
Figure 1 shows some results for a tanker considered in the VIRTUE project. For several hull form variants, the grid dependence of the objective functions (power and wake quality) has been studied by making computations on a coarse grid of 1.7 million cells (red markers in the figure), and one of 3.4 million cells refined in all directions (black markers). In the Pareto plot (Fig. 1), the blue lines connect computations for the same hull form. The grid dependence of these rather complicated objective functions is small, but some change of the Pareto front is still observed.

The current use in practical projects is to do the optimisation at full scale. As an example, we show a result of the optimisation of the aft-body of a chemical tanker in the STREAMLINE project. Figure 2 compares the full-scale wake of an optimised hull form and that of the original hull form, showing the large reduction of the wake peak. The wake object function, in this case the norm of the variation of the angle of attack, was reduced by 30%, combined with a 1% decrease in P_D.

The efficiency of the tools used, together with parallelisation over the PC network, appears to be very powerful. It allows doing a large number of RANS computations and to compute clear Pareto fronts, trends in the solutions and scale effects on those trends; with rather little setup time and turn-around time. The PARNASSOS-EXPLORER system thus helps to benefit from CFD-based optimisation in practical hull form design projects.

Part of the developments formed part of the VIRTUE and STREAMLINE projects, co-funded by the European Commission within the 6th and 7th Framework Programme. This support is gratefully acknowledged. *NA*

Figure 2 Left: full-scale wake fields of a chemical tanker, for original form and a variant with improved object functions; from STREAMLINE project. Right: body plans of the original (red) and optimised (black) hull form



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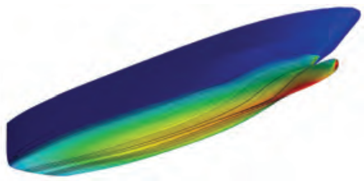

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Fast robust design optimisation methods applied to ship hydrodynamics

Paolo Geremia, regional manager, Engys, Italy, Thomas Schumacher, head of analysis and Eugene de Villiers, General Manager, Engys, UK describe the benefits of fast multi-objective design optimisation methods applied to hydrodynamics and coupled to CFD models for all vessel designs

Nowadays optimisation of ship hydrodynamics represents one of the most challenging design tasks due to the complexity of the engineering problem considered and the inherent multi-objective nature of the problem.

Achieving an optimal solution for a given range of design parameters in the shortest time possible is, therefore, becoming more and more important. In this regard, usage of the Open Source Computational Fluid Dynamics (CFD) software OPENFOAM [1] to perform flow simulations of hull hydrodynamics represents a validated and efficient method applied to ship design.

Furthermore, working with parametric CFD models coupled with design optimisation tools like DAKOTA [2] represents a further significant breakthrough in process design to perform geometrical shape optimisation.

The potential of a high number of design parameter combinations to be evaluated make the optimisation process a challenging task and the selection of the best optimisation approach a key factor. In this context, highly non-linear problems like ship hydrodynamics can be addressed by using advanced multi-objective design optimisation techniques, ranging from the well known genetic algorithms [3] to the most advanced Response Surface Methodology (RSM) [4]. During the last decade, these techniques have been proved to be robust and efficient when applied to complex non linear engineering applications such as CFD modelling.

An additional requirement when it comes to performing ship hydrodynamic optimisation is the stability and robustness of the optimal solution found for a given range of operating conditions. Application of uncertainty quantification methods plays an important role in case of non-deterministic conditions, allowing the designer to look for the optimal solution in terms of performance stability.

"The potential of a high number of design parameter combinations to be evaluated make the optimisation process a challenging task and the selection of the best optimisation approach a key factor."

The ship model considered for this study is the US Navy Combatant DTMB 5415, a prototype model conceived in 1980 shown in Figure 1, although the techniques can also be applied to commercial vessels.

Two open-water propellers whose shaft is supported by stern tubes and brackets are located in the transom stern of the hull. In this paper two different CFD application cases related to ship hydrodynamics were considered, and different fast optimisation approaches were examined in order to highlight the efficiency of the solution proposed applied to the ship design. The first application case is focused on the search of the optimal design of the rudder geometrical shape in terms of drag and lift performance for a given range of variability of operating conditions, including angle of attack and speed. Uncertainty quantification methods were used for this purpose and an efficient fast robust design approach was employed in order to minimise the number of iterations required to find the optimal solution.

The second application case refers to the design optimisation of the bare-hull geometrical model without any appendages considered. The objectives of the study are the minimisation of the ship forward resistance and maximisation of the ship displacement by modifying the geometrical shape of the bow. In this case, a different fast optimisation approach based on RSM techniques was applied, thus considerably reducing the computational time required by the optimisation run.

Robust design optimisation of the rudder

The first design application case considered in this work was the optimisation of the geometrical shape of the rudder of the DTMB 5415. The aim was to keep a high lift-drag ratio for a range of different operating conditions. More precisely the objective of the study was the minimisation of drag and the maximisation of lift for various speeds and angles of attack.

The optimisation was performed on the 2D hydrofoil cross-section of the rudder and consisted of two stages. In the first stage, both angle of attack and speed were kept fixed at their original values, and then the optimal shape of the hydrofoil for lift and drag was found. In the second stage, the best solutions found in the previous step were assessed by taking into account the variability of the operating conditions (i.e. the angle of attack and speed), and at the end of the run the best stable solution was found.

	Resistance			Lift		
	μ	σ	μ + 3σ	μ	σ	μ - 3σ
Best Drag	0.863376	0.177527	1.395958	0.888653	0.142788	0.460289
Best Lift	1.034079	0.240473	1.755499	1.056855	0.166644	0.556922
Compromise	0.980506	0.201355	1.584572	1.013078	0.158264	0.538287

Results of robustness study using PCE method

For this purpose, a NACA0015 profile with angle of attack equal to 8degs was chosen as baseline cross-section. The original profile was made parametric by the superposition of a third order parametric Bézier curve for both the upper and lower hydrofoil profile.

Four design variables were considered for the definition of the parametric curve, namely the X and Y position of two control-points. An automatic hex-dominant polyhedral mesh was created automatically for each design configuration using an enhanced version of the snappyHexMesh mesh generator available in OPENFOAM. A subsequent RANS CFD analysis using the k-ω SST turbulence model available in OPENFOAM was setup. For each design configuration, hydrofoil drag and lift values were computed and stored in a text file. DAKOTA was used as optimisation software and a derivative-free Multi-Objective Genetic Algorithm (MOGA) was applied to perform the initial optimisation phase. Figure 2 highlights the workflow managed by DAKOTA during the optimisation run.

The MOGA algorithm was set with a generation size of 20 individuals and asynchronous parallel design evaluations were performed by fully exploiting both DAKOTA and OPENFOAM license-free scalability. After 35 generations, a set of optimal solutions was found and three different candidate designs were taken for the next step, the first point as best solution for lift, the second for the resistance and the third a compromise solution.

In the next stage of the optimisation phase, the variable operating conditions of the rudder were considered to analyse the response of the system when changing design parameters from nominal operating conditions. In order to take into account the variability of the operating conditions a UQ approach was used, and the stability of the optimal solution for a given range of inlet velocity U_{in} and angle attack α was evaluated. For this purpose, for each design evaluated a perturbation on U_{in} and α based on a normal distribution $U_{in}, \alpha \sim N(\mu,\sigma^2)$ was applied.

A small perturbation was applied on U_{in} and α using the Polynomial Chaos Expansion (PCE) [5] approach for the three different optimal solutions obtained in the first stage of the optimisation run. A cost-effective design space sampling was performed for accurate prediction of μ and σ of water resistance and lift outputs. For this a 4th order quadrature PCE sampling was employed, thus leading to 16 design evaluations in total for each design configuration. The previous compromise solution revealed to be a good trade-off both in terms of stability and performance, as showed in Table 1.

Figure 1: US Navy Combatant DTMB 5415 CAD model

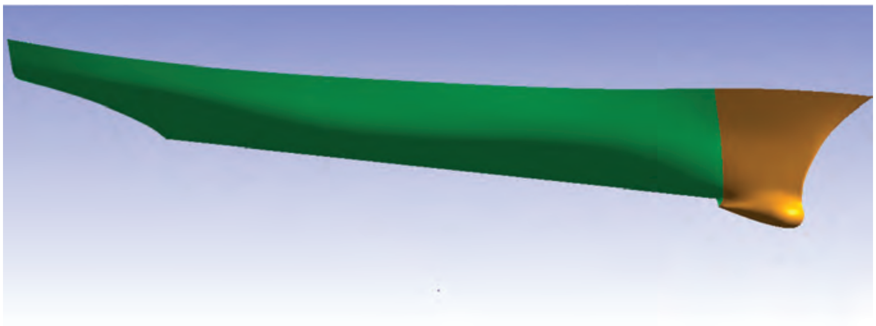

Figure 2: Rudder shape optimisation workflow driven by DAKOTA

Bare-hull optimisation

The second application case presented in this work is the shape optimisation of the geometry of the bare-hull of the DTMB 5415 model. A parametric CFD model of the bare-hull was coupled with the DAKOTA optimisation tool to perform a sensitivity analysis followed by an optimisation run to maximise displacement while minimising the forward water resistance.

For this purpose, first the available STL surfaces were loaded into the open source surface morphing tool blender, which allowed different hull geometries to be generated by morphing the geometric shape of the bow.

Second, a hex-dominant mesh of 1.5 million cells with five near-wall extrusion layers was created using an enhanced version of the snappyHexMesh tool available in OPENFOAM; the mesh was then employed to define the CFD model showed in Figure 3.

Third, the CFD solutions for displacement and resistance were employed to perform the sensitivity analysis to quantify relationships between design variables and output responses. For this purpose, DAKOTA's Design Of Experiments (DOE) techniques were used to efficiently explore the design space and to perform the global sensitivity analysis.

Finally, one hundred sample points were created using a Latin-Hypercube Sampling method and the most significant variables for displacement and resistance output responses were outlined. The 100 initial CFD sample points were used for training a Neural Network RSM to replace the CFD models by surrogate models of both the resistance and displacement output responses. A MOGA optimisation run using response surface models was then carried out and the total time required to run the whole optimisation study was reduced to a few seconds. The layout of the optimal solution was found as a compromise between the resistance and displacement objectives. The final design selected from the Pareto front was validated afterwards using a high-fidelity CFD analysis.

Conclusions

In this work the benefits of Open Source design optimisation methods applied to ship hydrodynamics were highlighted, in particular the advantages of using the CFD platform OPENFOAM coupled with the multi-objective design optimisation software DAKOTA. Different approaches of geometrical shape parameterisation were evaluated for a couple of test cases, including minimisation of ship forward resistance while maximising displacement, as well as design optimisation of rudder and other appendages for different speed, angle of attack and other operating conditions. Combined application of efficient PCE techniques and parallel computations using OPENFOAM were exploited to reduce the computational time of the design optimisation runs with a limited number of CFD simulation runs. Cost-effective RSM models were also applied to the model response functions for further speed-up of time-consuming CFD models without penalising the accuracy of the solution found. *NA*

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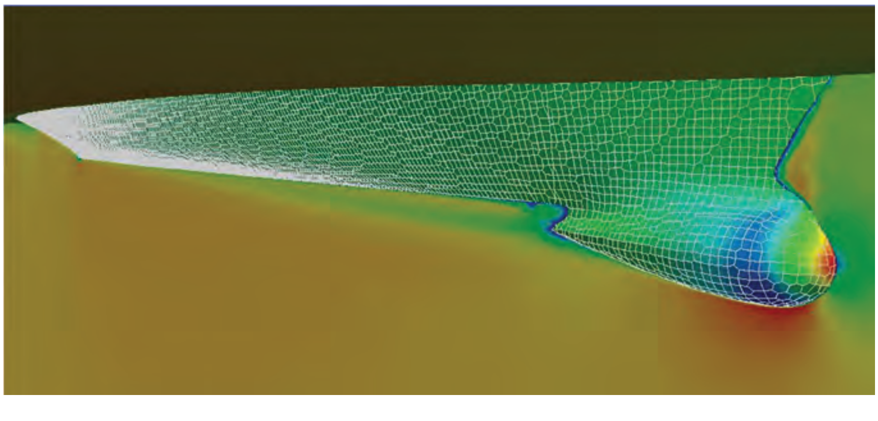


Figure 3: Bare-hull CFD model using OPENFOAM

Arctic interest drives icebreaker growth

Demand in offshore energy has seen increase in construction of icebreakers, as Finnish shipyard Arctech gets more orders

The Russian shipping company Sovcomflot ordered two multifunctional icebreakers (NB 506 & 507) in December 2010 from Arctech that are due to be delivered in 2013 that will supply the Arkutun-Dagi oil and gas field. The blocks were put together by Vyborg shipyard in Russia, with Arctech responsible for the design, procurement, construction of some of the blocks, hull assembly and outfitting of the vessels.

Both vessels will be similar in design, measuring 99.9m in length and 21.7m in breadth and they will have accommodation spaces for 50 crew members and special persons and 195 evacuees, and will be used in year round operation.

Arctech sees orders increase for icebreakers as Arctic exploration increases

The icebreakers will be operating in thick drifting ice in temperatures down to -35°C. The vessels will be capable of ice management and escorting purposes and will be equipped to carry various types of cargo and perform operations related to oil spill recovery, fire fighting, ocean towing as well as stand-by and rescue. The icebreaking capability of the vessels will be high; the vessels will be able to operate independently in 1.7m thick ice, and penetrate consolidated 20m deep ice ridges.

The vessels have a specially designed stern to navigate in ice and diesel-electric machinery, with twin azimuthing podded type rudder propeller units for propulsion. The power generation station will consist of four main diesel generator sets with a total power of 18MW. The rudder propellers will give the vessels better reversing capability and manoeuvrability in all ice conditions. For manoeuvring and position keeping, two bow tunnel thrusters will be fitted. Esko Mustamäki, managing director, Arctech notes that: "Installed power on icebreakers has gone down due to the propulsion units that are now being installed."

Energy consumption around the globe is increasing and particularly in the Arctic, which is pushing the construction of ice breakers. "I don't know how many icebreakers in the future will be single purpose or multipurpose, the question will be what to do with the single purpose icebreakers in the summer months", comments Mustamäki.

Mustamäki says that in future one of the challenges for icebreakers will be LNG and the use of it as a fuel. He adds that at the moment the same problem that of bunkering is faced by icebreakers as with other commercial vessels. However, he highlights that if these ships are working close to natural gas liquefaction plants then there would be a solution for bunkering LNG to icebreakers. *NA*

TECHNICAL PARTICULARS

NB 506 & 507

Length:	99.9m
Length in waterline:	93.9m
Breadth maximum:	21.7m
Draught, at design waterline:	7.6m
Deadweight at design draught, abt.:	3950dwt
Installed power:	18MW
Propulsion power:	13MW
Speed:	15knots
Speed at 1.5 m level ice:	3knots
Bollard pull:	+128 tonnes
Crew:	24 + 26
Gross tonnage:	7100gt
Cargo deck:	700m²
Range:	30 days
Classification:	Dual class LR and RMRS
LR Class notation:	+100A1 Icebreaker, Offshore Tug/Supply Ship, Fire-Fighting Ship 1 (Total monitor discharge capacity 2400 m³/h) with water spray, WDL (5,0tons/m² Aft to Fr. 68), RD (Brine 2.0t/m³; Mud 2.0t/m³), IWS*, Winterisation H (-35) B(-35), +LMC, UMS, DP (AM), NAV1, OIL RECOVERY, EP, ShipRight
ACS (B) LR Descriptive class notation:	COMF – C (3) (DNV), Standby Vessel (195) (DNV), Ice Class (DNV Icebreaker ICE – 10)

Transas's Russian evolution

The Transas offshore crane simulator will help train personnel to work in a challenging environment

Transas installs offshore crane handling simulator at the Russian Training Centre

The Russian training centre Arktimorneftegazrazvedka (OSJC "AMNGR") has recently been supplied with an offshore crane simulator by Transas. The system simulates that of a crane that is being used on offshore platforms and is designed for training of personnel operating in the arctic shelf. The offshore crane simulator can model control systems, hydraulics and crane interior arrangements (systems and components). The installation of the simulator will allow the training centre to launch its own offshore crane operator course.

Cargo handling on offshore platforms is associated with high complexity of operations and comes with significant risks. Training of crane handling skills and especially work in troubleshooting mode that are provided by the simulator are vital for ensuring safety of offshore operations, highlights Transas.

Instructors can introduce faults in hydraulics and systems which enables trainees to practice troubleshooting. At the core of the simulator is its math model that provides utmost realism to the user. Arctic harsh conditions impose certain restrictions on operations because of this special attention has been paid to modelling the environment and the model interaction (temperature, wind, wave etc.), which gives training a realistic edge, says Transas. The training can be brought one step forward by interconnection of navigational simulator and offshore crane simulator, allowing for joint training of a vessel and offshore oil personnel. *NA*

RS prepares for centenary celebrations

The Russian Maritime Register of Shipping (RS) will be celebrating 100 years of service next year, with improvements on the horizon

One hundred years is something special to recognise says RS. "100 years of existence is an important milestone in the RS activity", says Mikhail Ayvazov, chief executive officer of the classification society Russian Maritime Register of Shipping (RS). "Each member of the staff is contributing to improvements, which we planned to implement by 2013. These improvements are aimed mainly at modernisation of the processes, enhancement of communication with clients as well as business diversification", Ayvazov notes.

Ayvazov notes that: "In the last year we see very good trend with regard to newbuilding perspectives. All major newbuilding projects of Russian shipyards are supported by Russian Government". For example this year sees the start of the construction process of a unique oblique icebreaker in Kaliningrad shipyard, Yantar.

Adding to this, Baltiysky Zavod, St.Petersburg, has received a contract for the construction of a new diesel-electric icebreaker with 25mWt. Vyborg shipyard will also start the construction of the first in a series of three 16mWt diesel-electric ships.

Under the Federal Target Programme on ship construction, a new oblique icebreaker (project developed by Aker Arctic Technology Inc.) will be constructed to RS class by Yantar yard in cooperation with Arctech Helsinki Shipyard.

The vessel features a patented oblique design with asymmetric hull and three azimuth propulsors, which allow the vessel to operate efficiently ahead, astern and obliquely. The vessel can proceed on a continuous mode in 1.0m thick level ice both ahead and astern and in oblique mode it will be able to generate 50m wide channel in 0.6m level ice.

The vessel features high manoeuvrability during ice operations. Besides icebreaking, the vessel may be used for environmental protective purposes. The additional functions of the asymmetric icebreaker will include fire-fighting and rescue operations as well as ability to clear oil-spills from the sea. *NA*

After the flood?

Sir

Congratulations on a thought provoking article (A Titanic Legacy, April 2012). The loss of *Titanic* continues to be headlines but surely it cannot have much life left.

Although suffering similar shell damage to *Titanic*, *Costa Concordia* sank in a different manner. One sank bodily the other heeled over, the question is, was *Titanic* better designed in that she did not suffer from unsymetrical flooding?

I was brought up in the days of deterministic calculations; such methods give a picture of the results of flooding, which probability does not. I am/was a simple minded naval architect and when a statistician comes along with the phrase one chance in x thousands I respond with that ONE could occur soonest!!

I attended a bulk carrier conference 20 years ago the chairman of which made the statement that ships must be designed to survive any weather condition, I asked who would act as GOD and define those conditions; he replied he and other authorities!!!

The safety of ships is not just a question of design the operation is probably more important and human error is never far away be it in design, building, operation, or repair.

The author is incorrect in stating that *Queen of Bermuda* was withdrawn because of coastguard pressure. *Queen of Bermuda* (built 1933) and *Ocean Monarch* (built1951) were withdrawn from service in 1966 because of increasing trading losses; passengers were taking to the air having the option of a two to three hour flight instead of 36 hours at sea. Both ships complied FULLY with the IMCO regulations and we had good relationship with the coastguard. However, it should be remembered that the US were very slow to recognise the benefit of fire-fighting sprinkler systems, they preferred “so-called” fire resistant materials overlooking the fact that many fires are caused by soft furnishings and passenger belongings.

I conclude with further evidence that *Queen of Bermuda* had a thorough refit in 1962 being fitted with new boilers, new lifeboats and updating crew accommodation (a few million pounds down the drain) similarly *Ocean Monarch* had a major refit along with a FLUME stabiliser. She was sold to a Bulgarian company and renamed *Varna*.

For the record Hand W were meticulous in their damage stability analysis of *Queen of Bermuda*. I learnt a great deal from the expertise of messrs Cameron and Campbell who in their youth obviously had lessons of *Titanic* drilled into them, they were great naval architects.

Yours very faithfully
W.T.CAIRNS
Fellow RINA.

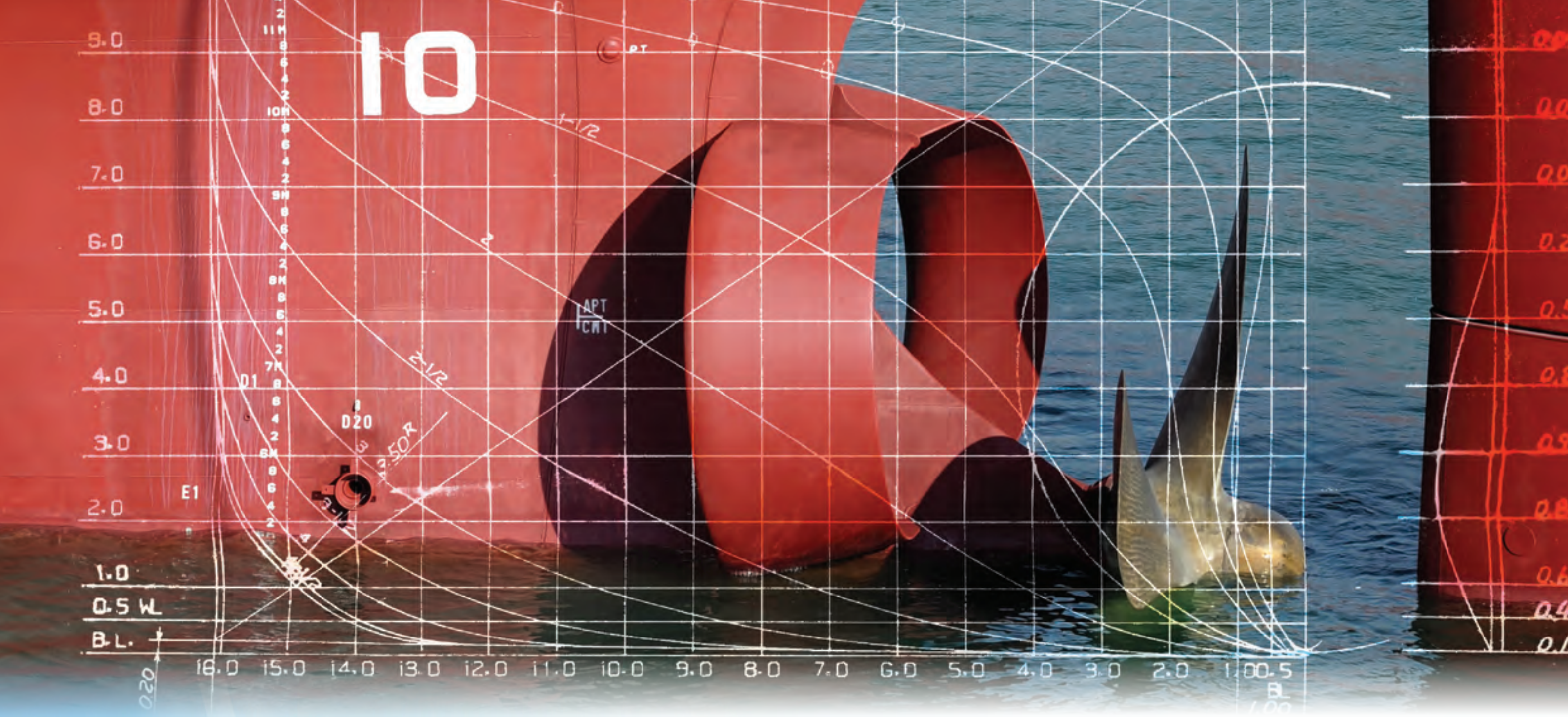
Sub standard!

Sir

I have read with interest Euan Haig’s article in the June issue and particularly his point in the last paragraph that no ship is unsinkable and is unlikely to be “uncapsizable”. There is one type of vessel that under normal circumstances cannot capsize and that is a submarine, due to the relative positions of centres of gravity and buoyancy. The only conditions under which a submarine can “capsize” is if it settles on a sloping bottom and it then rolls down the slope. This is of course not real capsize as there is no loss of stability, but the intrusion of an extra upsetting force from the sea bottom.

Since I first saw the reports of the loss of *Concordia* I speculated whether the fact that the captain beached the ship contributed to, or indeed caused, the so called capsize. I do not know what the regulations are for limiting asymmetric flooding resulting from longitudinal watertight subdivision in large passenger vessels but, I would expect that under any flooding scenario that does not immediately sink the ship due to plunging it would be expected to stay reasonably upright for sufficient time for all lifesaving appliances to be successfully launched and loaded. If the ship had remained in the relatively deep water where the accident occurred I wonder if the ship would have stayed upright for long enough for a successful rescue to be completed; she was after all very close to shore support and according to reports some considerable time elapsed after the accident before she was beached. The action of moving her over a very uneven bottom on which she was bound to settle almost guaranteed that she would roll over due to bottom forces.

Dr David Chalmers (Fellow)



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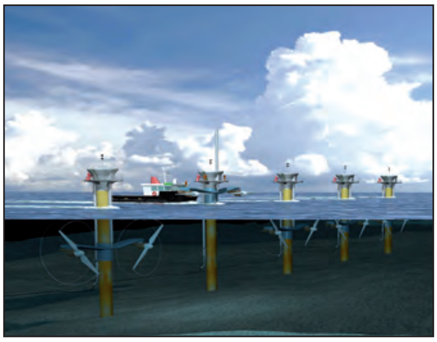

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