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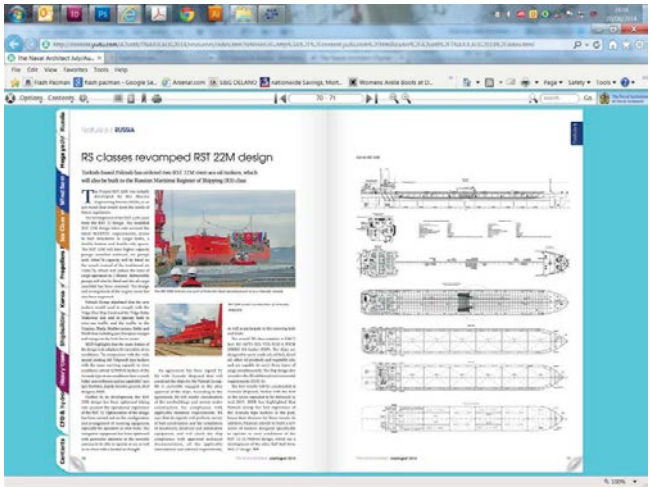

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Successful SMM in spite of industry's troubles

The collapse of Hanjin Shipping, along with Finland's ratification of the Ballast Water Treatment Convention dominated the news at SMM

As attendees left what was generally considered to be an upbeat SMM in Hamburg, they were left to reflect on the two major issues that dominated the news during the exhibition: the collapse of Hanjin Shipping and the ratification of the Ballast Water Management Convention (BWMC) by Finland.

The latter event was significant because the vessels on the Finnish register effectively took the percentage of vessels covered by the BWMC past the 35% mark, which is the level that triggers the enforcement of the Convention.

IMO now says that the BWMC will become effective from 8 September 2017, 13 years after it was first approved at the IMO's Marine Environment Protection Committee. However, operators may not be in any haste to fit the systems necessary to meet the regulation, given the level of uncertainty that still surrounds the enforcement of the Convention.

Reactions to the Finnish signing and its consequence can best be described as mixed. BIMCO is "deeply concerned" about the prospect of members installing systems now which may not be approved for use in US waters later because the US has not yet approved treatment systems that comply to its own, more stringent, national standards, says Lars Robert Pederson, BIMCO deputy secretary general. "Shipping will have to invest significantly in the installation of ballast water treatment systems by next September – only to find the investment is wasted if their system does not meet US standards."

BIMCO believes systems approved to the present IMO standards are not robust enough to ensure that those installed on ships perform to the regulatory requirements to treat ballast water. "We therefore call upon IMO to expedite the revision of their G8 guidelines for approval of ballast water treatment systems."

For his part, ICS Chairman, Esben Poulsson says: "The fixing of a definite implementation date, after so many years of delay, will at least give shipowners some of the certainty needed to make important decisions about whether to refit the new mandatory treatment equipment or otherwise to start sending ships for early recycling. Unfortunately, the entry into force of the new IMO regime will not resolve the extreme difficulties that still exist in the United States.

"The impasse in the US is a particular concern for operators that have installed ultra-violet systems." ICS says the situation has been compounded by the Coast Guard announcement last year that it will not accept the methodology used by other IMO member states to approve UV treatment systems when assessing the number of viable organisms in treated ballast water.

In the other major news event, the collapse of Hanjin Shipping Line is a further indication of the weakness of the South Korean industry. Hanjin failed to attract government support at a time when it was engaged in a lengthy industrial dispute over the decision to cut Korean jobs followed by the founding of Hanjin's yard in Subic Bay in the Philippines. Hanjin Heavy Industries and Construction-Philippines (HHIC-Phil) is now operating and recently announced the capturing of an order for three containerships of more than 20,000TEU.

The Hanjin yard in Korea remains open, but the representation of the South Korean yards at SMM was minimal with only Hyundai Heavy Industries having a presence at the show. Most Korean yards are now burdened with heavy debt levels and shrinking order books for both shipping and the offshore market, and there appears to be little respite on the horizon for these embattled yards.

One commentator pointed out that the other two major shipbuilding nations, China and Japan, were also suffering, but while China will recover through its domestic demand and government support, and Japan has dedicated customers and has largely continued to produce the vessels it produced during its heyday, it was difficult to see what support the South Korean yards could find.

Meanwhile, *The Naval Architect* has agreed with the German towing tank HSVA to follow the progress of its latest research programme HOLISHIP project on holistic vessel design (see *The Naval Architect* September 2016, pages 48-51). The four year project is due to start work in earnest in the coming months with the first bi-monthly progress report due in November. *NA*

Shipyards

China set for more yard consolidation

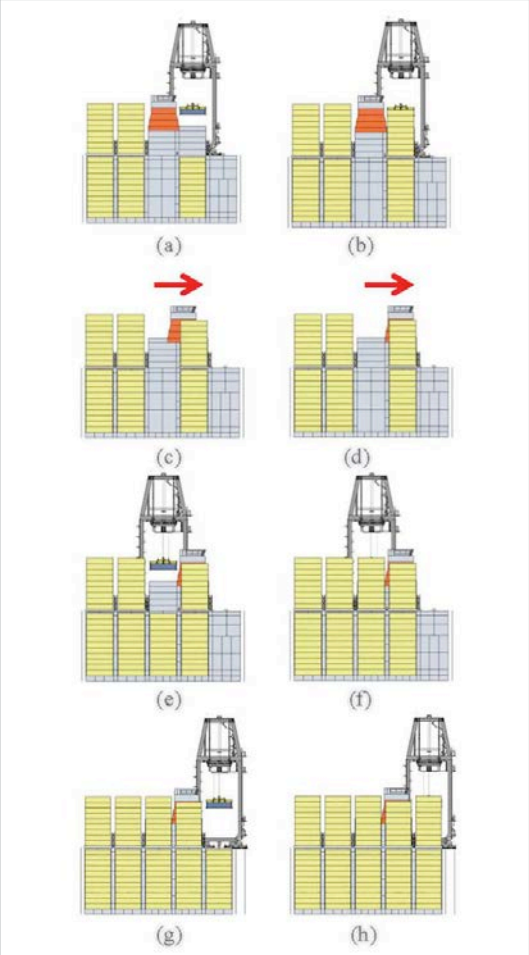
China COSCO Shipping Group, which operates two shipbuilding and shiprepair subsidiaries, is expected to merge its companies by the end of this year.

At present, China COSCO Shipping Group plans to integrate COSCO Shipyard Group Co. Ltd and COSCO Shipbuilding Industry Company into one company, creating an entity with complete shipbuilding, shiprepair and offshore engineering capabilities. If this merger takes place it is planned that where there are two shipyards in one city, such as Dalian, the yards will be merged.

The China COSCO Shipping Group's plan is seen as part of China's major shipbuilding industry reorganisation. However, China COSCO Shipping Group staff are conducting a survey of the integration possibilities, and say they are not ruling out other possible solutions.

COSCO Shipyard Group Co. Ltd has six shipyards in China's coastal cities of Dalian, Zhoushan, Nantong, Guangdong and Shanghai: COSCO (Qidong) Offshore, COSCO (Dalian) Shipyard, COSCO (Zhoushan) Shipyard, COSCO (Guangdong) Shipyard, COSCO (Shanghai) Shipyard and COSCO (Nantong) Shipyard.

COSCO Shipbuilding Industry Company has two main shipyards: Nantong COSCO KHI Ship Engineering Co. Ltd and Dalian COSCO KHI Ship Engineering Co. Ltd.



The loading procedure for SkyBench

Ship design

HHI's SkyBench receives DNV GL AIP

Hyundai Heavy Industries (HHI) announced on 8 September at the SMM show in Hamburg that it has received the second approval in principle (AIP) from DNV GL for its SkyBench vessel design (see *The Naval Architect* 'HHI's moveable feast' pages 30-40 October 2014), an innovative design that will maximise the cargo capacity of large containerships.

The classification society has verified the strength and structural analysis of the SkyBench system, "including the overall finite element analysis conforming to S11A rule, a partial ship analysis, an overall hatch corner's relative deformation check, a spot fatigue check for several critical hatch corner locations, and a detailed analysis of the design with a solid model for the parking device," explained HHI.

In the first AIP, awarded at Oslo's Nor-Shipping in June last year, DNV GL confirmed the concept design for SkyBench.

SkyBench has a mobile accommodation block that is mounted on rails and can move over the span of two container bays. The SkyBench allows for additional storage as it utilises the void space beneath the sliding block. In addition, the safety of crew can be improved by the detachable design of the SkyBench which can be used as a lifesaving flotation unit should the containership sink.

The bridge and three upper decks of a 'twin island' can be constructed as a separate sliding block mounted on rails which can move over the length of two 40ft container bays. In combination with a resizing and relocation of fuel tanks and the utilisation of the void spaces beneath the accommodation block in the traditional design, SkyBench allows the addition of two extra 20ft container bays. The resulting cargo increase amounts to 270TEUs on a 17-row wide 10,000TEU ship, 350TEUs on a 20-row 14,000TEU ship and 450TEUs on a 23-row wide 19,000TEU ship.

It takes 10 minutes for SkyBench to operate at port, using four electric drive train units to move the block backwards from its normal position. The two

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40ft side casings on which the accommodation block rests provide structural strength and holds lifeboats, provision cranes and utility rooms.

Regulations

IMO set to approve H2 rules

The third session of the IMO's Sub-Committee on Carriage of Cargoes and Containers (CCC), which took place during the week of 5-9 September, has endorsed the draft interim recommendations concerning bulk cargoes of liquid hydrogen.

The rules will now be put forward for approval at the Maritime Safety Committee's 97th session which is due to take place from the 21-25 November.

IMO said in a statement: "Draft interim recommendations have been developed as the International Gas Carrier (IGC) Code does not specify requirements for liquefied hydrogen in bulk. They are based on the results of a comparison study of similar cargoes listed in the IGC Code, e.g. liquefied natural gas. They are intended to facilitate the establishment of a tripartite agreement for a pilot ship that will be developed for the research and demonstration of safe long-distance overseas carriage of liquefied hydrogen in bulk."

In the recommendations from CCC are the general requirements and special requirements for liquefied hydrogen, such as the provision of a portable hydrogen detector for each crew member working in the cargo area; selection of fire detectors for detecting hydrogen fire; and appropriate safety measures to prevent the formation of an explosive mixture in the case of a hydrogen leak.

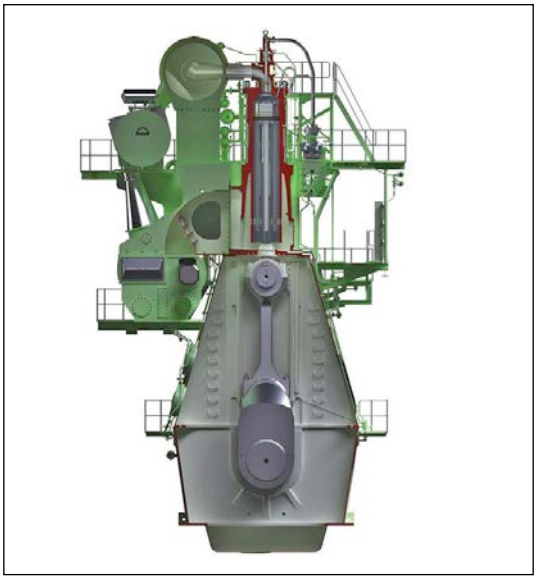
Engines

Three new MAN units added to Mk10

Marine engine producer MAN Diesel & Turbo has announced three new, weight-optimised, large bore engines that will form part of the group's Mk10 engine portfolio.

The three engines are the MAN B&W G90ME-C10 type delivering 6,240kW per cylinder, S70ME-C10 type delivering 3,430kW per cylinder and the S60ME-C10 type delivering 2,490kW per cylinder.

According to MAN Diesel & Turbo the latest engines are "weight-optimised, compared to their MK 9 counterparts, and form the new design platform for a new Mk 10 engine portfolio. Key to the new platform is the development of the TCEV (Top Controlled Exhaust Valve) and FBIV (Fuel Booster Injection Valve) components".



An illustration of the G80ME-C9 engine

The three new designs are the first of a new generation that will ultimately involve the upgrading of all S- and G-engines to the Mk 10 platform.

"For some years now, our primary R&D target has been to develop the next generation of our ME platform. During this time, the goal has been to utilise the full potential of the ME engine concept by reducing the complexity of the hydraulic system and increase system performance; the new TCEV and FBIV technologies have been developed within this scope," explained Ole Grøne, Senior Vice President Sales and Promotion – MAN Diesel & Turbo.

In the meantime, six years after its introduction, MAN Diesel & Turbo has confirmed the 1,500th order for its G-type engine.

Greek ship operator, Almi Tankers, will take delivery of the ultra-long-stroke 7G80ME-C9 type engines for two 317,000dwt VLCC's to be built by Hyundai Heavy Industries in Korea.

"Coincidentally, Almi Tankers also placed the order for the very first G-type engine. The crude carriers are due for delivery in, respectively, February and April, 2018. In both instances, the engine is Tier III-compatible," said a MAN statement. *NA*

Correction:

Since publishing the September issue of *The Naval Architect* and article "New designs and future headings", it has come to light that Tallink's LNG-powered ferry, *Megastar*, will be equipped with two "type C" LNG tanks and not stainless steel tanks as stated in the article. We would also like to clarify that the "old IGF code" stated was technically incorrect as the IGF code had not yet been introduced and in fact refers to the interim guidelines preceding the IGF code.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Adding a touch of class

If common structural rules have been introduced for tankers and bulk carriers to save yards designing different hulls for different class societies, David Tozer, global business manager for containerships at Lloyd's Register is "really pleased" that this process has not been adopted for containerships as yet, *writes Sandra Speares*.

He says container shipping is still very young with ships continuing to develop and new technology introduced. Having different approaches by different class societies means that they react very quickly to new ideas through observing what is happening "out in the real world".

While the size of containerships has been increasing all the time, the method of lifting containers onto the ship remains broadly the same as used when containerisation was invented. "A revolution is due, but I can't see anything on the horizon just yet", he told delegates at the Ship-Port Interface conference organised by ICHCA International.

As far as "future proofing" ships is concerned, the days are gone when ships were designed to trade from Asia to Europe at 25 knots, "no matter what". Ships now have to be designed for their economic life whether for an eight year investment period or the full 20-25 years that the ship will be at sea. "This is a real challenge".

The shipowner today has many questions to answer, not only deciding on the type of ship required but whether the hull is strong enough, dealing with whipping and springing and other issues as well as the ship's speed profile and the type of engine and fuel required.

"As the ships are getting bigger, technology is responding, but it is important to make sure that the standards are there to meet the risk." With pressure to load the maximum amount of containers onto ships, ensuring that the ship's structure, container lashing, and all the different components are fit for purpose to get the ship and its cargo to its destination safely and in a commercially cost-effective way is vital.

For example, the combing on the side of a containership is one of the highest stressed pieces of the structure you will find on any ship, he says. "It is like a piano wire that holds the ship together and if it breaks you will almost certainly lose the ship." The detail that goes into designing and building that structure is therefore absolutely crucial.

Other issues include the correct stacking of containers and the weather conditions in which the ship is operating, as well as the ship's heading and speed. By "playing by the rules" it is possible to carry heavier stacks, but only by taking all these issues into consideration, he stresses. The advent of lashing bridges which are three or four tiers high, complicates things further, he adds.

The strength of the lashing bridge is now going to become part of the calculation for the stow. Also, with higher lashing bridges, it might be better to use external rather than internal lashing, which opens "a big can of worms" in terms of the calculated forces in the lashing system. Compression of the containers and twist lock separation are important he adds.

In short, maintaining boxes stacked up on the ship is "incredibly complicated". Taking in seasonable capabilities, speeds, crews' experience of wave conditions and the like all allow cargo on the vessel to be increased, provided, once again, "everyone plays by the rules."

On 1 July 2016, new requirements to verify the gross mass of a packed container entered into force under the International Convention for the Safety of Life at Sea (SOLAS).

Knowing the accurate gross mass of a packed container is critical to ensure correct stowage and stacking and avoid collapse of container stacks or loss overboard.

"We assume in our methods that the container weights are as declared," he told delegates. Even placing a bin carrier carrying spare twistlocks on top of the container stack could result in the stack collapsing, he warned. In short, there is a lot less margin for error on today's container vessels.

The other part of the equation is loading the cargo and ICHCA has been involved in the development of MSC guideline 1352 which covers the stowage of containers on deck. It applies to new and existing ships and provides a clear standard for providing a safe place of work for people lashing the containers onboard. Many flags have now adopted the guidance as mandatory for their tonnage.

He says he does not think that containerships will get very much bigger than they are at the moment and believes a milestone has been reached. It is, therefore, a "time to regroup and get our act together". This industry, he says, "has been getting away with it for the last few years, we have now to tighten up our act so we can now safely operate ships at this size and prepare ourselves for what might come next". *NA*

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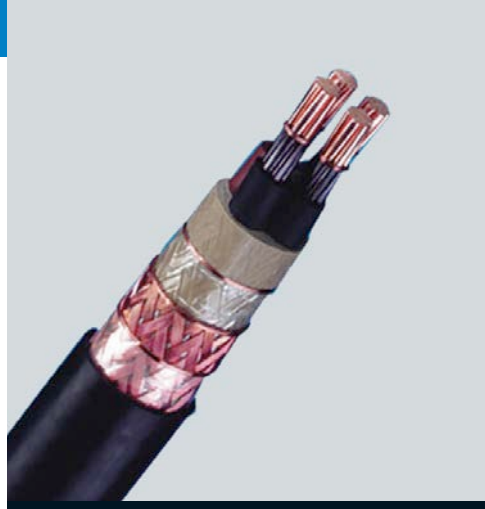

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Smart shipping

Building the digital bridge

NAPA and FURUNO have signed a letter of cooperation as they seek to advance the digitalisation of the maritime industry with the marrying of their respective software and hardware provisions.

The cooperation will pair NAPA's Performance Monitoring and NAPA Logbook software with FURUNO's existing hardware and satellite communication solutions.

Juha Heikinheimo, president, NAPA Group, explains it comes as part of a natural progression for both companies in which NAPA can expand its network to provide worldwide services based on FURUNO's well established hardware network, while FURUNO can expand its software abilities with the use of NAPA's digital expertise.

This, Heikinheimo continues, is just one collaboration in a wider picture of partnerships that are being formed to cater to shipping's digital revolution.

Muneyuki Koike, senior managing director, FURUNO, says: "We are confident that the combination of NAPA's Shipping Solutions and FURUNO's expertise in navigation and communication equipment with its worldwide service network will create very powerful synergy, and we are looking forward to an exciting growth of the partnership within the maritime IoT world."

www.napa.fi / www.furuno.com

Power & propulsion

Funding for largest ever Flettner rotor

The European Commission and Tekes, the Finnish government's funding agency for innovation, has awarded Norsepower €2.6 million (US$2.9 million) to continue research and development of it Rotor Sail Solution (a modernised version of the Flettner rotor) in the hope of achieving greater fuel savings and return on investment.

The fund will be used in the creation of new, upscaled Rotor Sail models for tankers, bulk carriers, large ro-pax and full size passenger vessels "where smaller Rotor Sails would be inefficient in achieving the most impressive fuel savings," says the company.

The new models will include the world's largest ever Flettner rotor, which is planned to be 30m in height and 5m in diameter.

"Our Rotor Sails have the power to reinvent the existing market and make auxiliary wind propulsion a natural choice for merchant shipping," says Jarkko Väinämö, CTO at Norsepower. "What is really exciting for us is the ability to leverage our existing knowledge and expertise to continue to offer an easy to use, hybrid propulsion solution that enables significant fuel savings and emissions reductions."

The first vessel to be retrofitted with the original solution, the 9,700dwt ro-ro vessel *M/S Estraden*, was independently found to have saved 6.1% in fuel consumption by NAPA, a Finnish data analysis, software and services provider.

www.norsepower.com

Power & propulsion

Azipod nozzles wider propulsion market

At SMM this September, ABB launched a new Azipod propulsion unit that promises to be five-10% more efficient than previous versions; a leap in efficiency that aims to make Azipod propulsion attractive to more vessel types.

The new linear flow Azipod XL introduces a nozzle with stator plates. These direct the water flowing from the propeller to reduce turbulence and energy loss, producing optimum thrust for the vessel according to ABB.

The Azipod XL concept can be designed to give high bollard pull thrust at lower speed while maintaining good characteristics at higher speeds.

Juha Koskela, managing director, ABB Marine and Ports, points out that while Azipods are widely used in the cruise industry and often on complex offshore vessels, the "improved fuel efficiency and bollard pull of the Azipod XL will increase its competitiveness into new sectors such as tugs, ferries and LNG tankers."

Superior bollard pull could open up new markets for ABB's new Azipod XL

Modifications to the unit are relatively simple, which will reduce the chance of failure, says a spokesperson from the company. These have been tested in laboratory conditions using scaled versions.

ABB states: "The Azipod XL represents the biggest jump in the systems' fuel efficiency in recent years…if the

newest model replaced all existing Azipod units it would save the shipping industry 2.2million tonnes of fuel, and 7million tonnes of carbon dioxide, over the next 25 years."

The company also announced the amalgamation of its existing EMMA and OCTOPUS software applications to form a software suite that combines external information, such as weather or cargo load parameters, with the ship's process and propulsion information. This offering, which comes under the OCTOPUS title, is intended to act as a digital hub for vessel data that can be used to improve efficiency.

Such data can include information on a vessel's trim, fuel consumption, power plant optimisation, hull cleanliness, and electricity use, amongst other onboard systems.

Mikko Lepistö, senior vice president, vessel information and control, says: "For the first time we are bringing together two important features in the maritime industry, energy efficiency optimisation and safe voyage execution, into the same software and analytics platform."

www.abb.com

Paints & coatings

A coat to remember

AkzoNobel aims to make biocide-free fouling coatings less expensive and more environmentally friendly utilising the bio-renewable oil found on sheep's wool.

A new fouling control coating, Intersleek 1000, deploys the new "Lanion technology" in a formula that is touted to deliver fuel and CO_2 savings of 6% compared with vessels using biocidal self-polishing copolymers (SPC).

The extracted oil improves smoothness and is designed to stay within a film on the coating, lasting as long as the coating beneath, says Dr Richard Towns, AkzoNobel.

An Italian-owned ro-ro has taken part in a five-year trial of the paint and has qualified for 1,500 carbon credits following independently verified fuel savings.

"The 1,500 carbon credits represent the removal of 1,500tonnes of CO_2 from the atmosphere and were accrued through a 6% fuel saving that was independently validated and verified by RINA services and the Gold Standard Foundation, as part of the carbon credits issuance process," says a spokesperson for AkzoNobel.

www.akzonobel.com

Cables

Space-saving wiring approved

DNV GL has granted type approval of a wiring solution that could save between 100 and 150m in cabinets onboard cruiseships, according to its developers.

SmartWire-DT, produced by Switzerland-based Eaton, aims to improve the connection and communication between controls and switching devices, sensors, and actuators, combining energy supply and data communication feeds in one cable. In doing so, wiring can be reduced by up to 85%, enabling cost savings.

It has potential applications in a number of control processes onboard passenger and merchant ships, including HVAC systems, water treatment systems, and in control systems for hatches, lifts and cranes.

"Current shipbuilding projects show that a 30% saving on space within control cabinets is possible through using SmartWire-DT," says Sebastian Kuster, Eaton's product manager for Marine Automation. "Onboard a cruise liner, for example, this can translate to a reduction of between around 100 to 150m in control cabinets, along with the corresponding space savings."

Components that are connected in the SmartWire-DT chain can autonomously relay information about load and status, providing early-warning of potential failures.

www.eaton.eu/marine

Seals & bearings

Options for EcoSeal range

Stone Marine, a designer and manufacturer of marine sealing systems, has expanded its environmentally friendly main shaft seal range, EcoSeal, to offer a design that is tailored to the thruster and Azipod markets.

The new offerings, EcoSeal T and EcoSeal TS (a split version of EcoSeal T), can be fitted into tight spaces, according to the company, and offer the same benefits as the original EcoSeal, including a double barrier design to prevent oil leaks.

EcoSeal T and TS have been designed with the thruster and Azipod markets in mind

The seals also offer savings when used as retrofitting solutions, as they can be fitted using the old seal liners.

The design of the EcoSeals takes thermal expansion, hydraulic pumping, and axial movement of the shaft into account, which allows it to be operated at depths of up to 50m, at high speeds and in high temperatures, according to the company. It can be fitted to a variety of ship types, from shallow draft dredgers to very deep draft heavy lift ships.

www.stonemarineseals.com

Power systems

Lithium-ion innovation

Becker Marine Systems announced its production of a new lithium-ion-based battery system at SMM in September that will be "low-cost, compact and easy-to-install onboard," according to the company.

The compact battery rack, titled COBRA, is currently in the test phase and is intended to be used as an independent system or in combination with hybrid drives. Its development follows the growing worldwide interest in alternative fuels and Becker suggests the unit could be deployed in conjunction with more of its products, such as the LNG PowerPac, which was designed to provide power to moored ships.

The COBRA battery rack has been pre-ordered by passenger ferry operators interested in alternative fuels

Deliveries of the new product are expected to commence in 2017, with a number of orders already placed by passenger ferry operators, according to Becker.

www.becker-marine-systems.com

Seals & bearings

Revised design eases installation

The latest version of SKF's Simplex intermediate shaft bearing for propulsion shaft lines adds stiffness while reducing weight, improving durability and installation according to the company.

The housing has been lightened and stiffened in comparison with its predecessor, which in the case of a mid-sized unit was approximately 50kg heavier.

SKF says the new Simplex model features a dowel pin design to facilitate easier installation and that the bearing shell is now made of steel in its entirety instead of the previous cast-iron offering. A new and lighter chock liner design has also been employed.

In addition, the seal's design has been simplified and a new top-mounted transparent oil scraper cover included, allowing easier assembly and maintenance.

www.skf.com

Wastewater systems

Complete system offering on horizon

ACO Marine launched ACO PowerVAC at SMM in September, an in-house-developed vacuum pumping unit that can create up to 8m in suction lift.

The pump is designed for vacuum toilets, black water collection and wastewater transfer systems onboard all vessel types. Its 8m lift potential means it is capable of pumping effluent directly to holding tanks from the double bottom tanks, says Mark Beavis, managing director, ACO Marine.

"The PowerVAC units are self-priming and insensitive to dry running and foreign objects," adds Beavis. "So there is no requirement for macerating of black water in front of the pump, which vastly improves the solid separation process in downstream treatment systems aboard the vessels."

The product has been launched as ACO Marine works towards a complete in-house sourced, vacuum-based wastewater management solution. The company is currently finalising a partnership with a vacuum component manufacturer to develop a range of marine vacuum toilets, vacuum interface valves, and all other sanitary components, the last pieces in the wastewater puzzle for the company.

www.acomarine.com

ACO PowerVAC can create up to 8m in suction lift

Jobs still a challenge for naval architects

In what is still a very challenging market for many businesses, what is the outlook for naval architects and the businesses employing them? Faststream looks back on another indifferent year in naval architecture recruitment and what to expect for the remainder of 2016 and beyond

We have all seen the news over the past 18 months about the troubles facing the offshore and newbuild sectors and you do not need to look far to read about the horror stories which are being published on a daily basis. This has understandably had a huge effect on recruitment throughout the maritime industry and it has been no different for naval architects.

Whilst there are pockets of opportunities available for naval architects, such as the cruise sector, caution has become the watchword for many maritime businesses and employees alike. During this time there has been a distinct change in candidate dynamics and the way in which companies are approaching recruitment and this is having a direct impact on recruitment.

Faststream CEO Mark Charman takes a detailed look at the changing approach to recruitment across the sector.

Employers and employees alike must define who they are and what they want in these times of change says Faststream CEO Mark Charman

Different companies, different approaches…

Faststream can report a 50% decrease in naval architect positions available on our books when we compare the first half of 2016 to the same period last year. Whilst this may paint a very grim picture, this can be attributed to the change in how companies are recruiting staff. We personally are seeing far less volume in terms of the amount of roles we are working, but we are working strategically with companies on far more senior and strategic roles than we have previously seen. Likewise, some businesses are finding it easier to attract new recruits themselves and companies are falling into one of three camps:

Company one: 'The distressed purchase'

These companies have a recruitment requirement and they need a solution… yesterday. Someone has been fired, someone has left or due to unforeseen circumstances a vacancy has come up and it needs filling quickly. These companies will write a generic advert and advertise this vacancy on industry job boards, put it on their own website and approach candidates on CV databases. They are looking for a high quality of applications and will interview large numbers of candidates.

Company two: 'Active but selective'

These companies have a developed recruitment process and a joined up approach to bringing in talent. They may have an in-house recruitment function and will likely use multiple external recruiters which can lead to lots of duplicate CV's landing on the hiring managers' desk from the multiple sources they are working with. They will be looking for the best talent in a very small pool of candidates, often leading to vacancies becoming left open for a long period of time. They will however be quick off the mark when they find what they are looking for.

Company three: 'Employer of choice'

These companies will have recruitment and retention at the top of their agenda. Their employer brand is important to them and they will have a well-defined candidate proposition, with thought to why someone would leave their job to come and join them. They will usually work exclusively with one recruitment partner, typically a sector specialist, who will act as their eyes and ears in the marketplace. They will very rarely advertise vacancies, favouring a headhunting approach to finding talent. These companies are looking for very specific hires, will be very selective with the candidates they bring in for interview and will be unwilling to compromise.

Each of these approaches will come with its pros and cons, and if you are a candidate looking for a new role then you will need to take time to understand how different businesses are approaching recruitment and think about which company is right for you and your career. The best positions are more difficult to secure, and this is certainly the case for naval architects in the current climate.

A changing candidate dynamic…

Whilst the downturn has led to changing tactics from employers, there has also been a distinct change in candidate dynamics and with this, the creation of three very specific candidate types.

Candidate one: 'Out of work and active'
These people are feeling the increasing pressure of being out of work and are desperately looking for new roles. They are searching job boards, recruiter websites and companies' own careers sections for new roles on a daily basis. Companies will be getting regular applications and speculative emails from these people and they will be applying for positions which are not always relevant to their skills and experience.

Candidate two: 'In work and active'
These people are riding out the storm with their current employer, but have begun to keep a closer eye on new opportunities as they return from their summer breaks. They have become increasingly selective about what they apply for and in most cases will expect to be approached professionally about new opportunities, often being notified prior to positions coming onto the open market. They feel extremely nervous about job security and are in fear of their current employer finding out – subsequently they are staying under the radar and are often only visible through their own professional networks. Money is playing a key part in their motivations to move roles as they may not have seen the salary increases of 'yesteryears' in recent times. The reward must outweigh the risk of moving jobs in these uncertain times.

Candidate three: 'Passive'
They are happy, paid well, valued and being bear-hugged by their employer. The thought of a new job will probably not even be on their radar. They are in demand, extremely difficult to find and will not share their details in the public domain.

Challenging times do not necessarily make recruitment easier. In fact, recruitment has become even more difficult than before for many businesses as the talent they look for becomes increasingly passive.

What next for naval architecture recruitment?
Many businesses employing naval architects have become much more optimistic about their hiring strategy in recent months and we are pleased to report positive signs in the marketplace. Organisations are more proactive in adding vital skills to their business and areas such as the cruise sector are actively hiring as the competition to create bigger and better vessels increases.

However, for many naval architects, such as those from the offshore sector, the struggle will continue. These people are looked upon as risky hires on the marine side as employers believe they will return to offshore and the money offered in that area, when the market returns.

My advice to businesses and employees – recognise and embrace the changing landscape and define who you are and what you want. In these changing times recruitment is not only more difficult, it is also very different. *NA*

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SHIP ECONOMY & TRADE

Shandong shipbuilding faces up to challenges

Shandong Provincial government has proactively introduced relevant documents to promote the shipbuilding industries to undergo structural adjustment and industry upgrading. Shandong Province is undergoing the transformation from "made-in-Shandong" to "innovated in Shandong," writes Liu Zhiliang

Shandong Provincial government and the Party Committee recently officially issued the document entitled "Insight into the Deepening of Supply Side Structural Reform".

The document points out that from 2016 to 2018, the Shandong Province shipbuilding industry productivity rate has risen to over 80% and has attained the objective of solving oversupply, which is a reflection of the supply side structural reform taking place in Shandong.

Experts in the shipbuilding industry maintain that this structural adjustment and upgrading has demonstrated the transformation from Made-in-Shandong to Created-in-Shandong. At the same time as targeting the specified market area, Shandong shipbuilders are also looking to design ships that are characterised as having a high value added element and that are high-tech in a bid to gain a competitive edge.

Shandong shipbuilding industry intends to move into the design of more specialised vessels

Defining transformation philosophy

Despite the recent sluggish domestic and international market, Shandong shipbuilders realised its distinctive development, especially in terms of high-end offshore facilities, large size ro-ro and high-end offshore fishing vessels. Yet, compared with developed countries and the advanced domestic areas, Shandong shipbuilders still lag behind, particularly in the areas of enterprise structure, industry support, productivity and innovation. A shortage of orders has led to the slow-down of production in shipyards.

Such problems as industry support, productivity and a lack of innovation have tested the long term development of Shandong shipbuilding companies.

Insiders say that if Shandong shipbuilders cannot focus on speeding up structural adjustment, developing innovation, establishing modern shipbuilding methods, and developing its ship design techniques, it will be impossible to develop the yards into healthy, modern enterprises.

There is an urgent requirement to adjust the structure and upgrade the industry. Experts say that Shandong province, for the sake of accelerating the shipbuilding industry upgrading process, has issued different documents and policies, including 'Suggestion for Dissolving the Oversupply, Shandong Yacht Industry Development Plan (2014-2020)' and 'Shandong Shipbuilding Industry Upgrading Implementation Plan'.

These documents clarify the target and implementation plan and the key issues in the next stage, offering guidance for future upgrading and planning. During this year, the provincial municipal committee and provincial government provided specific guidance for the very real problems in front of the shipbuilding industry, with two documents entitled 'Made in China 2025 Shandong Guidelines' and 'Suggestions for Promoting Supply Side Structural Reform'.

With the introduction of different policies, Shandong has gradually formed its philosophy of transformation for the industry. In the future, its shipbuilding industry will be challenged by two questions. On the one hand, it needs to accelerate the pace of merging and acquisition; on the other hand, it should encourage enterprises to develop ships with high-tech and high added value in an effort to realise product development and transformation.

Active countermeasures

At the same time as adjusting the structure and upgrading the industry, Shandong ship enterprises must give priority to

extending its business area through the development of high tech industry methods and more sophisticated vessels, all of which are the derivatives of the supply-side policy that is based on an increase in demand from the market.

During the past two decades, AVIC Weihai Shipyard and Penglai Zhongbo Jinglu Shipbuilding have been engaged in building bulk vessels mainly. Jinglu has a great advantage over the AVIC Weihai Shipyard in terms of its high-end fishing vessels, which have received acknowledgment in the market and give their designs a strong market reputation.

Yet recently, both shipyards have successfully bid for and been awarded contracts for ro-ro vessels. Currently, AVIC has signed a 4+2+2 contract with Stena RORO of Stena AB, which is one of the largest ship-owners in Sweden. The contract is to be implemented in Weihai Shipyard. For Jinglu, it has a contract with Changdao Xianglong Passenger Shipping Company for a 49.8m-long passenger vessel and a 60m ro-ro ship.

The experts say that these new orders signify an increase in confidence from the market in the Shandong shipbuilding industry and a move to higher-value vessel orders, which will, in turn, bring fundamental changes to the management, technology and talent team of the industry. Consequently, this will pave the way for future industry adjustment and upgrading.

Based on the requirements raised in the Shandong Province Shipbuilding Industry Transforming and Upgrading Implementation Plan, the future beyond the three mainstream ships, namely, green bulk vessels, container vessels and oil tankers, will see Shandong pay greater attention to special vessels, salvage, fibreglass fishing vessels, offshore fishing vessels, marine administrative vessels, and resource investigation and scientific investigation vessels. In addition, the yards will work towards developing gas powered river vessels or other clean fuels that are worthy of exploration.

Shipyards are also being encouraged to develop their offshore vessel building capabilities so that the offshore gas exploration in Chinese territorial waters can gain traction.

Innovation-drive and coordinated development

Innovation is the foundation on which demand for high-tech, high end vessels are built. While some enterprises are struggling to develop research & innovation-driven development, the industry supervision commission, Shandong National Defence and Technology Office, is also proactively involved in coordinated innovation and trying to resolve the issue of inadequate innovation, which is currently seen as a hot potato.

In recent years, the Shandong National Defence and Technology Office has advocated the cross-industry, cross-area and cross-geography coordination regardless of the identity of the enterprise or its property. This mode is better demonstrated in the offshore equipment industry.

At the end of 2012, headed by the Shandong National Defence and Technology Office and CIMC Offshore Institute, the 122m (400ft) jack-up SD-400 automation project was initiated, which involves the coordination of the following entities: Drilling Technology Institute of Shengli Oil Engineering Company of Sinopec, China Oil University, Ocean University of China, Tianshi Offshore and Oil Equipment Institute and Shandong Traffic College.

By the end of 2015, the SD-400 integrated innovation project had finished its inspection and acceptance, which had broken down the barriers that stymied the researchers. This is a coordinated innovation and guarantee system which has integrated different disciplines, industries, areas and systems.

Local area competence is supported through the use of more than 80% of parts being manufactured domestically. It is claimed that, for the next stage, Shandong Shipbuilding industry will need to break down the barriers to the systems promoting the integration of resource factors from different industries. This is a copy and paste of the SD-400 R&D process, which is providing the blueprint for the offshore industry. The technology advantages are soon to be converted into industry strength and revenue. This is also a process of changing the single advantage into industry and regional advantages.

Driven by orders, the overall coordination which involves the upper reach study institute and lower reach enterprises must be encouraged. Only in this way can there be an increase in both domestic and overseas orders, realising production modulation, information popularisation, lower costs, and higher revenue as the target for the industry. *NA*

Innovation is key to SDARI's future development

Having successfully bid for the building next door to its headquarters, SDARI will build a research centre that it says will launch the company to the forefront of 21st century vessel design. And the company outlines some of its immediate plans for its future development

The Shanghai merchant ship Design And Research Institute (SDARI), a leading naval architect in China, claims it has achieved a record high market share in China of over 60% by taking on the design of 30 Valemax VLOCs, container feeders, chemical carriers, ro-pax carriers and other designs in niche segments.

In addition, the company is developing its services including its cruiseship designs, intelligent design systems , smart ship designs and is looking to enter into the ultra large containership sector.

"However the cake is too small, and even a big bite could not feed us," says SDARI president Jintao Hu. "In spite of the headache from the offshore and production design segments we are generally in good shape with our accumulation and strong government support. We have an ambitious plan to build a future that is more innovative, efficient, internationalised and with a diversified business." This year SDARI has launched several projects to build up its innovative centre and to develop its digitalisation projects.

e-SDARI

One such project has been e-SDARI, an intelligent co-design and data analysis system based on the internet, explains SDARI chief information officer, Lu Li. An advanced ship data centre is to be built, which will integrate all data from current internal isolated systems such as office automation, human resources quality control, marketing and ship design systems. The data centre also aims to provide a data storage and analysis service to clients.

High performance calculations can also be provided through a private cloud link established to satisfy the increasing demand for numerical calculations, including CFD calculations, FEM analysis, noise and vibration assessments, and piping and ventilation simulations.

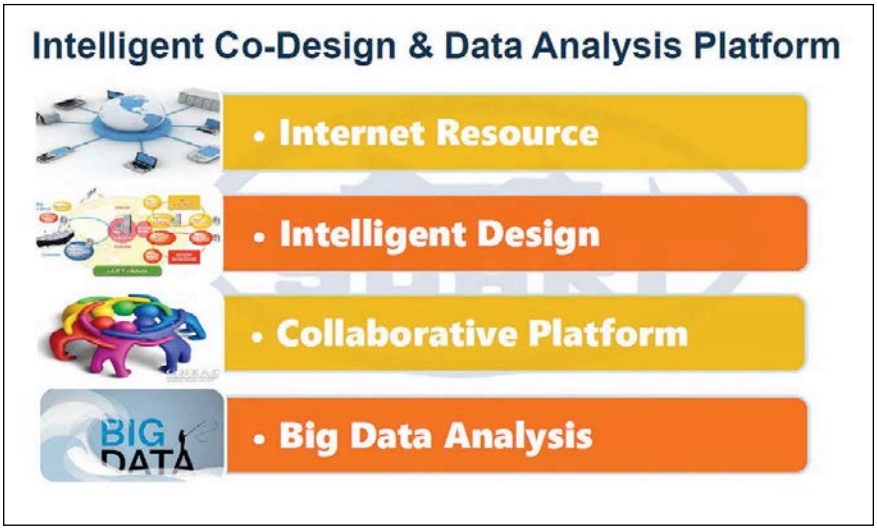
Another task for the system is to build up an integrated 3D design platform from concept to production design. "The intelligent design platform could easily get any information or material relevant to your current work at any place, and it can even make proposals for you if you give it some input", says Li. e-SDARI will be an open collaborative platform which will invite any interested qualified engineers or organisations to join in with on-going design projects.

Smart Ships

In recent years some systems based on data analysis, such as route optimisation and energy efficiency optimisation, were adopted by shipping companies. Ship-to-shore connectivity made the ship's operation transparent. These systems and technologies make the shipping easier, ecologically friendly and smart. Smart Ships with smart functionality and connectivity will likely be the next demand from the maritime industry.

"So, what is a Smart Ship? Unmanned? There is no technical definition so far. Whatever it is, however it is defined, the Smart Ship is

SDARI is hoping to break into the large containership market as part of its expansion



An intelligent design and data analysis platform, e-SDARI, will bring together data from a number of sources into one place

coming. Like something new to other industries, it will come around step by step," says Xin Li, deputy director of the R&D department, and head of SDARI's Smart Ship development team.

SDARI believes, based on existing technology, that there will be three stages in the development of Smart Ships. The first stage will be the Smart Ship with Big Data. By collecting and analysing the data onboard, a Smart Ship will have optimisation advice and decision-making support, and it could be completely monitored on shore by ship-to-shore connectivity. "It takes operators to a data platform which they've never had before, and it will change the way ship operations and management are conducted," says Li.

The second stage will be the Smart Ship within the scope of the IoT (Internet of Things). All the systems and equipment onboard will be connected. "The software, with high reliability, will not just give decision-making support, but will control the systems and equipment which are not essential to the safety of the vessel without a human in the loop," explains Li.

In the third stage the ship will be unmanned. At that time, the vessel can sail itself and it will be connected to other ships, ports and any other relevant stakeholders. "It does not make sense for a shipping company to have just a single unmanned vessel on the ocean, the technology works at its optimum when every ship is connected and every ship is a Smart Ship," says Li.

In fact, the technology already exists. Before adoption by the industry, many issues, such as cyber security, regulations, software reliability, labour policy etc, have to be addressed.

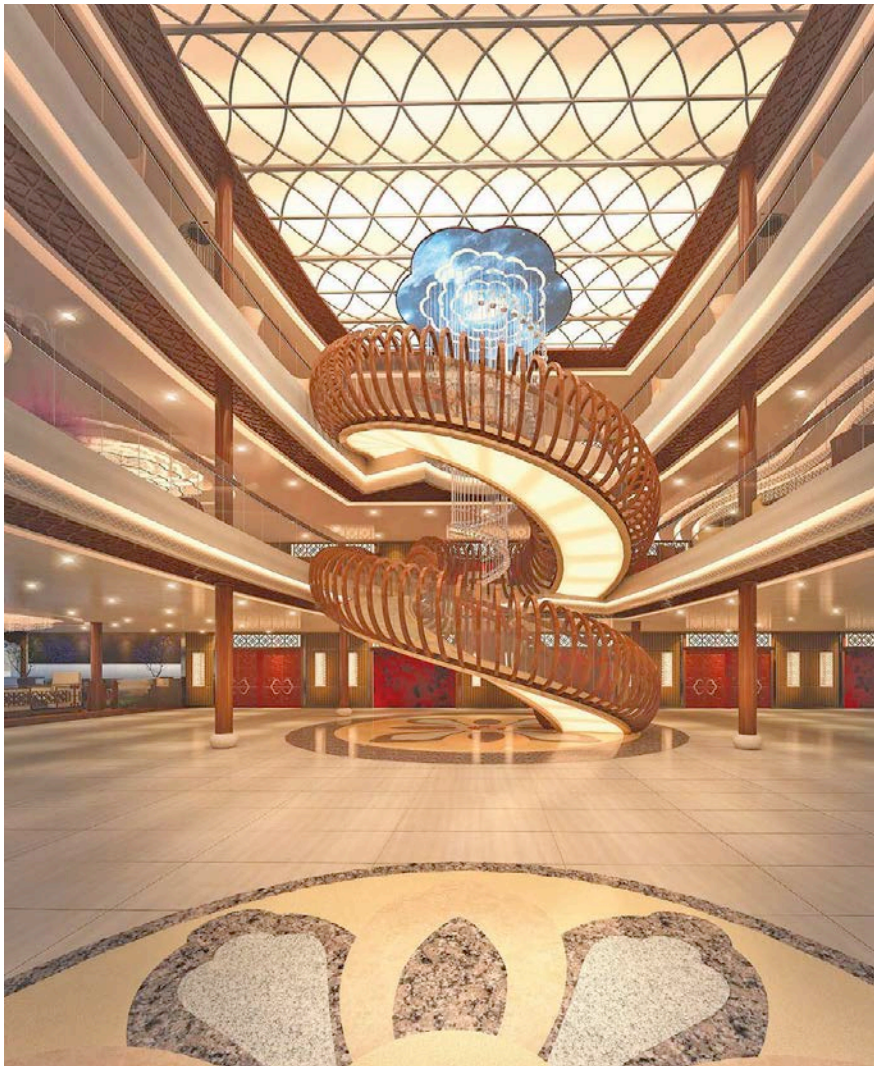
SDARI started to think about Smart Ships three years ago and has made up an action plan for the development of Smart Ships, step by step. By cooperating with suppliers, shipyard and classification societies, a smart bulk carrier "i-Dolphin" with 38,800dwt as a sample is under development and will go into the shipping market at the end of next year. Through this project the above first stage of the Smart Ship will be achieved and the functions of the considered system will be verified, says SDARI.

Cruiseships

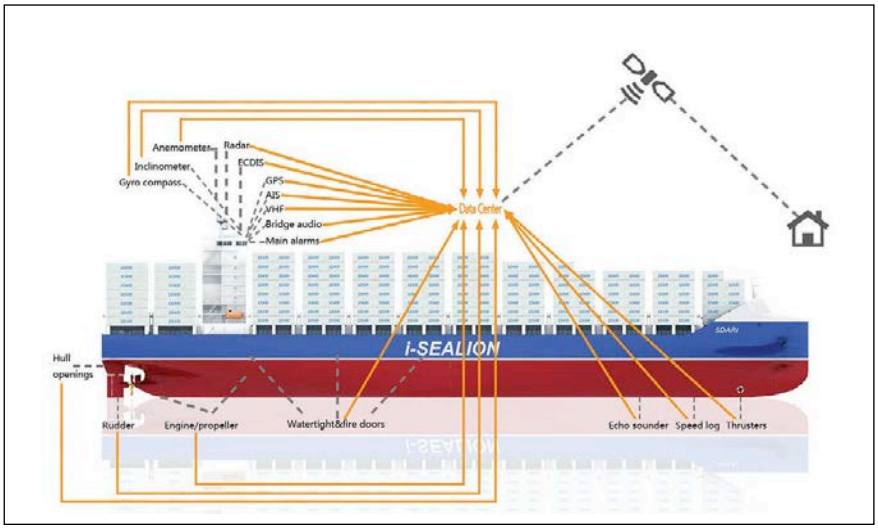
Cruiseships are a very hot topic in the industry. "Even the industry had made a big improvement in the past decades, but building a cruiseship is another story. It is much more of a challenge than expected," says Minjiang Zhang, the chief designer of SDARI's ro-pax division. From the design point of view, it is not enough just to design the more complicated systems as a naval architect and engineer. Culture, Art and architecture are more important for cruiseships.

Cruiseship management of the hotel systems, entertainment systems, logistics, catering services etc. require careful study.

Another major area of development for SDARI is its move into cruiseships for the Chinese market



Learning from its European counterparts SDARI believes it can produce the kind of dramatic and artistic interiors that will suit Chinese tastes



The three stages of the Smart Ship, Big Data, internet of things and then unmanned vessels, will develop in the coming years

A specialised team has been organised to make research on these systems. In the past five years, with support from government, SDARI has conducted overall research into a 70,000gt cruiseship, including such aspects as general arrangement, performance, structure, machinery, electricity and art. "Through this research work, SDARI has a head start into the cruiser segment," says Zhang. Cooperating with experienced European consultants, classification societies and other relevant parties can help us to speed-up the progress. SDARI is well prepared for its contribution in the design of cruiseships to be built in China.

Ultra Large Container Ships

Besides SDARI's strong feeder ship reference, the company has also developed its ULCS (Ultra Large Container Ships) department over the past ten years.

"Recently the philosophy for containership design has changed a lot," says Jie Lin, the chief designer for containerships at SDARI. Derived from the previous single point optimisation, the operational profile simulation for a vessel's whole lifecycle has now been adopted for hull form optimisation, which will lead to improved fuel efficiency during real operations.

In order to get best efficiency, advanced CFD tools are used to get the best hull through thousands of candidates considering various design variables and constraints. Energy saving measurements including rudders that are combined with fin ducts and highly efficient propellers are applied.

During the development, except focusing on environmental protection methods including SOx, NOx and CO_2 emission control, ballast water management etc., cargo safety and flexibility including an innovative lashing method and a comfortable and ergonomic living and working environment are also included.

The special technical points concerning the ULCS, including global ship Finite Element Analysis, spectral Fatigue Analysis of critical structural detail, springing and whipping analysis, and vibration assessment, are carefully studied. By cooperating with classification societies, a series of ULCSs from 9,000TEU to 22,000TEU is promoted to the market. *NA*

Working with the virtual world

"It's a new way of doing things, but it's clear to me that it's going to become the standard way of designing ships over the next few years," says Robert J. Spencer, Knud E. Hansen

The virtual world and its benefits are already leveraged by industries ranging from healthcare to space travel, but, as might be expected, the maritime industry is playing catch up with the current pace of technological change. That is to say, up until now.

A software team from Knud E. Hansen, combining the practical shipbuilding experience of naval architects with the technological expertise of programmers, launched what it believes to be the first virtual reality (VR) design tool of its kind at SMM in September.

The tool, named ShipSpace, allows designers and other players in the design process to experience the space of a ship to scale using the CAD data from a vessel's 3D model.

Its developers envisage serious benefits for naval architects and shipowners, simultaneously improving designs and the design process. Robert J. Spencer, head of simulation products at Knud E. Hansen and Ken Goh, general manager of Knud E. Hansen's Australian branch, highlight three significant areas of improvement for architects.

"The first is just getting a really good sense of scale…I'd summarise [it] as just better spatial reasoning," says Spencer. "When you're looking at a monitor, even when you know the dimensions, you really can't understand [or] get a visceral feeling for the scale of things. You can know, yes, that's 20cm or that's 8m, but until you're actually out in a space that has an 8m ceiling, you don't really grasp what that means. And so, by getting that more visceral understanding in your bones of how big a space is, [it] just helps to make sure you can optimise it."

Spencer believes the tool will consequently avoid mistakes but will also allow designers to minimise spaces. In other words, if a room feels sufficiently sized when it is experienced in VR, designers will avoid the impulse to enlarge what seems to be too small on paper; they can test the real environment for themselves.

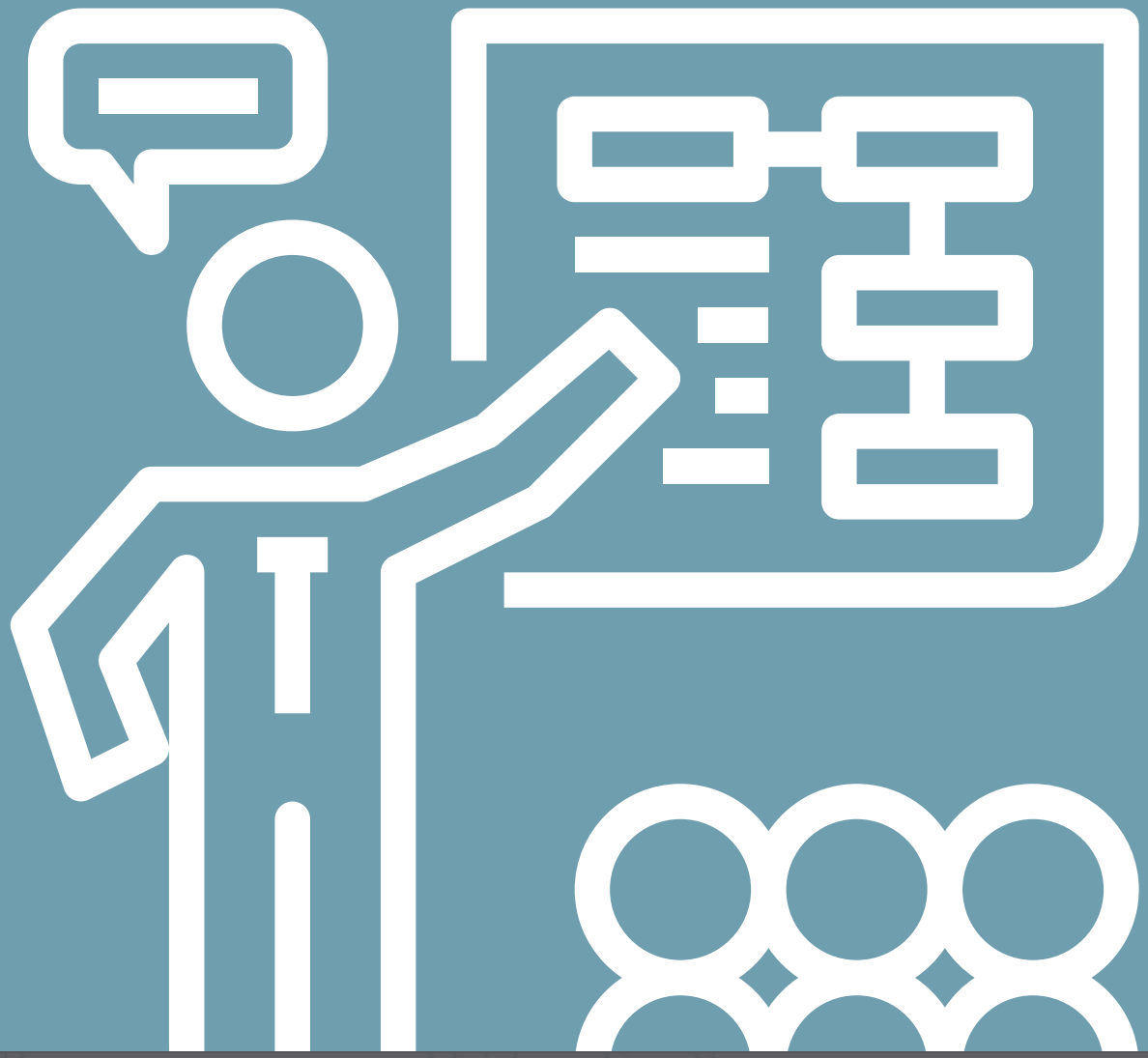
ShipSpace allows the user to experience the design of a ship at full-scale based on CAD data

Goh adds: "Lots of areas on the ship are quite complicated in shape, and it's quite hard to understand, even from a computer monitor, what these shapes are like until you're actually in that space and can see, oh, this sloped surface here, we can't put some piece of equipment on that. And that helps to optimise the ability to utilise space in a ship."

The second significant area is communication. Communication in and between different design teams – even those that are working in 3D – is challenging when referring to different parts of a CAD model and their location. "There's a lot of coordination that's messy," says Spencer. "Whereas with ShipSpace, you [different designers] can both be in the same space, looking at the same things; you can point and say: 'this thing.'"

This ultimately simplifies the process for designers, but also makes the design of a vessel more accessible to those that can't read plans.

The third benefit, domain expertise, ties into this idea by empowering non-designers with an active role in the design process. Spencer hypothesises an example of designing a galley: "An engineer can educate themselves well enough to design a galley, but engineers aren't known for their culinary expertise." A chef on the other hand can't read a plan, but they can tell you what is needed for a galley. "With ShipSpace you can get a chef, you can put them in their galley, and he can stand there and say: 'No, I'm standing here with a frying pan and I can't reach where it now has to go; I need to be able to stand in one place and move this from there to there,'" says Spencer.



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"Normally these sorts of things happen afterwards, where they'll create a mock-up or fly-through, or something like that, and then say: 'is this ok?' At which point you can pretty much guarantee that they're going to go, it's ok...because at that stage it's too expensive to go back and start changing things."

It is by moving this incorporation of domain expertise further forward in the design cycle that Knud E. Hansen believes its system will reduce design risk and add substantial value to the achieved end product. Even now, some owners have to spend another couple of hundred thousand dollars on brand new ships that haven't even seen full service yet to rectify areas that don't work, explains Goh.

While the cost of the licence to use the system is not disclosed, Goh says: "The cost of people employing this system for their design and making sure, getting domain experts in to advise those issues, the cost of actually using [the] system is insignificant compared to what can be saved."

The rate of production is also sure to improve, according to Goh, especially when it comes to resolving clashes and things like pipe runs. "3D modellers often have to design their systems separately from each other… and then they all think, oh you're going to get this over you and I'm going to go over here and sometimes they have to cross, and then it's often left to production to sort out the interfaces and also the clashes they find.

"An evolution, or a way to be able to use this tool, is to be able to resolve those clashes – communicate with members of them in a 3D environment. We've been doing experimentations of moving things around in the virtual space, which we think is going to be very valuable as a design tool for both designers and the shipyard in the future."

Detailed features can be observed in ShipSpace's virtual world

In addition, any segment of the shipbuilding market that has a strong requirement to impress with visualisation, such as luxury yachts or cruiseships, will be able to leverage this tool to their advantage with clientele.

The virtual mechanism

Any 3D model can be inputted into the system, according to Spencer. "So, when the ship is designed – so long as it is designed in 3D, and a 3D model comes out of it – it doesn't matter what package it's been developed in, we can export the 3D data from that design package [and] import it into our system."

A decision was reached early on in the development of the platform to make sure ShipSpace was compatible with pre-existing CAD software and acted as an additional tool rather than as a separate entity that designers would have to radically adapt to. Spencer clarifies: "If we make [architects] have to make a second model that destroys the point – being able to use the models that they're working with is, to us, the most valuable thing."

The logic to this decision, more than simply maintaining as wide a market as possible, is further explained by the appreciation that "there are a lot of very specialised CAD tools out there that designers have become very familiar with, and are very fast and efficient; and a mouse and pointer is still the most efficient, fastest and most accurate way of specifying things – we don't want to change that. However, it is not the best way of visualising things, so we're adding that visualisation step."

Questioned about the fact many yards still do not use 3D models, the pair suggested the development of a functioning virtual reality tool would encourage those that were either reluctant to make the change or on the verge of making the change to 3D models. "I can say that it is pushing people that have been thinking about 3D and saying: 'no it's not worth it, our people are faster in 2D,'" states Spencer, "[as] now there's this clear benefit – working in 3D you can actually see what you're doing."

The software suite ultimately acts as a new stage in the design process, and Spencer

emphasises that the virtual model is not a specially created VR version; it is created based on the real design data. It works by exporting the data from any of the main CAD tools into an intermediary format that the virtual reality model can be created from. If a CAD system is discovered that cannot be exported from, Knud E. Hansen says it has the capability to create a new exporter.

In terms of system requirements for any would-be users, the system that displays the reality is very powerful, and as such is provided by Knud E. Hansen. But beyond this addition there is no change, according to Spencer, as the designers are simply using their standard tools.

To date, no limit has been found to version one of ShipSpace in terms ship size or complexity, although Spencer jests: "I'm sure there is one, but I'm not sure there are any vessels that are that big."

To put this in perspective, Goh explains that the trial version presented at SMM of an Antarctic research vessel is one of the most complicated vessels that Knud E. Hansen has designed, and features one of their most complicated 3D models too. "All the details, even from bolts round the bottom of cranes – we haven't taken any of that information out, it's been put into the system," says Goh. This is certainly the case, and, as experienced during *The Naval Architect*'s very own trial, this level of detail was clearly visible. Spencer explains that the system has 600million polygons which allow it to function at this high level.

The system was very easy to use and intuitively allowed the user to access most areas of the ship using a handheld controller that could be seen in the virtual reality model. This worked in two ways, either allowing movement within sight, for example moving along a corridor by moving a circular pointer to where you wished to stand and then "teleporting" with a click, but also by accessing "orbs" that would relocate the user to a section of the ship that was further away.

Future developments

The two designers are mindful that the system is only version one and development is set to continue, opening up new design opportunities. For example, use of the system will move even further forward in the design cycle, with the potential to make some concept designs in 3D instead of 2D. In addition, using the design tool throughout a ship's evolution will aid in the resolution of clashes with the yard and can help to familiarise crew with a vessel before its delivery; "operational development and training is actually one of the areas of use that owners are actually very interested in with virtual reality technology," says Goh.

Interest in the tool has been diverse, continues Goh: "We've had interest from areas that we didn't even think about… because this technology is so new that really we're opening the door to the technology into the maritime industry, and even in all aspects of where virtual reality is starting to make an impact in the rest of industry, people are only just getting the concept and putting their own ideas about how it could be used, so this is going to be a common way to develop things within 2 to 5 years." *NA*

LNG-powered bulk carrier premieres use of high manganese steel

LNG is a cleaner source of energy than oil and, as emissions regulations become tougher, a number of owners have decided to use the fuel. The Korean Register outlines the development of an LNG-powered bulk carrier that has been designed to use high manganese steel in its construction

Global demand for LNG is increasing. LNG is an environmentally friendly source of energy and the number of shipbuilding orders for large-sized LNG carriers for transportation is on the rise.

At the same time, the use of LNG for marine fuel has emerged as one of the most feasible methods of complying with the regulations in MARPOL Annex VI regarding air pollutants in ships' exhaust gas.

As a result, the construction of LNG-fuelled ships is increasing while LNG vessels and offshore structures, including LNG bunkering ships, small and medium sized LNG carriers and LNG bunkering terminals continue to be developed.

New ways to increase safety levels are needed in terms of system design and cryogenic materials, which will improve the economic feasibility for cargo tanks, fuel tanks and piping systems of LNG carriers and LNG-fuelled ships.

The Korean Register (KR) - an International Association of Classification Societies - member - has been investigating the properties of a newly developed, high manganese (Mn) steel which possesses mechanical properties comparable to those materials for cryogenic service listed in both the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and the International Gas Fuel Code (IGF).

The new Mn steel which has been developed by the Korean steel conglomerate, POSCO, could be used for the cargo tanks, fuel tanks and the piping systems of LNG carriers and LNG-fuelled ships. The toughness level of the high Mn steel easily meets the requirements of the IGC and IGF Codes, being similar to that of 9% nickel steel.

Figure 1: Prismatic pressure tank under cryogenic test

High Mn steel has also shown superiority over existing materials in terms of ultimate tensile strength and elongation. In addition, the relatively small thermal expansion coefficient of high Mn steel offers the advantage that the displacement caused by temperature change is minimal when designing cryogenic equipment and devices.

Consequently, high Mn steel can be used to strengthen the structure of cargo tanks, fuel tanks and piping systems of LNG carriers and LNG-fuelled ships.

One of the benefits of high Mn steel is its economic feasibility. The continuous rise in demand for LNG-fuelled ships, related equipment and devices is leading to a shortage of nickel. High Mn steel is manganese-based steel and does not contain any nickel elements, potentially offering a solution to ease the issue of nickel scarcity.

Table 1 shows the price competitiveness of high Mn steel. The price of high Mn steel is considerably less than the other low-temperature materials such as aluminium alloy (AL 5083), Ni steel (9% Ni), or stainless steel (SUS304).

KR has also investigated the mechanical properties of the base metal of high Mn steel, specifically its tensile strength, yield strength and charpy impact energy. KR has assessed the metal's weldability to check if the mechanical properties of weldment of high Mn steel satisfy the minimum requirements.

As a result of these investigations, KR has approved the base metal and welding consumables.

Following on from this, KR has participated in the certification of several applications of the high Mn steel.

A cylindrical pressure tank with a volume of 24m^3 was manufactured for LNG storage. The cryogenic test was omitted and the hydrostatic test with the maximum pressure of 15bar for 50minutes was conducted in the

Price competitiveness	High-Mn steel	Al alloy	Ni steel	Sus
Material Price	53%	100%	114%	88%
Welding Cost	9%	100%	133%	33%
Total Cost	56%	100%	205%	128%

Table 1: Price comparison between high Mn steel and existing materials

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presence of a surveyor. KR approved the pressure test record.

A prismatic pressure tank with the dimensions 11.8m × 2.1m × 2.5m with a volume of 52m^3 and design pressure of 10bar was fabricated. KR surveyed the prismatic pressure tank as if it was manufactured for LNG storage. The tank went through the cryogenic test shown in Figure 1 and its hydrostatic test and structural integrity were assessed. A hydrostatic test with a pressure of 15.1bar was carried out in the presence of a KR surveyor and was found to satisfy the requirements.

In the cryogenic test, liquefied nitrogen was used and the temperature measured throughout the test by thermocouple, monitored by KR's surveyors. KR approved the pressure tank for LNG storage.

A track record is needed to demonstrate that high Mn steel can be applied to give the structural integrity required to demonstrate the stable nature of the material and its failure mechanism.

For this purpose, the construction of a bulk carrier with LNG fuel tanks made of high Mn steel is planned. The shipowner signed the construction contract in the middle of June 2016 and plans to take delivery of the vessel in the second half of 2017.

The ship will be a 50,000dwt bulk carrier built at the Hyundai Mipo shipyard and will be 191m in length, 32.26m wide with a 12m draught. The vessel will be used to transfer limestone between Donghae harbour and Gwangyang harbour in South Korea.

The ship will have an eco-friendly and highly-efficient dual fuel engine installed, with an output of 7,550kW, which will be able to use bulker C oil and LNG as fuel. The vessel's pressure tank for LNG fuel will have a volume of 500m^3 and is planned to be constructed of high Mn steel.

This is the first time a bulk carrier will have been constructed to include the LNG-fuelled system and a fuel tank made of high Mn steel, under the application of the CSR-H (Harmonized Common Structural Rules), anywhere in the world.

KR has signed a direct contract with the shipyard to class this LNG bulk carrier with high Mn steel fuel tank, the very first of its type.

Applying CSR-H to the bulk carrier

The contract agreement to construct the bulk carrier with LNG fuel tanks made of high Mn steel was made between the owner and shipyard in the middle of June 2016. As a result, the vessel will be the first bulk carrier in the world to be built under the CSR-H.

CSR-H requires a comprehensive analysis in order to verify the structural soundness of the entire cargo hold region. This means a significant increase in the man-hours required for the design and approval process, even though the ultimate deadline is not changed.

KR will be collaborating with the shipyard and using its own-developed powerful structural analysis software SeaTrust-HullScan as shown in Figure 2, for the design and approval stages of the bulk carrier.

This software uses auto fine mesh modelling to support the work undertaken in the vessel's structural analysis. This highly regarded software is rated as 'excellent' and used by the top Korean shipyards and design companies, with over 200 copies distributed. Following its launch, KR used feedback received for over a year to continually improve SeaTrust-HullScan. Now, this software is evaluated as being superior amongst all class societies' software.

The specification development of high Mn steel

High Mn steel has only been recently developed and is not generally available for the construction of international vessels. To resolve this issue, a specification for high Mn steel must be developed in order for it to be listed in the IMO IGC and IGF Code.

With this in mind, KR is now working to develop these clear specifications. These will verify the safety of high Mn so that users can confidently trust and use the material in construction projects.

The specification will evaluate the base metal safety and weldment safety characteristics of high Mn steel. Tensile tests will evaluate the yield strength, tensile strength and the charpy impact test will evaluate the degree of impact energy absorption in cryogenic conditions.

The assessment of weldment safety will evaluate the high Mn steel weldment. Similar to the base metal evaluation, it will include tensile tests, charpy impact tests and a CTOD test in order to assess the precise fracture strength of any weldment.

In addition to these tests, if deemed necessary, additional tests will be included in order to fully evaluate the safety of high Mn steel.

Anticipating effect and future works

This bulk carrier will be the first case where CSR-H and a dual fuel engine are applied. The full impact of CSR-H on the design and approval stage will be analysed and the usefulness of a dual fuel engine will be evaluated. Throughout this process, KR will work to make significant and meaningful improvements.

Through the fabrication and operation of this bulk carrier with its LNG fuel tank made of high Mn steel, the vessel's structural integrity in cryogenic conditions of service will be fully investigated, helping the high Mn steel to be listed in the IMO IGC and IGF Code. Moving forward KR will attend all stages of the construction and will contribute towards expanding the application of high Mn steel. *NA*

Figure 2: SeaTrust-HullScan software

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New rules demand new solutions

Environmental regulations imposed on operators means that they must adopt new technology to comply with the new rules. In many cases the choice is LNG or HFO. Knud E. Hansen takes an informed look at the merits and demerits of both fuels on a medium sized cruise liner

Danish naval architects, Knud E. Hansen, have designed a medium sized cruiseship, ostensibly for a Greek operator to deploy in the Mediterranean, but the designers have made a comparison between the HFO fuelled version and its LNG variant.

According to the company's comparison, operating expenses for the LNG version were lower, including fuel consumption when the scrubber fuel consumption is included in the calculation. Scrubbers take out SOx from the exhaust when vessels are operating in Environmental Control Areas (ECA).

LNG–fuelled ships will not need scrubbers to meet the SOx rules cutting back on both capital expenditure and operating costs. In addition, the LNG ships will not need a selective catalytic reduction (SCR) to meet NOx rules, while HFO heating and purifying equipment would be unnecessary. Furthermore, there would be no need for settling and daily tanks for the fuel and no waste chemicals.

Gas carriers often take advantage of boil-off gas; LNG is stored in liquid form at -163°C and will emit small amounts of gas as the liquid warms, this boil-off gas is used for main engine power, but a cruise vessel can take advantage of the boil off rate to cover the high demand in electric load in the hotel section of the vessel.

In these days where safety is an issue as well as the availability of LNG in some parts of the world, the ability to switch fuels offers the cruise operator an "extra degree of redundancy," explains Knud E. Hansen.

The designer also explained that the LNG version prompted them to explore more innovative solutions in terms of engine room and consequently funnel location. Such solutions, however, are no longer unique to the LNG fueled vessel as, considering the new machinery system redundancy requirements of Safe Return to Port rules, similar arrangements are now feasible for any diesel electric configuration with only limited impact on construction costs. And the final advantage according to Knud E. Hansen is that the bunkering process can take place with passengers onboard saving time in the operation of the ship.

The list of disadvantages is shorter, but could ultimately prove more costly, at least in the short term. Higher capital expenditure will be needed to build the vessel with all the safety features necessary for using a low flashpoint fuel.

Safety will necessarily be a significant issue and the crew will need special training in the use of equipment and the handling of LNG.

In addition, the LNG tank arrangement uses up a lot of technical space. Membrane tanks negate this effect compared to other types of tanks such as Type C tanks, while the LNG tank structure adds up a considerable amount of weight.

Strict bunkering procedures require the isolation of the main fire zone (MFZ) although there are "no official regulations regarding the bunkering procedure, only universally accepted guidance," explains the designer. Bunkering LNG itself could also prove a difficulty in some parts of the world as the LNG supply and infrastructure necessary remains underdeveloped.

Meanwhile, a lack of experience in the design and operation of LNG powered cruise vessels means that investors are reluctant to risk being the first to make the investment.

Tank sizing was based on three operational scenarios. In all three of them there is the assumption that the energy requirements of the vessel can be covered relying solely on either LNG or HFO.

Scenario 1 includes five day cruises, with four trips per month with bunkering intervals at 14 days. In the second scenario there are 2.5 trips a month with 12-day cruises with bunkering intervals set at six-12 days.

Scenario 3 includes a 21-day transatlantic cruise, 1.4 trips per month, with bunkering intervals of every 10 days.

The outcome of this research was that an LNG tank of 2,000m^3, would be sufficient to cover the vessel's needs for the first 2 scenarios, while for the third one, a future retrofit and potential addition of a tank could be an option.

The pilot fuel has been calculated as the equivalent to 5% of the LNG thermal capacity that is onboard. Additional MDO to comply with the safe return to port rules and for redundancy purposes would also need to be taken into account.

For the two versions of the cruiseship design there are potentially small changes in the dimensions of the vessel, but the

TECHNICAL PARTICULARS

Reference Vessel

Loa: 250m
Breadth: 34m
Depth: 9.5m
Design draught: 7m
Service Speed: ..... 18 Kn
Persons onboard: 2650
Propulsion: ..... podded electric thrusters

LNG Version

- ..... 6 medium speed dual fuel engines.
- ..... LNG as main fuel, in combination with MDO for pilot fuel and compliance with SRtP rules.
- .. Membrane type of tank for LNG storage

HFO Version

- ..... 6 medium speed diesel generators
- ..... HFO in all normal operating conditions
- ..... Scrubbers and possible SCR/EGR.

midships. The vessel will include two engine rooms located fore and aft of the LNG tanks.

A reduction on the amount of equipment that will be required in the LNG version offers the possibility of rearranging the machinery area to gain space. This will also necessitate changes to the crew cabins location, crew public spaces and provisions area.

Changes in the vessel's profile due to double funnels, located on the centreline will also mean changes to the external open deck arrangement and facilities that would be combined with the two funnels.

On the LNG version the membrane tanks are preferred as these types of tank use the available space more efficiently. According to the naval architect: 80% of the vessel's inner hull volume in the certain compartment that will accommodate the membrane, will constitute the membrane. There is a difference of 30-40% in the usable volume of the area where the tank is located between Type C and membrane tanks."

In addition, there is "no minimum filling limit in membrane tanks (no thermal stresses restrictions as in type C tanks)".

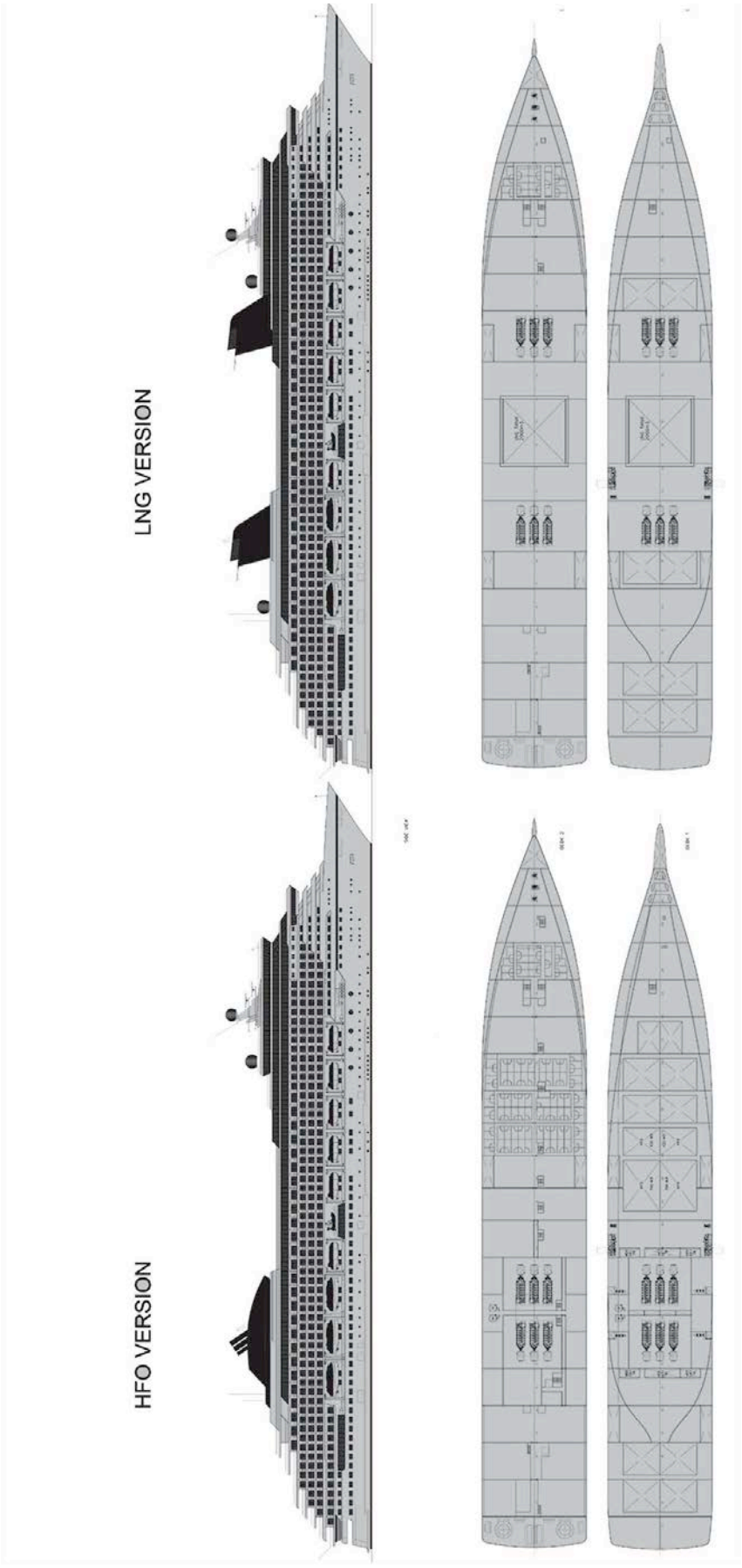
Irrespective of the type of tanks, cruiseships can turn the potential problem of boil off gas to an advantage through the powering of the hotel areas.

"Managing the boil off gas on a cruise vessel is not considered a major issue, due to the extended hotel load," says Knud E. Hansen. "Often, boil off gas is produced on purpose to cover the needs in electrical load."

When this is not the case, the 'excess' boil off gas can be used in various ways, including the innovative combination of an LNG fuelled vessel with significant battery storage onboard. The boil off gas can be used for battery charging via DC electric storage, increasing the LNG efficiency onboard while offering an eco-friendly solution.

The excess gas can also be used to fuel the auxiliary boiler and produce steam for various purposes or to fuel the incinerator. Other solutions, including gas combustion units, which just waste the energy, and reliquefaction units, are costly and apply mostly to other, more specialised types of vessel such as gas carriers. *NA*

Comparison of a 250m cruiseship powered by HFO or LNG



Dutch industry holds firm with hedged bets

The Netherlands maritime industry is expected to exceed last years' gross tonnage of deliveries despite the market downturn, says Netherlands Maritime Technology, a national association for shipbuilders and equipment manufacturers

Formed in 2014, Netherlands Maritime Technology (NMT) represents the merger of the Dutch Shipbuilding Association and Holland Marine Equipment Association. It offers a network that supports the interests of its diverse member body, providing independent research and promotion of the Dutch industry to the wider shipping industry. Ralph Dazert, market analyst at NMT, explains the current state of the Dutch shipbuilding industry in an exclusive Q&A with *The Naval Architect*.

NA: What trends is NMT identifying, and how are NMT and other Dutch maritime organisations, especially yards specialising in vessels over 100m in length, adapting to the current market turbulence?

Ralph Dazert, market analyst at Netherlands Maritime Technology: "Access to finance for newbuilds remains challenging…(but) niche vessels are finding reasonable access to financing"

Access to finance for newbuilds remains challenging. The offshore and short sea segments, which are important to the Dutch shipbuilding cluster, both suffer from overcapacity. Only niche vessels are finding reasonable access to financing.

A limited number of owners in the short sea segment that do have good access to funding are taking advantage by ordering large quantities of ships for fleet renewal. Several yards in the North of the Netherlands are thus able to show very good order coverage, until the end of this decade in some cases. The newbuilds all have an emphasis on low fuel consumption and low cost of ownership throughout their careers. These new ships are many times more efficient than the ships they are replacing, which often date from the late 1990s. Hull forms have been optimised and the required engine power is thus much lower than it used to be. In addition, a significant number of ships with Open Top notation for project cargo have been built in recent years and continue to enjoy popularity with owners. Yards in the North of the Netherlands are at the forefront when it comes to LNG propulsion. Several new Dutch-built ships on LNG for the short sea segment have entered service in the past two years, including the first LNG powered cement carriers in the world, *MV Greenland* and its sistership *MV Ireland*.

While several yards in the offshore segment are still working hard on the last deliveries of large orders placed in recent years, they are already adjusting their personnel numbers and production capacity to the current drought in orders. At the same time, a lot of design and engineering is taking place in order to be able to offer fresh and even more competitive designs to the market.

Obviously, the offshore wind industry has the full attention or our members. Large new offshore wind farms are being contracted at ever more competitive pricing, while the windmills themselves are getting larger. This means that there is already a need for larger installation vessels with larger lifting capacities. Several projects for new installation vessels, powered by LNG, are in an advanced stage of development, and we are hopeful that some of these contracts will come our way.

Concerning dredgers over 100m in length, Royal IHC has managed to replenish its dredger orderbook in a very challenging environment. The company is undergoing a significant restructuring, becoming even more flexible than it was, and this is starting to pay off. Several of the large dredgers now on order feature dual fuel engines able to run on LNG, while other ships will be built to the "LNG ready" notation.

Last year saw the first delivery of a megayacht over 100metres in length by a Dutch yard: the 101.5m *Symphony* by Royal Van Lent, a member of the famous Feadship consortium. Royal de Vries (the other member of Feadship) and Oceanco also have several yachts over 100m in their orderbooks. There is more to come; Oceanco has recently opened a large new covered dock at its Alblasserdam yard. It is the largest such facility built in the Netherlands in three decades and will allow it to build yachts up to 140m in length. The new yard that Royal Van Lent will build in Amsterdam will be even larger when it opens at the end of this decade; it will be able to produce yachts up to 160m in length. Royal De Vries already owns a second yard for very large yachts in Makkum. All these new yards are not replacements for existing yards; they are meant as an expansion of capacity in order to meet demand for ever larger yachts. Megayacht builders are nowadays active at the forefront of shipbuilding and, as such, they are highly respected members of our association.

Finally on the naval front, we are expecting some important decisions to be taken in the next few years on Dutch naval programmes, including replacement of submarines and replacement of a number of frigates. The export market is extremely important. Damen Schelde Naval Shipbuilding is actively marketing and continuously updating its Sigma range of naval ships. In addition, the yard is entrusted with the engineering and

The Netherlands is harnessing its expertise with LNG, delivering innovative new LNG ships such as the cement carrier *MV Greenland*

project management of several highly specialised vessels, such as the new large research icebreaker for use by the Australian government, which Damen will build at its Galati yard in Romania. While Damen builds globally, the "brains" of its organisation are firmly centralised in the Netherlands.

NA: How does 2016 compare with 2015 for orders? Do you think The Netherlands will maintain its position of fourth in Europe in terms of delivered tonnage for 2016?

2015 was a very good year in terms of deliveries, including big-ticket items such as four large flexible pipe laying vessels for charter to Petrobas. Also, the fitting-out of the massive offshore vessel *Pioneering Spirit* provided a significant boost to revenues of our industry. Many Dutch marine equipment suppliers still had a good year in 2015, as ship deliveries in the Far East continued apace, and the Dutch superyacht industry had a very good year, with a strong rise in the total value of delivered yachts.

The order intake at Dutch yards this year has been quite low so far, in line with the huge drop in new orders seen globally. While our yards are thankfully not active in large cargo vessel construction, we are feeling the impact of the slowdown in the offshore oil and gas industry. As to our position in the league table of deliveries, I still expect ship deliveries in 2016 to exceed the number of 2015 in terms of CGT. It is too early to tell whether this will be enough to maintain our position, although a spot in the top-five would seem to be feasible at this point in time.

We are fortunate enough to be sheltered from the full force of the downturn in world shipbuilding, as we do not compete in the field of large cargo vessel construction. However, our yards are also not active in the construction of large cruiseships, an industry which is currently lifting the output of several of our fellow European shipbuilding nations. Our marine equipment companies do, however, increasingly supply the cruiseship yards, and Dutch yards are highly successful builders of river cruise vessels. In addition, several of our yards have developed or are developing competitive offerings in the expedition cruise segment. Shipyard De Hoop has developed three expedition cruiseship designs in the 150-200 passenger range, and Damen Shipyards announced in May of this year that it will develop an expedition cruiseship for around 100 passengers together with Expedition Voyage Consultants Ltd.

Delivered in December 2015, *Sapura Jade* is the fifth of a series of six large pipe laying support vessels built by Royal IHC for Sapura Seadrill. The vessels have all been chartered by Petrobras for use off Brazil

NA: How have the yards that produce large inland cargo and river cruise vessels fared? Is the buoyancy of the worldwide cruiseship building market reflected in orders for river cruise vessels?

The river cruise sector has been positively booming in the past few years, with deliveries hitting 15 vessels in 2015. We saw the intake of new orders for river cruise vessels slow down during 2015, as the market needs some time to soak up the massive influx of new vessels in recent years. Our yards are however still optimistic about the river cruise segment, as the interest of passengers in river cruises has not diminished according to their findings. Inland cargo vessel production has been at a very low rate for several years, but it is slowly starting to pick up. We are now expecting around 40 deliveries of inland cargo carrying vessels in 2016. This is a significant improvement on 2014 and 2015, when deliveries averaged 30 vessels. While deliveries of inland tankers have continued all along, we are now also seeing the return of the construction of limited numbers of dry cargo ships, containerships and LPG carriers. It is important to note that LNG propulsion and hybrid propulsion are gaining ground fast in the inland cargo vessel segment. In addition, a large order for 15 LNG-fuelled inland tankers for charter to Shell should also provide a basis for good delivery numbers in 2017, although the short delivery timeframes of inland vessels make it difficult to predict future deliveries. *NA*

Ro-ro fire safety targeted

Fire onboard ro-ro vessels can be particularly devastating with the open decks and cars, trucks and equipment, such as reefer containers, offering readily combustible materials with sufficient oxygen to fan the flames. DNV GL offers advice on limiting the dangers for ro-ro ships

Fire safety on ro-ro vessels often depends on how operations are conducted onboard and the precautions that crew take in order to prevent fires.

New ships, however, can contribute to greater levels of safety through sensible design and this is an element of the safety regime that class society DNV GL has highlighted in its report, "Fires on ro-ro decks", released in June.

DNV GL states that the measures that should be addressed in newbuildings include "the location of lifeboats and other life-saving equipment and the location of air intakes for main and emergency power," adding that "Power circuits serving reefer units should be equipped with ground fault detection systems which trigger an alarm in a manned control station."

The class society also offers the voluntary class notation F-AMC, "whereby owners can demonstrate that they have enhanced the reliability of their fixed fire-extinguishing systems, improved the fire detection and CCTV systems, have additional firefighters' outfits available, and better UHF/VHF coverage".

A clear policy on which cargo and operations an owner or operator will accept onboard a ro-ro's spaces should be allied with the screening of cargo, while old and towed second hand vehicles in particular should be carefully checked before being allowed onboard.

Furthermore, "a policy on reefer units needs to be available. If accepted onboard, they should be placed in dedicated areas (weather decks when possible, and preferably an area covered by CCTV). Power transfer cables should be in good condition, replaced frequently and only handled by designated crew. Reefer units of dubious quality should be rejected. Stowage areas should be checked frequently during voyage."

Brittany Ferries' *Armorique* displays its car deck. The open plan design of ro-ro vessels means that any fire can be difficult to contain

In addition, power circuits serving reefer units should be equipped with ground fault detection providing an alarm to a manned control station.

A number of operational precautions should also be undertaken such as the prevention of cargo shifting during a voyage through improved cargo securing and weather routing. Access to all ro-ro spaces should be restricted during voyage. The charging of electric cars should be banned. Electric sockets should be marked and secured, and fire patrol on ro-pax ships should be instructed to remove charging connections if found. However, this does not mean that a carefully designed charging arrangement could not be approved for a future design.

Hydrogen vehicles must have safe locations, along bulkheads etc., to minimise any damage in case hydrogen is released and ignited.

Once a fire has taken hold it is essential that the fixed fire-extinguishing system can be released rapidly, particularly for open ro-ro decks where the window of opportunity may be less than 10 to 15 minutes.

Realistic training and familiarisation for crew on the use of the fixed fire extinguishing systems should be implemented with company defined goals for release times (for instance, 3 minutes for deluge systems and 15 minutes for CO_2 systems). Drills should be performed frequently in a realistic manner, preferably simulating failure of key components (see DNV GL best practice on the subject).

Care should be taken when opening closed cargo holds (in particular, those flooded with CO_2, as this media provides limited cooling). Smoke divers with infrared cameras should verify that no notable heat remains before venting out the CO_2, and the shore fire brigade should be on standby with the capability to quickly move trucks and cars out of the ro-ro space. *NA*

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Open-top containership history raised

Dear Sir,

In the July/August issue of *The Naval Architect* Knud E. Hansen's senior naval architect, Jesper Kanstrup, in the article entitled "Feeding the Beast" touches on the open-top container vessel, as follows: "Many have proposed an open-top container vessel, but to prevent water from being shipped over the sides of the vessel and into the open holds when the vessel is rolling in bad weather, the hull depth must be very high."

An Australian firm of naval architects published, in 1985, their notional concept of a hatchcoverless containership, but had not embarked on a serious design work – a task for which I accepted responsibility on behalf of Irish Owners-elect in 1986 for two ships. A provisional hull-form was developed quickly so that model-testing could begin, to prove that the concept was viable from the point of view of flooding of the open holds by seawater in heavy weather.

As the ships were to be built to Class VII Cargo Ship standard, the relevant Rules stipulate inter alia that the ships would have to withstand the consequences of a sustained tropical downpour of rain. Lloyds Register (with whom it was intended to class the ship) proposed a rainfall rate of 0.25tonnes/sq.m/hr. IMO proposed a less onerous rainfall rate of 100mm/hr.

Resistance and propulsion, wakefield and flowline tests, with the Institute's propeller, were carried out in the deepwater basin at the Norwegian Marine Technology Institute, Trondheim.

The most crucial part of the model testing programme was the seakeeping tests in a wave basin. This was required both by the Irish Administration and Lloyd's Register to confirm the adequacy of design freeboard and to form the basis of specifying the capacity of hold bilge pumping arrangements. The tests were carried out in the admirable facilities of the China Ship Scientific Research Centre at Wuxi, Jiangsi Province, where I attended two distinct series of tests in a very large wave basin.

The conclusion was agreed that the ship would have adequate freeboard and that as far as the ingress of seawater was concerned (and measured after every test), a realistic basis had been realised on which to calculate the capacity of bilge pumps, taking simultaneous rainfall into account.

Contrary to expectation, it immediately became clear the ingress of sustained heavy rain posed a far greater threat than that from the ingress of sea water in the worst condition tested, with large fans simulating the effect of maximum wind assumed at full-scale.

The two ships (built by Teraoka Shipyard Ltd., at Fukura on Awaji Island in Osaka Bay, Japan) are somewhat smaller than the feeder ships under construction by Knud E. Hansen and the question of free board becomes more significant in the design of bigger feeder ships.

Measurement for the tonnage of a containership with open holds was so contentious that the issue became the subject of a Judicial Review in the Dublin High Court. The chief surveyor of the Irish Dept. of the Marine and myself developed a workable and fair compromise, a version of which became the basis of measurement of both ships – this was only one problem during the design phase which was settled by common sense rather than the Rule Book in the design and building of these ships, and for bigger 'open' ships similar problems may be resolved in the same way.

Yours faithfully,

Patrick G. Martin (Fellow)

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