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becker marine systems

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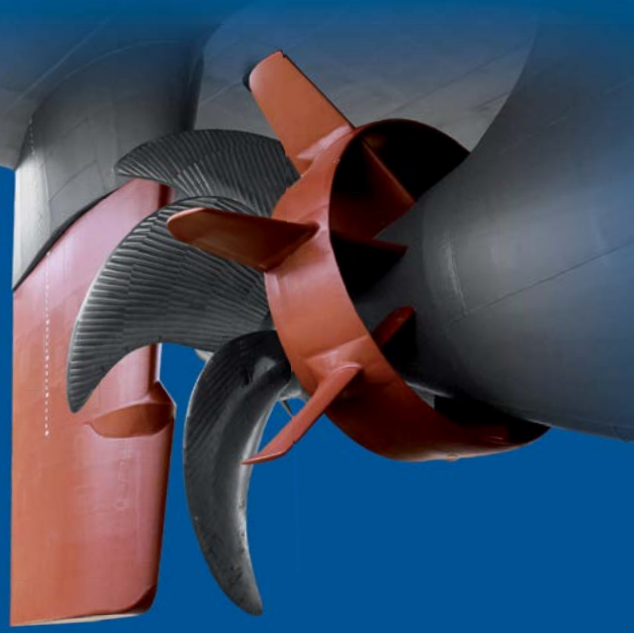

Above: Container Vessel Al Muraykh
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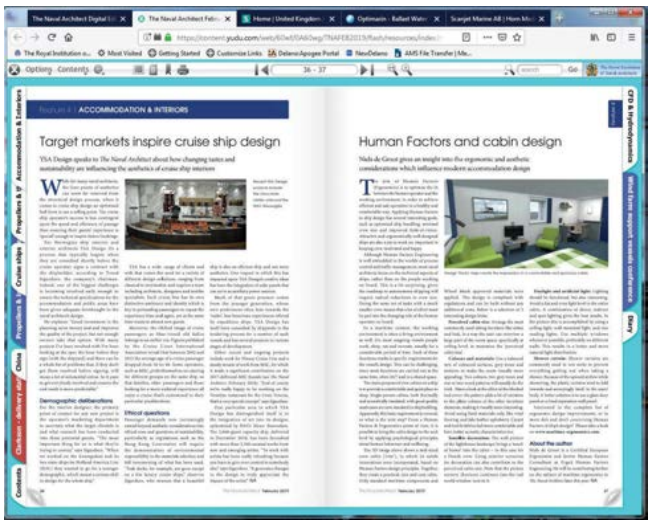

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UK Government pushes on with Maritime 2050

Maritime 2050 envisages a bold, emission-free future for British shipping. Image: DfT

The summer months are usually a fallow period when it comes to maritime news and it would be fair to say that this year has been no particular exception. For *The Naval Architect* it's usually a case of hustling for content and hoping that those we reach out to for interviews and contributions haven't disappeared on extended holidays or – in the case of academic institutions – are still checking their emails during the summer recess. Hopefully those travails won't prove too obvious in this issue's line-up and you'll find content to pique your interest.

Here in the UK, late July saw the arrival of a new Prime Minister in Boris Johnson, and with it the growing probability that Britain will leave the European Union with a 'no deal' Brexit in October. Whatever the reader's own personal position on this matter, I don't propose to try your patience with yet more redundant verbiage, after all we live in a time where the distinction between facts and opinions seems to be increasingly blurred.

But since this issue includes a feature on Environmental Legislation, it might be worth highlighting that July also saw the publication of the Department for Transport's (DfT) Clean Maritime Plan. The plan is described as the environmental pathway to zero-emission shipping and is part of Maritime 2050 – the government's vision for the future of the UK marine sector that was officially launched at the start of this year (see News Analysis in February's *TNA*). It sees the UK as one of the pacesetters for emission-free shipping and that the economic benefits could be worth US$650-890 million per year by the middle of the century.

In terms of analysis the report doesn't contain anything particularly revelatory for anybody that's been following the story so far. In line with the expectations of most in the industry, it concludes that many of the usual suspects among zero-emission alternative fuels and propulsion technologies need to be explored as part of a global transition.

However, it does cite separately commissioned 2019 research ('Reducing the maritime sector's contribution to climate change and air pollution', conducted by UMAS, e4tech, Frontier Economics and CE Delft), which found that the UK has a strong competitive advantage in hydrogen and ammonia production technologies, onboard batteries and electric engines.

The Government says in 2020 it will explore the possibilities for tax incentives to support zero-emission shipping as well as consulting on methods to encourage the uptake of low-carbon fuels. It also says that the Clean Maritime Council, a body established last year as part of the groundwork for Maritime 2050, will undertake a study to identify potential zero-emission shipping clusters in the UK. Another stated commitment is the establishment of the Maritime Emissions Regulation Advisory Service (MERAS), which will provide "dedicated support to innovators using zero-emission propulsion technologies, assisting them through the regulatory process."

Given the Brexit uncertainty – along with all its implications for international trade – and the strong possibility of an autumn general election, it's a challenging time to be drawing up any kind of long-term plans. Not surprisingly, the report is somewhat light on any defined financial commitment. It does, however, foresee a pivotal role for the UK's financial services sector, particularly with regard to maritime services and insurance, which it values at some £2 billion per annum.

Among its packed calendar, September's London International Shipping Week will see a pitch to investors with the launch of DfT and Maritime UK's Green Finance Initiative. The report notes: "...as a rule negative externalities associated with zero-emission shipping technologies mean that the return on investment for many technologies is not currently sufficient to attract finances at competitive rates…There is currently a systematic lack of independent information on the performance of energy efficiency technologies and alternative fuels, leading to high uncertainty, and deterring investment."

Framework is needed for assessing and disclosing the climate alignment of ship finance portfolios, the report adds, although it could be argued that internationally work is already underway. In June 2019, 11 global banks became the inaugural signatories to the Poseidon Principles, under which they will annually assess and publish the carbon intensity of their portfolios in line with IMO's 2050 GHG targets. The idea is to create a common baseline for determining the 'greenness' of their investments.

Much will depend upon how seriously this new covenant is taken, of course, given that good intentions regularly fall by the wayside in the event of a financial downturn and self-policing is a double-edged sword. We will have to wait and see how the UK or any other national governments seek to incentivise these commitments but, if nothing else, another summer of record breaking temperatures surely underscores the urgency. *NA*

Wind propulsion

ABS and MARIN partner up to examine wind-assisted propulsion

The US classification society ABS has teamed up with the Maritime Research Institute Netherlands (MARIN) to assess the performance and ease the uptake of wind-assisted propulsion technologies.

There has been a rising interest in wind technologies within the shipping industry as pressure to reduce greenhouse gas emissions increases. However, there is a "shortage of transparent and independently verified methods to predict the performance of wind propulsors", according to Patrick Hooijmans, MARIN's senior project manager ships.

Through this two-year joint industry project, ABS and the Dutch research institute aim to erase the barriers currently holding back these technologies. By investigating and establishing valid methods to evaluate wind-assisted propulsion, they hope shipowners and operators will have more confidence in their investment decision-making.

The project, which covers the majority of all wind technology being marketed, will seek to:

- Improve the methods for transparent performance prediction
- Use the improved methods to provide shipowners/operators with fast predictions for their fleet
- Review the regulatory environment to identify gaps and make recommendations on establishing compliance

Digitalisation

Trio to collaborate on marine engine digitisation

MAN Energy Solutions, Daewoo Shipbuilding & Marine Engineering (DSME) and HSD Engine have signed a pact to advance the digitisation of marine engine systems.

The strategic agreement, confirmed in Copenhagen in July, aims to create a framework for a future long-term digital cooperation. It signals the trio's intention to develop technologies and solutions for the digitalisation of marine engines and auxiliary systems data.

Driving digital transition in the maritime industry, they will analyse collected data and integrated it with smart ship platforms and intelligent diagnostic solutions. Any new innovative solutions that emerge as a result of the cooperation will be developed to help shipowners and operators improve efficiency and safety.

"The agreement at hand is a step in this direction and brings together market leading expertise in the fields of shipbuilding and engine design, manufacturing and operation to explore options for a joint digital development in an important segment of the maritime market," said Brian Østergaard Sørensen, head of R&D 2-Stroke Business at MAN Energy Solutions.

Earlier this year, MAN announced its new digital platform – MAN CEON – shifting its business towards digital based services. Likewise, DSME has been taking various steps to advance its digital solutions. It signed an agreement at Nor-Shipping in June with Korea Maritime and Ocean University (KMOU), NAPA and AVL to develop digital ships and related solutions.

Propulsion

Seaspan selects Schottel propulsion package

Canadian ferry operator Seaspan has opted for propulsion systems supplied by the German manufacturer Schottel for its two new LNG-battery hybrid ferries.

The newbuild ro-ros will be equipped with Schottel's transverse thrusters and combi drives. Commissioned around two years ago, the ferries are currently under construction at Damen Shipyards Mangalia, Romania. Once delivered, they will be classed by Bureau Veritas and join Seaspan's two other LNG-battery hybrid vessels, the *Seaspan Swift* and *Seaspan Reliant*.

Designed by Vard Marine, each 149m-long ferry will be powered by two natural gas-fuelled engines with 209m^3 storage capacity alongside 2MW batteries. By utilising the combi drive, the vessels' electric motors can be integrated vertically into the rudder-propeller. According to Schottel, this allows for a more efficient and quieter electric variant of the SRP and STP propulsion units.

The combi drives input power of 2,600kW and propeller diameter of 2.6m will allow a design speed of 16knots. In addition, the 550kW bow thrusters are to help ensure precise manoeuvring and can be mounted and dismounted while the ferries are afloat.

The newbuilds, which were ordered in May this year, are scheduled to start operation in 2021.

Schottel propulsion systems will drive Seaspan's new hybrid ferries

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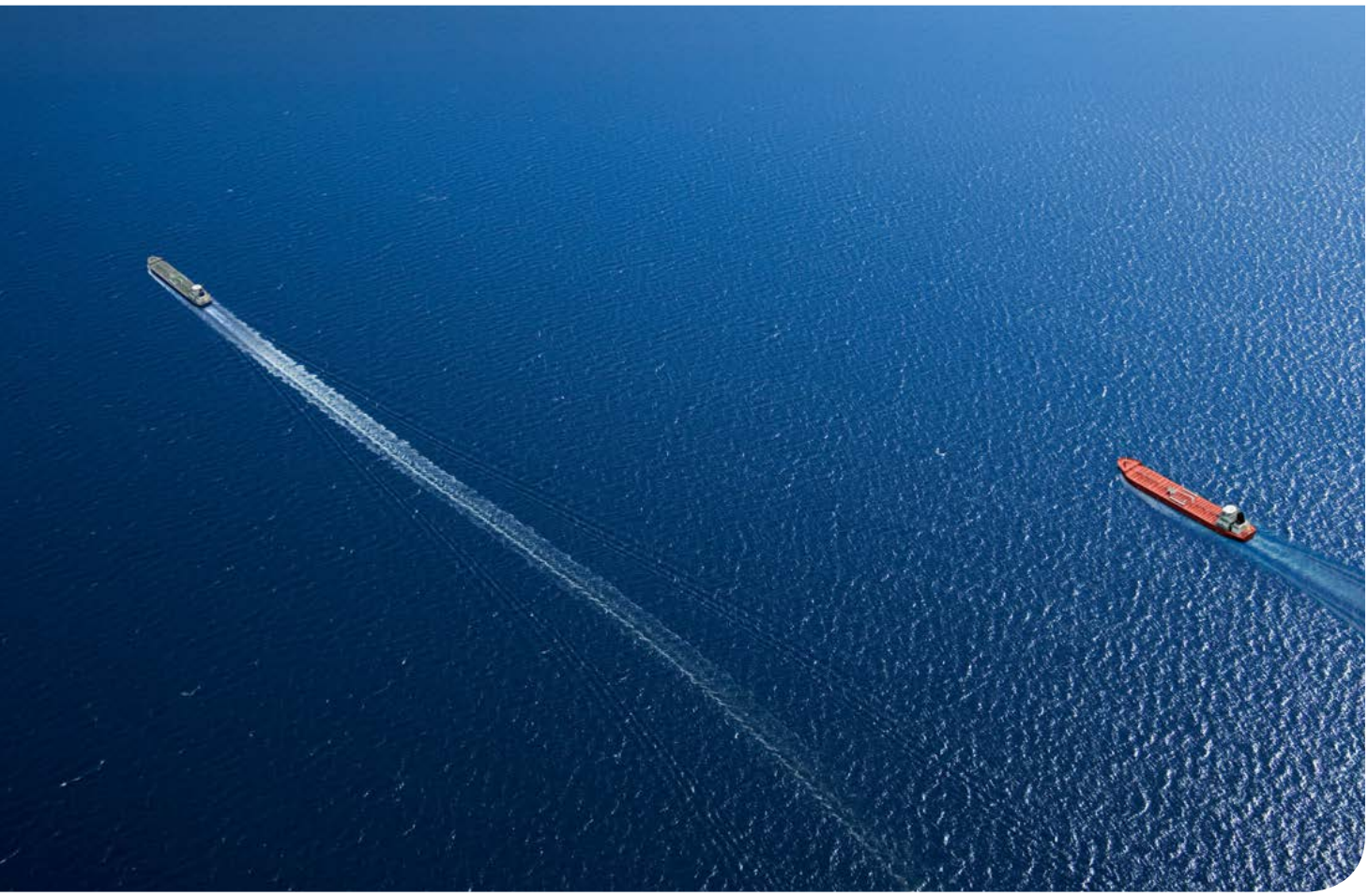

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Bulk carriers

Solar-hybrid solution to power first bulker

Monaco-based Marfin Management is to mark an industry first with the launched of a retrofit project that will see the bulk carrier *Paolo Topic* fitted with solar panels.

In partnership with solar panel specialists Solbian and Wärtsilä, the panels will be mounted on the ship's weather deck in a manner that ensures there are no fixed constraints on the load and unload operations. The solar production of this first prototype will be monitored and assessed but is expected to increase overall efficiency.

Beyond solar panels, the vessel will be driven by engines and batteries and feature Wärtsilä HY – a hybrid power module – which will allow for overall control of the ship's power production systems and power distribution. The Finnish tech company claims that the project is both a first in commercial shipping and that it will achieve a "drastic reduction" in fuel consumption as well as maintenance costs.

The project agreement was signed by all partners in Monte Carlo, Monaco at the beginning of July. Built in 2016 at Onomichi Dockyard in Japan, the 60,200dwt, 200m-long *Paolo Topic* has 76,554m^3 of capacity across five holds.

Zero-emission design

Japanese consortium to advance electric shipping

Four major Japanese companies have formed a strategic partnership to develop new zero-emission fully electric vessels.

Mitsui OSK Lines (MOL), Asahi Tanker, Exeno Yamamizu Corporation and Mitsubishi Corporation have formed a new company, dubbed e5 Lab, with the aim of promoting clean modes of marine transportation. It will address issues and solutions surrounding the five e's: electrification, environment, evolution, efficiency and economics.

One of e5 Lab's first goals will be to design and construct and the world's first zero-emission battery-powered coastal tanker by mid-2021. The company hopes to develop other types of electrical vessels in the future, ultimately encouraging a wider uptake of the zero-emission coastal and ocean-going vessels.

The quartet have identified a series of challenges Japan's maritime industry is currently facing. This includes controlling GHG emissions, improving working environments, adopting advanced sensor technology to improve ship maintenance and management, embracing autonomous technology and large-capacity batteries, and developing a sustainable growth model within the industry. Through the venture, the group will combine resources, technologies and operational know-how to provide new infrastructure services for the industry.

Paolo Topic will be equipped with solar panels and Wärtsilä HY

Propulsion

Kongsberg extends scope of silent propellers

Norway-based Kongsberg has rolled out its Blade Air Emission technology to commercial shipping, offering shipowners operational benefits and the opportunity to lessen their environmental impact.

Developed by the Kongsberg Hydrodynamic Research Centre in Sweden, the propeller design has been used to limit the signature of naval ships for several years. The technology has now been adapted for commercial ship propellers to reduce the effect of underwater radiated noise on marine life, such as whales and dolphins.

The Blade Air Emission concept is applicable to both conventional fixed pitched and controllable pitched propellers. It helps decrease erosion risk, thereby reducing maintenance costs associated with repairing and replacing eroded propeller blades, in addition to cutting cavitation-induced noise.

Propellers accept cavitation to optimise vessel performance and efficiency, however, by balancing the amount of air circulated around the blades, the negative effects can be optimised without affecting ship performance. *NA*

Correction

The article 'Demystifying zero-emission ships' in *TNA*'s Jul/Aug issue incorrectly stated that ZEM-Tech's Madadh MacLaine "believes the shipping industry could see the first zero-fuel VLCC by 2020". Ms MacLaine has clarified that she believes the industry will "have the technology to design a zero-fuel VLCC from 2023". We apologise for the misunderstanding.

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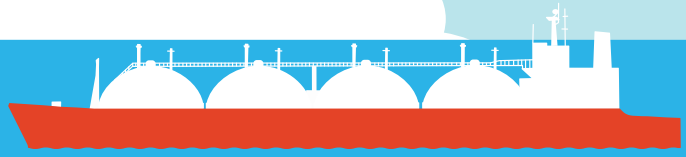

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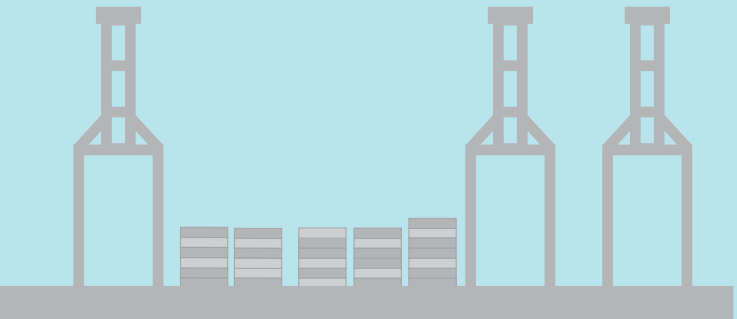

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2020 focus switches to enforcement

Establishing who will crackdown on those that ignore the sulphur cap and how non-compliance penalties will be imposed remains a labyrinth of uncertainties, writes Malcolm Latarche

With the IMO 2020 sulphur cap deadline rapidly approaching, it is almost certainly too late for most operators to have a choice of strategy for complying after 1 January 2020. Although scrubber installation time has fallen to under two weeks, the preparation and manufacturing period is measured in months. In any case, finding capacity in a yard for the installation will be almost impossible at this late stage.

Operators who have little alternative but to make use of compliant fuels will be spending the rest of 2019 using up remaining fuel, cleaning tanks and replacing lubricant stocks with others more suited to the new low sulphur fuels. Those operators with more clout with bunker suppliers may have secured compliant supplies but for the rest, 2020 is likely to be an obstacle that needs to be surmounted.

It is now the question of enforcement that is grabbing headlines. It would appear that those owners and environmental lobbyists that were hoping for a hard deadline may be disappointed, as even some signatories to MARPOL Annex VI are having second thoughts about the economic impact of SOx reduction on local economies. So far Indonesia has taken a stand and India's shipping minister has questioned whether the concerns of developing countries have been given enough weight.

Worries that some operators might cheat and continue to use HSFO was behind the IMO's decision to ban the carriage of non-complaint fuel for use onboard any ship not fitted with a scrubber, but the push for the decision came from the industry itself. At the end of July, it was announced that the Trident Alliance – a consortium of ship operators dedicated to ensuring fair competition – had expanded its membership to 49 shipping companies, with CSL Group and Oldendorff Carriers joining its ranks.

Shortly after that, the Trident Alliance felt obliged to comment on Indonesia's announcement that it would be unlikely to rigorously enforce the 2020 rules for domestic shipping. Most of the Trident Alliance members – but not all – are Europe-based organisations and it is from Europe that most of the demands for a crackdown on offenders after 2020 have come.

The big fear of European operators is that their competitors from other parts of the world would be the most likely to ignore the regulations despite flag states having signed up to the regulations. It probably did not occur to them that the flag states would be complicit in sidestepping the rules on economic grounds.

Indonesia has limited the exemption to its own flag ships operating solely in Indonesia waters on the grounds that if it enforced the 0.5% limit, the economic hit to the local economy would be significant. Because only domestic ships are involved, there is no competition with ships engaged in international or even regional trade that is obvious. Indonesia also uses high sulphur residual fuels for power generation, so applying the IMO rules to domestic shipping – even though it is supposed to under the requirements of MARPOL Annex VI – would not massively improve the country's SOx emissions.

The Trident Alliance has not been impressed by the Indonesian stance and responded by issuing a statement in which Trident Alliance chair, Roger Strevens said: "The only sure-fire way to successfully implement the new global sulphur cap is to follow the regulations to the letter. Any local deviations from this would create unfair competition and may lead to non-compliance on a wider scale. Furthermore, it is extremely unhelpful to make such decisions so late in the day given the expense and effort the industry has already expended in preparing."

The statement made the point that vessels in international trade can compete with those operating in domestic trades on some voyage legs. International trading vessels that commit a violation within Indonesian waters could be sanctioned for it by other port states at a later point in their voyage, hence they could not revert to the older and cheaper 3.50% level.

Aside from the unfair distortion to the competitive landscape, it is unclear how a failure or refusal to enforce the new sulphur cap would not expose a state to legal consequences. States, such as Indonesia, that are party to IMO's MARPOL Annex VI do not have the facility to exempt merchant vessels from compliance. Additionally, states party to Annex 6 can be held liable for non-enforcement by the other states that are party to it.

The question of penalties for non-compliance is fraught with problems. In domestic waters or on the high seas, it is up to the flag state to decide what, if any, penalty to impose. However, port states can also penalise other flag ships for non-compliance and are free to set penalties at whatever level they wish. How this will pan out once 2020 arrives remains to be seen but most expect that the strongest enforcement and highest penalties will be in Europe. *NA*

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Internet of Things

Digital smart ship system earns ClassNK approval

ClassNK has granted type approval for Alpha Ori Technologies' (AOT) Internet of Things remote monitoring and decision support platform, SmartShip.

The patented digital solution uses a cloud-based infrastructure to gather and transmit data from all parts of the ship, which it then uses to create a platform that connects the various systems. With the collected information, crews and managers are provided with operational advice. It also offers optimisation by combining a vessel's operational data with external information to supply real-time performance evaluation.

The Singapore-based company states that the SmartShip platform takes a "holistic approach to solving maritime pain-point issues for every stakeholder in the logistics value chain".

Approved as a Computer Based System, the platform enables onboard operation of multiple systems with varying degrees of autonomy. It has the potential to improve safety, reduce costs and enhance a vessel's performance, it is claimed. SmartShip includes features such as total fuel consumption optimisation, situational awareness decision support system and predictive maintenance applications.

To date, the system has already been installed on over 30 vessels with another 60 ships currently undergoing the set-up process. The mid-sized gas carrier, *Hourai Maru*, delivered in March this year was the first ship to be certified with a ClassNK-approved SmartShip.

Safety

Viking scores first HydroPen order

A major unnamed shipping operator has signed a contract with survival gear company, Viking Life-Saving Equipment, for the fleetwide installation of the container firefighting solution HydroPen.

Viking to tackle container fires with HydroPen order

The breakthrough deal marks the first order for the system and includes the supply of MED approved mobile water monitors. Developed by Danish-based manufacturer Rosenby Engineering, Viking became the exclusive distributors of the system in August 2018.

Typically, when container fires are located at heights beyond the crew's reach, the fire is fought indirectly by dowsing the burning container and its surroundings with water. This method can destroy cargo, be dangerous for crews and ultimately be ineffective.

The HydroPen, however, eliminates the height barrier by using a pressurized water system to drill through container doors. It then automatically switches to fire extinguishing mode, putting the fire out at its source.

A drilling unit is hoisted to the doors of the burning container by means of a telescopic lift, which is supplied with the system. It can spray water, foam and CO_2 into containers, yet, only needs a ship's existing fire hoses and water pressure to function.

Only one crew member is required to use the system and training is minimal, according to the company. A recent estimate by transport and logistics insurer, TT Club, states that on average, a major containership fire incident occurs at sea every 60 days.

Software

New NavCad features boost efficiency

HydroComp has released its latest version of NavCad, which it claims will enhance user efficiency and improve prediction fidelity.

The maritime software provider has added two new features for high-performance propellers: prediction of 'progressive pitch' propellers and an updated model for surface-piercing propellers (SPPs).

A 'progressive pitch' propeller has a cambered propeller face, yet, the library series propellers (such as Gawn or B-Series) are flat-faced. The software's upgraded prediction determines the increase in KT and KQ for a propeller's 'face curvature ratio' (a new metric to quantify the added camber in a propeller). The company believes that this will be of great benefit to those evaluating outboard and stern-drive propellers, as well as contemporary propellers for high speed craft.

The new SPP model offers NavCad users with a model for a 5-bladed cleaver-style wedge-section propeller, while a four-blade variant is under development. The company's research also allowed for the construction of a new performance metric for a 'minimum critical speed', below which SPP propeller performance begins to fall off. This latest design can provide information to ensure that the Vessel-Propul-

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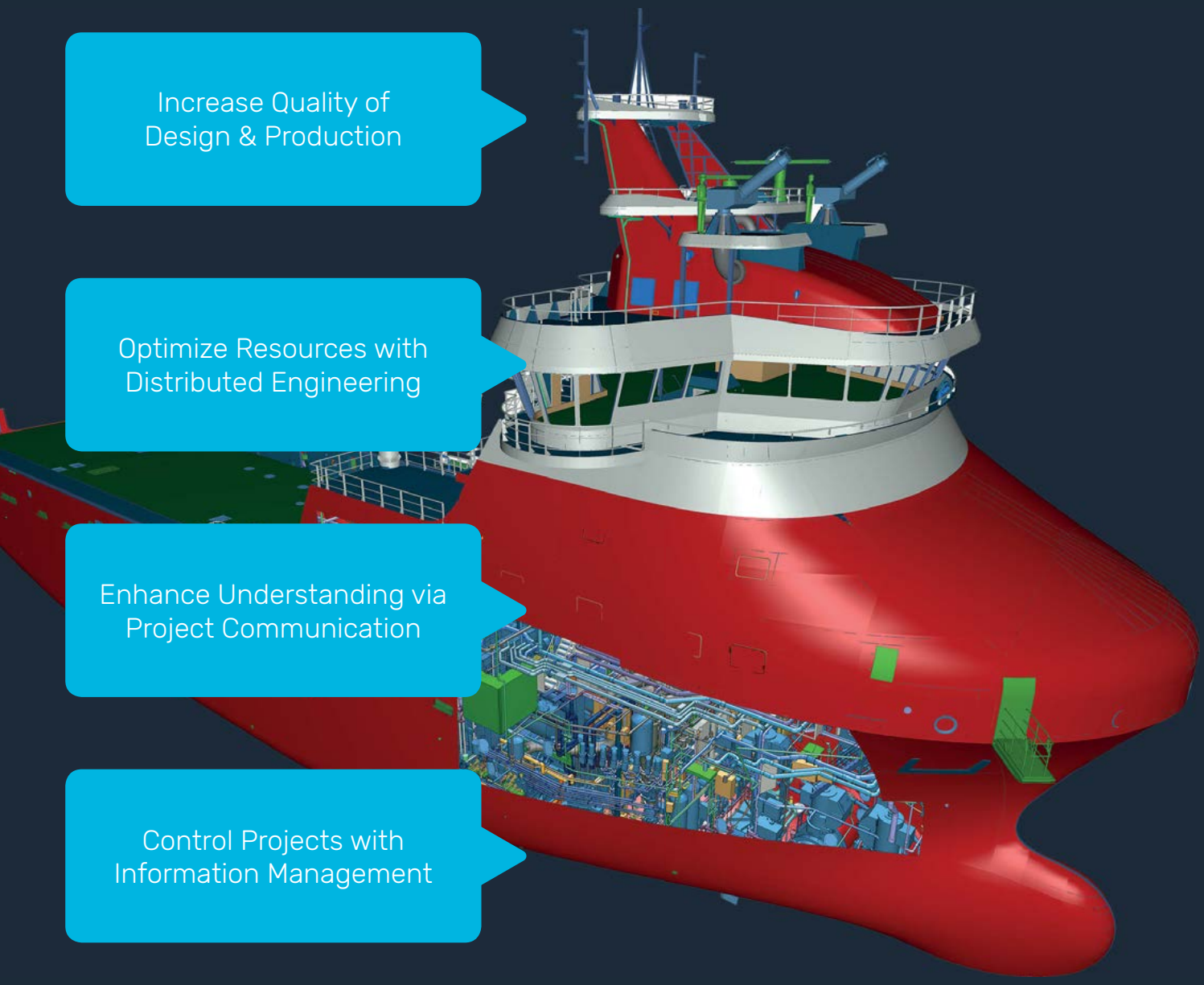

Project courtesy of Wärtsilä Ship Design Norway AS

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sor-Drive system running SPPs have the proper gear ratio for the proposed speed and power.

Additionally, HydroComp has updated its ADVM method to expand its scope to fuller vessels, such as workboats and full form merchant ships, and further improved its prediction accuracy. It also has an improved predictor of the longitudinal contribution of a design's sectional area curve and beam distribution wave-making resistance. This provides a better tool for optimisation of hull geometry where it is most effective and has the least demand on computational resources, states the company.

BWMS

USCG type-approval applicant list grows

Denmark-based ballast treatment system manufacturer Bawat is the latest to apply for US type-approval. The application, received in July, is the 29th request the USCG Marine Safety Centre has attained to date.

The Bawat Mk2 system, which uses no filters, UV additional or chemicals, is primarily aimed at tankers and bulk carriers. It functions by way of an in-tank recirculation system that uses deoxygenation and pasteurisation – using heat from the main engine – to lower the concentration of living organisms in ballast water to regulation level (see *TNA,* April 2018).

Bawat's system received IMO type approval in 2014. If approved by the USCG, it will be the first ballast water treatment system (BWTS) that uses heat to be accepted by the US Coast Guard.

Three additional companies have recently submitted a BWTS for type approval: Evoqua Water Technologies, COSCO Shipbuilding Industry and Hanla IMS.

Evoqua is seeking approval for the latest version of SeaCure, its electrochlorination system, which is said to have one of the smallest footprints for its flow rate. COSCO's Blue Ocean Shield is based around a mechanical filter, and is described as a medium pressure UV disinfection system. Lastly, the South Korea-based Hanla IMS has requested approval for their side-stream filtration, electrolysis/electrochlorination system, EcoGuardian.

Eco-technology

Samsung introduces marine batteries to market

In response to the growing demand for hybrid ships, Samsung Heavy Industries (SHI) and its sister company Samsung SDI have developed Korea's first marine lithium-ion battery system.

SHI has received type-approval from DNV GL for the battery system, marking a first for the South Korean company. SHI says the certificate will allow it to produce a battery system at a reasonable price for the Asian market, encouraging competitiveness within the eco-tech sphere. Currently, most batteries are typically supplied by Northern European manufacturers at a higher price.

The battery system is intended to reduce fuel consumption of generators by optimally controlling and managing onboard generators and power load.

SHI has also joined forces with Wärtsilä to explore and develop other applications for its lithium ion battery system.

Coatings

Wallenius Wilhelmsen opts for Jotun's HPS

Leading paints manufacturer Jotun has inked a contract with Norwegian/Swedish shipping company Wallenius Wilhelmsen to outfit 42 ro-ro vessels with its Hull Performance Solutions (HPS).

Introduced in 2011, the coating system combines SeaQuantum X200 antifouling with digital-based ship monitoring applications. Its technical solutions measure hull and voyage performance while the antifouling works to enhance the ships' efficiency.

"Working together we will be able to optimise hull performance and help Wallenius Wilhelmsen fully comply with global regulations and targets, while meeting its own stringent environmental objectives," said Gunhild Tveitan, Jotun's business development manager Scandinavia.

Biofouling contributes to the spread of invasive species as ships carry various organisms across marine ecosystems. By reducing the amount of fouling and, in turn, vessel drag, the coating can help cut fuel consumption, CO_2 emissions and improve environmental performance. *NA*

Wallenius Wilhelmsen has agreed to use Jotun's HPS antifouling system on 42 ships in its ro-ro fleet

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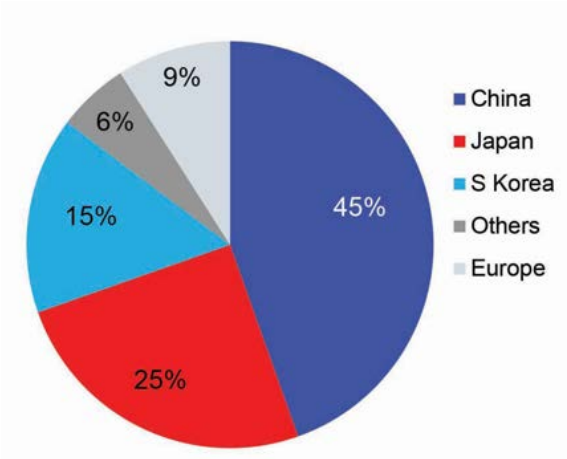
Clarkson Research Services: Historical and Scheduled Delivery

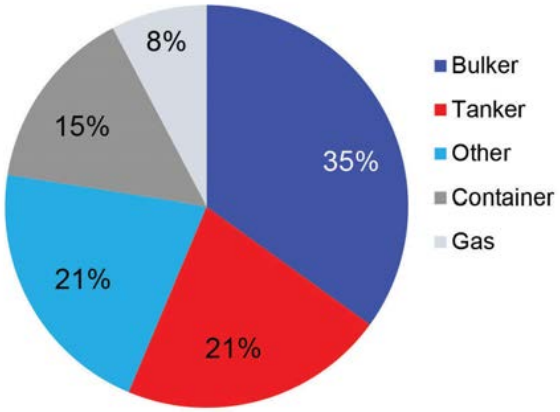
Data extract from World Fleet Register available at www.clarksons.net/wfr

Vessel Type	2008		2009		2010		2011		2012		2013		2014	
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half
VLCC >= 200,000	18	23	33	20	30	24	35	27	27	22	21	9	14	10
Suezmax 125-200,000	8	5	22	22	26	11	26	18	30	15	23	4	4	4
Aframax 85-125,000	26	42	63	33	39	31	28	31	30	15	14	6	4	13
Panamax Tankers 55-85,000	17	26	26	12	15	16	19	10	9	6	7	5	3	1
Products 25-55,000	73	92	92	67	66	46	45	27	27	30	49	29	49	49
Products 10-25,000	8	5	5	5	7	6	8	6	13	5	9	4	1	8
Chem & Spec. 10-55,000	83	103	106	69	76	60	53	41	39	9	8	13	12	11
Tankers < 10,000	60	93	71	70	65	51	52	51	69	34	35	28	25	22
Capesize > 100,000	21	24	33	77	101	111	129	122	149	65	63	40	56	38
Panamax 80-100,000	15	17	27	21	60	61	81	97	140	94	101	68	62	35
Panamax 65-80,000	23	20	18	15	18	33	36	44	53	39	34	42	42	20
Handymax 40-65,000	66	61	84	100	168	166	199	198	228	146	147	119	98	102
Handysize 10-40,000	75	75	119	157	163	169	174	172	221	116	116	80	96	67
Combos > 10,000	0	0	0	0	3	2	3	0	0	0	0	0	0	0
LNG Carriers	25	26	22	17	15	12	5	10	1	2	4	13	14	19
LPG Carriers	27	33	25	18	18	18	16	14	13	8	22	16	14	14
Containers > 8,000 teu	25	26	21	14	29	33	48	30	51	28	51	33	59	42
Containers 3-8,000 teu	69	62	59	59	76	41	31	21	39	19	46	29	26	25
Containers < 3,000 teu	137	109	69	69	54	26	33	31	33	37	29	17	22	27
Offshore	15	16	11	11	22	25	27	23	30	10	12	19	32	30
Cruise Vessels	6	3	3	3	9	4	4	2	6	1	6	0	3	2
Passenger Ferries	21	7	11	11	10	13	11	10	11	8	6	6	12	8
Other	156	156	152	162	172	180	182	182	190	99	97	79	72	62
TOTAL	**974**	**1,024**	**1,072**	**1,023**	**1,242**	**1,139**	**1,245**	**1,167**	**1,409**	**808**	**900**	**659**	**720**	**609**

Orderbook by builder region (number of vessels)



Orderbook by sector (number of vessels)



2015		2016		2017		2018		2019	Scheduled Orderbook		
1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2019	2020	2021
9	11	23	24	29	21	21	18	38	28	41	12
7	3	8	19	35	22	25	7	23	12	30	9
22	10	31	22	36	28	26	24	38	19	24	27
2	1	7	13	10	11	7	6	6	6	17	7
60	57	60	42	39	25	27	22	48	47	81	14
4	0	3	2	6	6	8	4	4	14	12	4
36	29	43	36	38	31	45	41	32	42	49	2
12	14	23	15	24	28	41	38	20	44	17	7
46	42	65	39	55	20	30	21	29	63	110	44
57	41	71	40	75	27	39	25	67	79	144	52
19	4	1	2	6	1	2	2	1	1	7	0
144	121	124	94	124	54	58	32	54	95	133	42
100	83	85	45	68	30	47	41	46	59	78	13
0	0	0	0	0	0	0	0	1	2	3	2
16	16	15	18	20	12	32	23	22	23	45	55
25	40	49	33	45	17	26	9	15	21	41	9
58	62	37	26	34	36	47	23	26	25	56	43
18	6	2	0	2	5	7	3	6	1	8	0
27	35	39	25	36	40	48	36	41	78	138	40
25	14	25	21	18	24	25	13	9	32	44	21
5	1	8	2	7	3	8	4	11	12	25	24
13	8	6	16	21	10	11	18	16	37	33	18
69	49	50	57	48	55	49	45	51	120	105	35
774	647	775	592	776	506	629	455	604	860	1,241	480

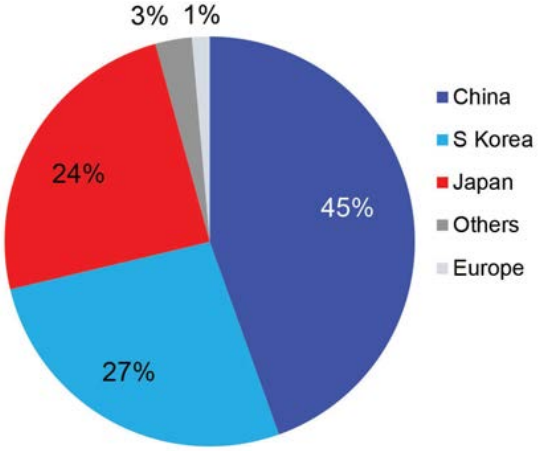
Data includes all vessels with LOA estimated at >100m

Where scheduled month of delivery is unknown an arbitary month of build has been applied for orderbook data

The orderbook by year of delivery on this page is based on reported orders and scheduled delivery dates and do not necessarily represent the ep ected pattern of future deliveries

All data taken as of 1st ul ly 2019

Orderbook (DWT) by builder region



Source:
Clarkson Research Services

Uncovering 2019 employment trends in naval architecture

Adam Graves, associate director of maritime at Faststream, analyses a recent survey of naval architects, revealing today's work culture and salary standards

Global people specialists in maritime and offshore recruitment, Faststream conducted a global salary survey and employment review of over 5,000 naval architects and marine engineers. In this review, key themes are reported around employee retention, pay and bonus, unpaid overtime, benefits, and what matters most to employees at work.

Pay rises

We all seek a pay rise at whatever stage we are at in our careers, but in this market who was actually rewarded with a pay rise?

Only 56% of employees reported they received a pay rise in the last 12 months. It was those with the lowest level of experience that received the smallest proportion of pay rises – only 46% of employees with 0-2 years' experience received one. However, the most experienced employees also suffered from lower pay rises as only 52% of employees with 16 plus years' experience achieved one. The sectors with the lowest rates of pay rises were research (33%), oil and gas (45%) and vessel management (49%).

So, who did get a pay rise? Women employees were the main beneficiaries, with 65% seeing a salary increase. However, over 25% of women indicated they only received this after changing jobs.

Those working in defence (81%), flag registries (75%) and classification (73%) were the more probable sectors to achieve a pay rise. Within defence, many employees received a pay rise of 10% or more. Those who had 3-5 years' experience were the most likely to receive a pay rise, with 70% of these employees achieving one in the last 12 months.

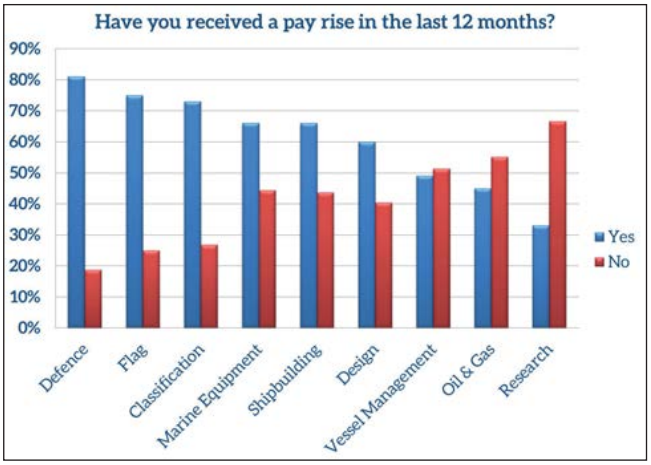
Benefits

When we analysed the data on benefits being offered, some interesting findings emerged. We quickly realised that the UK seemed to be doing better in many areas than the global averages, especially in regard to 'soft benefits'. 40% of UK employees are being granted flexi-time compared with 32% (global average) and more than 44% are benefiting from home working compared to a mere 30% (global average). These soft benefits, which encourage employees to balance work and life more fairly, are becoming commonplace in the UK and they seem to be having a positive impact on employee wellbeing. Our consultants are often asked about these during the application and interview process.

The UK is also leading the way with enhanced pension benefits, yet, only 24% of UK employees reported receiving private medical insurance for their families. Globally, only 28% of our respondents reported that they benefit from a family orientated medical insurance plan, which candidates are feeling more and more strongly about when they are reviewing a job offer.

It wouldn't be right to not make a note on Brexit, given its impact on the maritime industry. We were surprised to discover the lack of relocation support being offered by UK companies (11.4%). Additionally, we've seen a big shift in non-UK candidates steering away from opportunities in the UK over the past 12 months. There is a massive skill pool across the European community

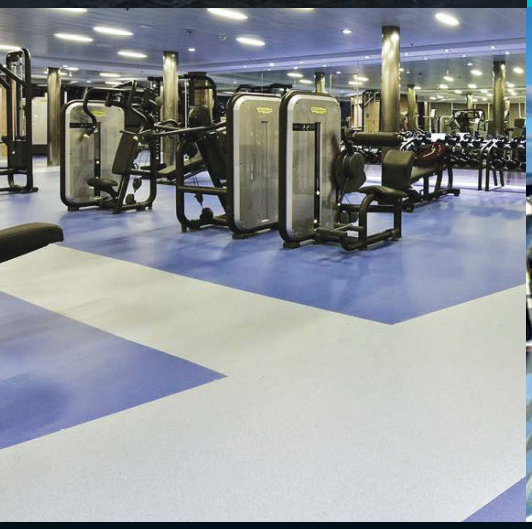
Employees with 3-5 years' experience are most likely to receive a pay rise and stay in their current role



Those working in defence and flag registries were most likely to have received a pay rise within the last year





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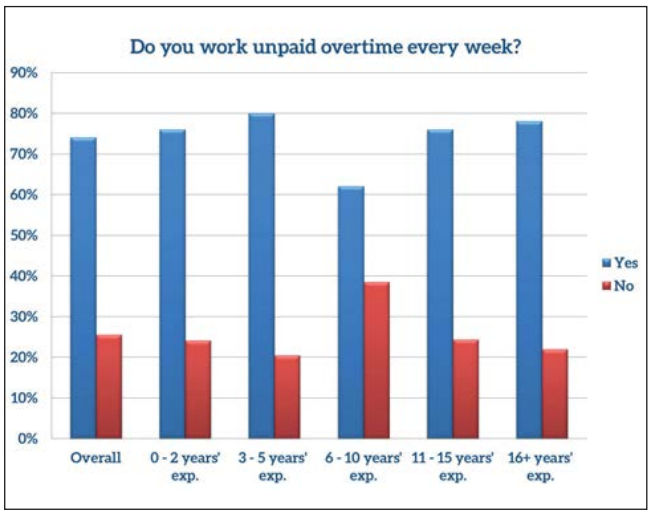

Regardless of experience, the overwhelming majority of naval architects and marine engineers report working unpaid hours on a regular basis

within naval architecture and marine engineering and we felt employers could be offering more support to attract top talent into the country.

In a sector fighting to retain top talent, it was unsurprising to find a healthy 46% of employees receiving some form of monetary bonus. The UK statistic again came out on top with almost 50% aiming for a bonus. When we looked at the data, we saw big bonuses geared towards personal performance (accounting for almost half of the bonuses on offer in the UK). The remaining bonuses were largely based on company (rather than a team) performance.

Despite all of what we see on social media, we were somewhat taken aback by the low number of staff events being held. A mere 20% of employees reported attending these types of social events and/or team-building opportunities. We would advise employers to think about the benefits of bringing your team together away from the coalface to encourage stronger relationships and an overall more positive and collaborative company culture.

Unpaid overtime

As already mentioned, the UK is doing more to offer flexi-time and home working, and yet we found that 74% of UK employees were still working quite a lot of unpaid overtime. Perhaps your employees are more likely to go the extra mile when given a bit more freedom? Those working in Europe reported working marginally less unpaid overtime (70%), but more unpaid overtime was seen by those working in Asia (75%) and the US (80%).

Globally, the highest reported levels of unpaid overtime came from those with 3-5 years' experience (80%) and 16 plus years' experience (78%). In the research sector levels dropped to 56% but within the marine equipment sector, 100% of respondents reported working lots of unpaid overtime.

These results could be put down to the passion of employees and their desire to 'get the job done' or it could be a culture in their business that overtime is expected. Either way, it is certain that the majority of people are working more hours than they are paid for, which our consultants often hear from candidates as a frustration factor. This could be having an effect on staff retention and should be reviewed by employers.

Retention

Over 62% of employees said they saw themselves with their current employer this time next year. There were no significant differences between sectors, just a small increase in the likelihood of retaining staff in the sectors that were offering pay rises: defence and classification. This was also apparent in the section of respondents who had 3-5 years' experience. They were more likely to receive a pay rise, which equated to them being more likely to stay in their current role.

A huge 79.5% with this level of post-graduate experience said they saw themselves staying with their current employer. Those who had 6-10 years' experience were the least likely to stay with their employer next year, with 46% stating they would be looking for a new role. Consistent with this, our consultants reported that the 3-5 year experienced candidate was particularly challenging to attract, yet remains in very high demand by most of our clients.

What affected those wanting to move on to another job? 50% had not received a bonus in the last 12 months, 58% had not received a pay rise and 38% of those looking to move on to a new role had received no pay rise or bonus in the past 12 months.

What matters most to employees?

In our 2018 employment survey, we asked employees what mattered most to them out of five factors. We were delighted that although our respondents were highly educated, they chose training and development as their primary interest.

A pay rise can shift an employee's opinion on what matters most to them at work

	2018	2019	Female	Male	Pay Rise + 10% Plus
First	Training	Salary / Bonus	Work-Life Balance	Salary / Bonus	Work-Life Balance
Second	Salary / Bonus	Work-Life Balance	Salary / Bonus	Work-Life Balance	Company Culture
Third	Company Culture	Career Progression	Company Culture	Career Progression	Salary / Bonus
Fourth	Work-Life Balance	Company Culture	Career Progression	Company Culture	Career Progression
Fifth	Career Progression	Training	Training	Training	Training

This was rated higher than salary, career progression, work-life balance and company culture.

In 2019, we asked the same question and received a very different result. In 2019 salary and bonus were rated overall as the most important factor at work, but when we analysed those who had a pay rise of 10% or more, their priorities changed and work-life balance and company culture were rated higher.

Why has training and development become so much less important to employees in the last 12 months? Have employers changed their training programmes to facilitate more training in the areas such as software and new technology that employees were crying out for? Or has the need for a better work-life balance started to outweigh a desire for training? In 2018, it became very clear that a large number of employees were looking at changing sectors where they would be given the chance to retrain (for example from offshore oil and gas to cruise). The general market outlook, not least in oil and gas, has certainly improved over the last 12 months and our consultants in 2019 are seeing fewer employees looking to jump ship.

Clearly, there was a slight gender imbalance between salary/bonus and work-life balance, where both genders reported these as the top two factors. Women gave priority to work-life balance while men chose salary/bonus.

Just over 32% of employees across the world were offered flexi-time, which leaves 67% of those working in naval architecture and marine engineering stuck in regimes where hours are dictated to them. We also looked at the number of employees who were doing unpaid overtime. 75% of respondents were doing unpaid overtime, of which over 40% were working seven plus hours of overtime per week. This is a huge number of hours to be working unpaid on top of what is normally a 40 hour week. It is not surprising that employees are crying out for better work-life balance. From an employer's perspective, flexi-time and home working can be inexpensive benefits to provide, all they cost is trust.

About Faststream

Established in 1999, Faststream is a global people specialist recruiter in the maritime, shipping and offshore sectors, with over 100 employees operating from three key maritime locations in the UK, Singapore and North America. We source hard to find talent for clients across the globe and offer services including permanent recruitment, contract and interim recruitment, payroll services, executive search, benchmarking and salary surveys. *NA*

KVH targets vendors with service-based IoT connectivity

A cost-effective data solution for remote monitoring and maintenance?

Maritime application of the Internet of Things (IoT) was, for a long time, filed in the column of 'nice ideas'. The problem being that onboard connectivity has traditionally been so poor and erratic it simply wasn't practical to attempt to transfer Big Data to or from a vessel. In fact, the closest most ships got to IoT was the handwritten Noon Report. For equipment and engine manufacturers it's represented a significant obstacle to realising the vision of continuous, condition-based monitoring, analytics and maintenance.

But for marine communications services provider KVH it provided food for thought. Best known as an antennae manufacturer and the largest VSAT operator in shipping, it launched AgilePlans in 2017, a connectivity-as-a-service model. Whereas traditionally a shipowner or manager might pay tens of thousands for an antenna, or acquire it on a long-term lease, they could now purchase an antenna, airtime, warranty, shipping and installation for one monthly fee.

"It's basically like you have on your broadband at home but on a higher sale," explains Mark Woodhead, KVH's executive vice president, mobile connectivity. "We saw sales goes up 100% in a year and it now makes up 77% of our business. It's been massively successful and we've hardly seen any returns. There's no commitment and if you want more or less data you step up or down to a different package."

AgilePlans' success inspired KVH to take a closer look at IoT. "As we're a manufacturer we decided to do some testing, installing antennae onboard vessels and maintaining them. So, for the last 12 months we've been taking 150 data points in real time from our equipment, running it on algorithms on an edge server and then transmitting the results back."

The results of the performance analysis helped inform KVH's product development and Woodhead says it made a huge difference to the business. It seemed a logical step to start offering this new IoT service to shipowners in much the same manner as had proven so fruitful with AgilePlans, but then came a surprise.

KVH Watch: real-time monitoring for equipment makers

"When we started talking to [the shipowners] we discovered they were really not that bothered," Woodhead reveals. "They were far less interested in the performance of the equipment than the equipment providers themselves. We realised we were being stupid about it. As a manufacturer we'd seen the benefits of using the product to look after our equipment, so why not turn the idea around and sell it to the manufacturers?"

By combining the business model of connectivity as a service with the IoT solution it had been using on its own antennae, KVH developed KVH Watch. The solution allows equipment manufacturers to support their onboard products with secure IoT connectivity for remote monitoring and real-time intervention.

"Equipment manufacturers have all had the same problem: they're desperate for the data but couldn't afford the cost of an antenna to get it off the vessel. We will get several tenants for the same antenna and they will each pay a monthly fee. It will include Watch Flow, which is a dedicated bandwidth for machine-to-machine data delivery, and this will send from the manufacturer's onboard edge device to their own platform or cloud-based system."

One of the first customers for the new service is Kongsberg. Announced at Nor-Shipping, KVH will act as a "connectivity partner" for Kongsberg's Vessel Insight digital platform. "Kongsberg are a classic example of an equipment manufacturer who need to provide remote vessel support for a variety of reasons, such as resolving problems and performing maintenance checks. It costs around US$5,000 to send a skilled technician out to a vessel, so it's very expensive."

Another area where IoT connectivity could prove highly significant is resolving arguments about warranty claims; what is the cause when a piece of equipment breaks down and, in some cases, who is to blame. "It's becoming a massive issue for P&I clubs and until now there's been no data to support it," says Woodhead.

KVH Watch is still in its early days and the next phase will be to forge partnerships with the key equipment manufacturers. "If you take engine manufacturers, for example, there are some very big players out there, all of whom have the same problem.

"What's fascinating is that everybody needs data, even boiler operators, but nobody's been able to do anything with the sensors because of connectivity. Vessels have been like remote islands, but I think over the next year or so we'll see massive changes." *NA*

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Ocean University of China's state of the art 'marine lab' delivered

New deep-sea oceanographic research ship *Dong Fang Hong 3* has claimed the title of the world's largest noise-free research ship, according to Chinese media

Designed by China State Shipbuilding Corporation's (CSSC) 708th Research Institute (Maric) and built at CSSC's Jiangnan Shipyard, *Dong Fang Hong 3* was delivered on 30 May to the Ocean University of China following the completion of sea trials.

With a name that translates literally as 'the east is red', it continues the tradition of the original Chinese research ship *Dong Fang Hong*, built in the 1960s, and the 1990s-built (and still in service) *Dong Fang Hong 2*.

At 4,750gt, 103m long and 18m wide with the capacity to carry up to 110 research personnel and crew (61 cabins), the ship is one of the largest and most heavily staffed scientific research ships in the world. With 600m^3 of operations deck and a 600m^3 lab area, the *Dong Fang Hong 3* will be used for deep-sea scientific research and educational training.

Unlike commercial vessels, their exacting technical requirements mean that research ships often have a protracted design and development process. Jiangnan Shipyard needed to work closely with Maric, Ocean University of China, Shanghai Jiao Tong University, class societies CCS and DNV GL and other technical providers, so that the traditional design and production cycle of 'shipowner/ designer/ shipyard/ shipowners' became more like 'shipowner + designer + shipyard + class society + third-party technical support unit'.

As a marine laboratory, the vessel is engineered to comprehensively probe the seabed using a multi-beam detection system. It is also equipped to carry out atmospheric detection, as well as chemical, biological, geological and other experimental analysis. To maintain the highest levels of hygiene during lab tests a purpose-built air conditioning system has been installed. Understandably, its owners are confident it is on course to become an important platform for exchange and cooperation in the field of international marine science.

Dong Fang Hong 3 at its official launch in January 2018. Credit: CGTN

Dong Fang Hong 3 has the distinction of being the first Chinese vessel, and only the fourth globally, to achieve DNV GL's SILENT-R notation – the most stringent standard for underwater noise emissions. Noise reduction was an integral part of the design process and according to the standard measurement by DNV GL's acoustics department, the ship's underwater noise emissions when sailing across its speed range meet the requirements for Silent-R approval, especially in the most difficult 31.5-100HZ noise control. The Silent Class notation is voluntary, although it gives shipowners of acoustically sensitive vessels realistic criteria for noise radiation.

During sea trials the vessel achieved impressive stability, maneuverability and swing performance results. The *Dong Fang Hong 3*'s economic speed is approximately 12.18knots while its maximum speed is 15.55knots. It was recorded that the ship's fuel consumption was one of the best in comparison to a similar electric propulsion ship of the same tonnage.

The maximum three-minute heading deflection angle is no more than 10 degrees at maximum speed, the full-speed turning diameter is about 1.5 times the ship's length, and the ship's maximum heel angle is about 8.5 degrees. *Dong Fang Hong 3* can cruise for 15,000nm continuously and will be self-sustaining for up to 60 days.

Originally expected to enter service by 2018, CSSC's Jiangnan shipyard began constructing the vessel six years ago, in 2013. The *Dong Fang Hong 3* was the first ship at Jiangnan to be built using Dassault Systèmes' CATIA 3D experience platform for digital design and construction. It can check the accessibility, operability and maintainability in of a vessel in advance, and ensure the rationality of the design from the beginning. Features such as segmented pipe manufacturing were deployed to improve the quality of production.

Alongside three other existing vessels owned by the Ocean University of China, the *Dong Fang Hong 3* will form part of China's only university expedition fleet capable of conducting research near-shore and in deep-sea areas. ***NA***

TECHNICAL PARTICULARS

Dong Fang Hong 3

Length, oa	103.8m
Breadth	18m
Depth (to main deck)	8.7m
Draught	5.9m
Gross tonnage	4,750gt
Deadweight (summer max.)	1,826dwt
Crew	110

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OWNERS' FEEDBACK

Ship Size	Number
1,000~1,100 TEU	29
1,500~1,800 TEU	61
2,200~2,800 TEU	58
Total	148

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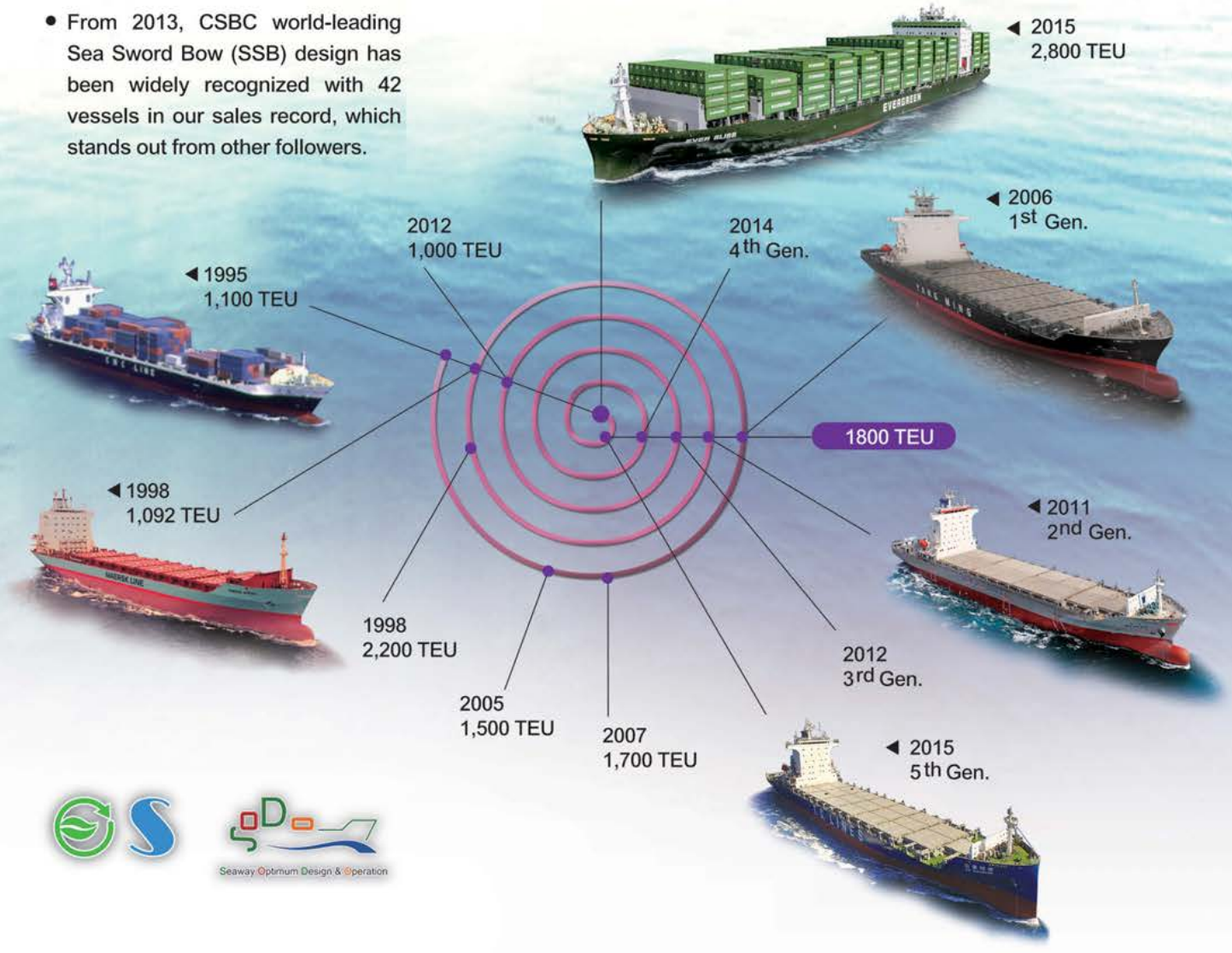

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Chinese shipbuilders make strides in difficult times

China hasn't escaped the shipping industry's current hardships, yet Chinese shipyards continue to enhance their capabilities, show off their newfound strengths and deliver increasingly complex vessels

China may have retained its position at the top of the world shipbuilding league but like shipbuilding nations around the globe, a lack of new orders is continuing to affect Chinese yards, including the state-owned giants.

There is no disputing the fact that Chinese shipbuilding has made tremendous strides through the first two decades of this century. During that time its ability to build ever more sophisticated vessels has been shown time and again. However, its reputation has generally been made as a quantity rather than quality builder.

In the heady days leading up to and just beyond the 2008 economic crash, Chinese shipbuilding expanded at a rate that was almost unprecedented. In that time, yards which had specialised in repair work were converted to shipbuilding facilities while many new yards and builders were established.

As China opened up to western commerce, some private shipbuilding enterprises were formed, some operated by local private companies and some, such as Shanghai Edward and Yantai Raffles, were the result of co-operation agreements with foreign concerns.

The expedition ship *Greg Mortimer* on the slipway at China Merchants Heavy Industry (Shenzhen), ahead of its launch in March this year. Image: Ulstein

Sales and mergers

Those days are now a fading memory and the current situation is one of mergers and closures. So much so that even the two state-owned conglomerates are soon to be merged into one unit. Until 1999, China State Shipbuilding Corporation (CSSC) was the sole state-owned shipbuilder with yards all around the country. In 1992, China Shipbuilding Industry Corporation (CSIC) was established as a spin off from CSSC to control and develop the yards in the north, while CSSC continued to control the remaining yards.

A decline in orders across the globe and corruption at the top of the country's two state-owned organisations has driven the restructuring of Chinese shipbuilding. Private organisations that have failed to demonstrate their financial viability have been denied licences and after a year of rumours, it was announced at the beginning of July that the two state enterprises would again be run as a single entity. This summer also saw Sun Bo, the former head of CSIC, sentenced to 12-years in prison for corruption.

In the private sector, the administrators of Zhejiang Ouhua Shipbuilding failed to dispose of the yard in an online auction, while ASL Marine sold Jiangmen Hongda Shipyard, which will be used in the future for concrete production. Likewise, the country's four largest shipbuilders, including China Merchants Industry Holdings Co. (CMIH), China International Marine Containers Ltd. (CIMC) and AVIC International Holding Corp. (AVIC INTL), are in talks for a strategic merger.

China's difficulties are by no means unique. The main yards in South Korea and Japan have faced their own onslaught of mergers and closures. Official statistics for Chinese yards have often been seen as unreliable, as they sometimes include domestic and military vessels as well as export newbuildings.

The latest figures, released in July, by China's Ministry of Industry and Information Technology suggest the country's output in the first half of this year stood at 19.66 million deadweight tonnes, up 4.2% year-on-year. According to the government figures, China captured almost 52% of global new orders, while its outstanding orderbook accounted for nearly 43% of the world's newbuilding orders.

Those figures, whether they are fully accurate or not, reflect the fact that newbuild tankers and bulk carriers are in highest demand (primarily because the commodities carried in those vessel types make up the majority of world trade). Additionally, these are the vessels China has long concentrated on building and is now a go to destination for.

Last year, China's shipbuilding output reached its lowest point for some time.

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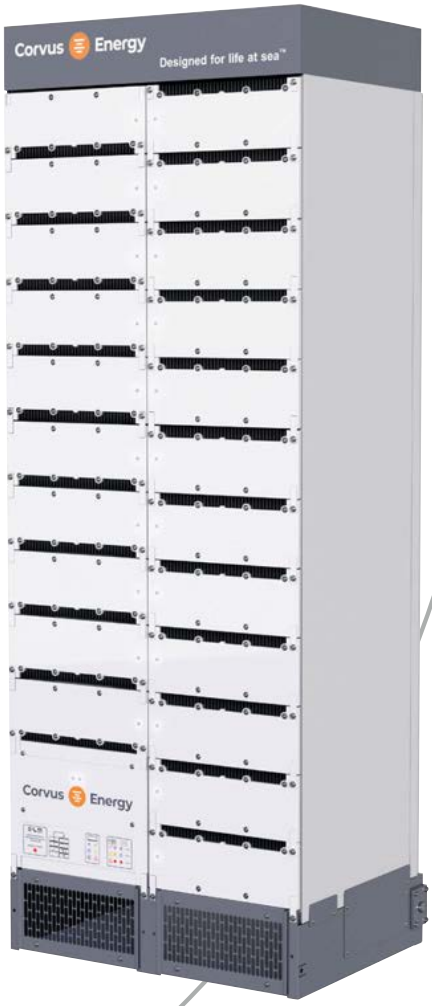

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Counting commercial vessel types along with passenger and offshore ships, the country produced just 612 ships for a total 34,964,507dwt. Three years earlier, the figures were 808 ships for 39,602,318dwt (see Table). The output for the first half of 2019 indicates that this year is likely to be another low, even though the scheduled deliveries for the second half suggest otherwise. This is because ships are frequently delivered behind schedule and the figures include some vessels that may have already been cancelled or put on ice by intended owners.

Smarter ships

China is definitely making inroads into building more sophisticated ships. It is also operating more complex ships for its own account, as demand for consumer goods transported by container has grown and the country looks to move some of its energy needs from coal to LNG.

China was quick to join the large containership constructors league. Denmark was the first to build 10,000TEU ships in 2005/6, South Korea followed suit in 2007, while China delivered its first vessel – the 10,062TEU *COSCO Oceania* – in April 2008. To date, China has delivered 104 containerships of 10,000TEU and above, including 13 over 20,000TEU.

The latest in the list of delivered vessels is the 21,237TEU *COSCO Shipping Star*, which is the fifth in a series of six sister vessels built at Shanghai Waigaoqiao. The vessel was delivered in June this year and made its European debut on 1 August when it arrived in Felixstowe.

COSCO Shipping Star and its sisters are currently the largest containerships built in China. They will be surpassed next year, however, when the first of the nine 22,000TEU ships being built at Shanghai Jiangnan Changxing for French operator CMA CGM are delivered. That ship will be able to claim the title as the world's largest containership but may not hold the title for long.

They will be more famous for being the first of the Ultra Large Containership generation to have been designed from the outset to be fuelled by LNG. When ordered in 2017, the idea of a deep-sea containership running on LNG was considered revolutionary, not least because at the time there was almost no infrastructure for LNG bunkering outside of Europe.

The nine 22,000TEU ships will not be the first LNG-fuelled containerships built in China as that milestone has already been passed. Last December, Guangzhou Wenchong Shipyard delivered the 1,368TEU feeder containership *Containerships Nord* to CMA CGM subsidiary Containerships as the first in a four-ship series. The very first LNG-fuelled containership, *Wes Amelie*, was also built in China in 2011 at Jiangdong Shipyard but its conversion from conventional diesel to LNG was done in 2017 in Germany.

High-end orders

Currently, LNG carriers and cruise ships are considered the pinnacle of sophistication in terms of ship type. China built its first LNG carrier, the 114,291m^3 capacity *Dapeng Sun*, in 2008 at Hudong-Zhonghua Shipbuilding and has since built 37 more for various owners with an additional 23 under construction or on order.

The larger size vessels were all delivered from the same yard as *Dapeng Sun* but smaller sized combination LNG/LPG vessels have been built at several different yards including Taizhou Wuzhou Shipbuilding, AVIC Dingheng Shipbuilding, Jiangnan Shipyard and Nantong Sinopacific among others. Once all of the Chinese built fleet and current orderbook of LNG and combination carriers are complete, no less than 15 yards will have gained at least one reference.

China has also achieved a long-held ambition with orders for cruise ships now in double figures. Six of the vessels are expedition cruise ships for Sunstone cruises, all being built by China Merchants HI Jiangsu to a design featuring the unique Ulstein X-Bow hull form. The first of the six, *Greg Mortimer* was expected for delivery in August 2019. The ships can accommodate 160 passengers and have a gross tonnage of 7,892.

These are breakthrough vessels but the icing on the cake was an order with Shanghai Waigaoqiao for two 135,500gt vessels. The design for the two vessels was done in conjunction with Fincantieri and the ships will be operated by a joint venture between CSSC and Carnival Corporation. The US$770 million vessels will have a passenger capacity of 5,246 across 2,125 cabins and the first should be delivered in mid-2023.

With LNG being one of the means of meeting the IMO's 2020 sulphur cap, more vessel types are being built gas-fuelled on delivery or gas ready. China has not lost out on this new market and has built chemical tankers, bulk carriers and ro-pax ferries compatible with LNG.

Guangzhou Shipyard has built two of the latter type for Swedish ferry operator Destination Gotland. *Visborg*, delivered in December 2018, is Destination Gotland's first LNG-powered ro-pax. *Visborg*'s sister, *Thjelvar*, is due for delivery later this year.

Another Chinese newbuilding to set a first was the 25,600dwt bulk carrier *Haaga*, built by Qingshan Shipyard for Finnish operator ESL Shipping. After delivery last August, the ship made its maiden voyage from Japan through the Northern Sea Route. Its sister ship, *Vikki*, made a similar maiden voyage a month later. ***NA***

Table: Chinese deliveries and known orders 2015-2024

Chinese merchant, passenger and offshore shipbuilding output		
2015	808 vessels	39,602,318dwt
2016	714	36,372,633
2017	709	39,235,289
2018	612	34,964,507
2019 January-June	274	19,512,631
2019 June-December*	780	28,886,623
2020 orderbook	606	42,674,624
2021-2024 orderbook	220	18,108,760
*scheduled delivery dates		

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A booming saga for German-built passenger ships

From mega to boutique cruise ships, Meyer Werft shows off its versatility and the strength of German shipbuilding with the delivery of its latest newbuild, the *Spirit of Discovery*

The *Spirit of Discovery* is the second cruise ship Meyer Werft has delivered this year

Saga Cruises' long-awaited *Spirit of Discovery* made headlines in July as the first vessel to be named at the Port of Dover in over a decade. Although the ship is being trumpeted for its Britishness, with its acute tailoring to the English market and British style interiors, the vessel strongly represents the expertise of German engineering.

Built by Meyer Werft at its main shipyard in Papenburg, Germany, the €350 million (US$400 million) *Spirit of Discovery* is Saga's first purpose-built cruise ship. It replaces the company's *Saga Pearl II*, which was constructed in 1981 and underwent a £20 million three-month refit after being acquired by the UK-based cruise line at auction in 2009.

The newbuild gave Saga what it never had with its older second-hand vessels: a blank drawing board. The fresh start allowed the company to incorporate customer focused features – including speciality restaurants, multiple bars, a theatre, library, observation deck and spa – as well as state-of-the-art ship technology.

At 236m long and 31.2m wide with a passenger capacity of 999 people, the UK-flagged 58,250gt newbuild is an unusual size in today's cruise ship marketplace. It measures in at around 100m less than the typical mega ship and has the highest number of cabins dedicated to single passengers of any cruise ship in operation.

While the *Spirit of Discovery*'s size is a unique selling feature, it also proved to be a challenge during the design and construction process. Space planning played an important role, as the integration of equipment into smaller spaces was a delicate task in comparison with larger vessels. However, Meyer Werft was able to take advantage of the ship's compact size by constructing it in its "reactivated" building dock one – a smaller dock normally used for block construction.

DNV GL, which classified the vessel, had personnel based at the shipyard throughout the build in order to provide a quick response to any changes that needed to be made. This ensured production could be conducted smoothly without major delays.

TECHNICAL PARTICULARS

The Spirit of Discovery

Length, oa	236m
Breadth	31.2m
Depth	10.40m
Draught	7.3m
Deadweight	5,120dwt
Gross tonnage	58,250gt
Decks	11
Capacity	999 passengers
Crew	530 approx
Propulsion system	Diesel-electric

Designed for efficiency

Saga collaborated with naval architects at Meyer Werft and Finland-based Foreship to design the ship's hull for an optimised modal speed of about 16knots. The vessel is powered by four nine-cylinder MAN 32/44 engines, which possess a 5,400kW capacity, and is outfitted with Siemens mono SISHIP eSiPods – marking the first time this pod system has been used on a large passenger ship. Siemens is responsible for the vessel's full power and propulsion package, including the power distribution and propulsion converters and generators. The system is reportedly

more efficient than conventional diesel electric solutions, with minimal noise and vibrations produced.

In order to comply with Tier III NOx regulations, the *Spirit of Discovery* is equipped with a selective catalytic reduction system. For further emissions control, four hybrid Yara Scrubbers were installed, ensuring that the ship's adherence to the IMO's upcoming sulphur cap.

To save energy and boost efficiency, various methods of waste heat recovery were utilised. Likewise, to save fuel, CO_2 was used for cold room refrigeration. Overall, the ship's energy saving measures are expected to achieve an 8.5% reduction in fuel consumption.

Digitalisation and communications

Kongsberg was selected to supply the *Spirit of Discovery*'s power management and navigation systems. The bridge features dual ECDIS, speed pilot, track pilot and a digital navigation workstation. Additionally, the ship is outfitted with S-band and X-band main radar, and stern radar.

Cobham Satcom supplied dual-band VSAT antennas while OmniAccess provided the VSAT coverage using constellations of geostationary orbit satellites. Passengers will be able to access onboard WiFi at all times through networks provided by Lufthansa Industry Solutions. Moreover, to ensure the vessel's technology can be further developed, a scalable IT system with high bandwidth was installed onboard.

Rising demand

Meyer Werft is currently constructing Saga's second newbuild, the *Spirit of Adventure*. Expected for delivery next summer, the boutique vessel will measure the same length and share many technical aspects with its sister ship. However, the two ships' interiors will differ, with AD Associates designing the *Spirit of Adventure* while SMC Design outfitted the *Spirit of Discovery*.

The German shipyard is simultaneously working on the *Norwegian Encore*, which will be handed over later this year, and P&O Cruises' 180,000gt LNG-fuelled newbuild, scheduled for completion in 2020. Thanks to Meyer Werft's restored usage of its building dock one, the yard is on track to finish constructing three newbuilds this year and next year, rather than the usual two.

Despite the tough competition between shipyards, German shipbuilding continues to enjoy a steady demand for cruise and passenger ships. Meyer Werft alone has a full orderbook until the end of 2030 with cruise ship deliveries planned until 2024. *NA*

Clean energy revolution ignites interest in waste heat

As environmental pressures escalate, heat recovery systems are gaining popularity as a promising efficiency solution. A new compact system developed by Germany-based Orcan Energy offers savings for all ship sizes

Against the backdrop of toughening climate related policies and a growing carbon conscious, waste heat recovery systems (WHRSs) have made a resurgence within the shipping industry. According to Global Market Insights, the global waste heat recovery system market is expected to surpass US$80 billion by 2025, as sectors including chemical, heavy metal and maritime all seek to reduce their carbon footprint.

Shipping first adopted WHRSs in the aftermath of the 1970s Oil Crises but only began re-examining the technology in recent years. The renewed interest in utilising waste heat has prompted new technological developments, making the systems more versatile and applicable to a wider range of ship types. Among the companies breaking into this reopened market is Munich-based manufacturer, Orcan Energy, which is striving to help shipowners cut emissions and save money with their compact efficiency PACK.

Orcan's packs transform lost heat into mechanical or electrical energy through the Organic Rankine Cycle (ORC), essentially the reverse of a refrigeration system, whereby a refrigerant is continuously circulated. By basing its system on the ORC instead of the more traditional steam Rankine cycle or steam turbine, Orcan can offer both oceangoing and inland vessels the chance to take advantage of their lost heat.

"We basically made waste heat recovery technology available to 'the masses'", says Bas Flipse, Orcan's sales coordinator of marine applications. "A big steam turbine will never work on an inland waterway vessel, small ferry, coastal vessel, etc., but our system works well with these kinds of ships."

The clean tech company has been devising solutions for transforming waste heat into electricity for industry and power generation since 2008. Around two years ago, however, it branched out into the shipping industry when it began actively selling its efficiency PACK. Last year, Orcan went on to gain approval from Lloyd's Register for its WHRS.

Transforming lost heat

As much as 50% of the total fuel energy supplied to a diesel engine can be lost to its surroundings without any provision for heat recovery. Orcan's packs withdraw heat from sources – such as exhaust gases, jacket cooling water, steam or thermal oil – by way of a heat exchanger and transfer it to the efficiency pack by an intermediate hot water loop. The waste heat enters the cycle via an evaporator and drives the ORC.

In the evaporator, the refrigerant is vaporised and routed to the expansion machine in the form of superheated steam. Once the highly pressurised refrigerant expands, it releases mechanical work and turns the expander's rotary screws. This rotational energy is in turn used to drive a generator that produces electricity.

After the expansion machine, the still gaseous refrigerant is liquefied again in the condenser and then re-pressurised by the feed pump. At this point, the refrigerant has completed the cycle and again enters the evaporator to absorb waste heat.

To make each pack, Orcan uses off-the-shelf components from manufacturers with worldwide spare parts available. This

Orcan Energy's compact efficiency PACK can lower a vessel's CO_2 emissions and improve its EEDI

means production costs are kept down and little maintenance is required. "We never strived for the highest theoretical efficiency, but for an economically viable product that would be accepted by the maritime community", says Flipse.

Fuel and efficiency gains

Measuring in at around the same size as a shower cubical, the pack is based on a one-size-fits-all model. "We had several design requirements like compactness and modularity in order to make it suitable for many types of ships", says Flipse. "This means that we now have a product that is compact enough to be installed on inland waterway vessels, but due to its modularity we can also combine multiple units for ships that produce greater quantities of waste heat."

Not only are the packs usable with most ship types, they can function with every kind of fuel and engine type – one pack is capable of operating with any engine rated at 1MW or higher.

In terms of energy, a single pack can generate up to 100kW, with multiple units being able to drive even higher quantities. Depending on engine model and operating profile, a vessel could save around 6% in fuel in full load or 9% in partial load. For example, an installation of four units, Flipse says, could translate to a total fuel saving of approximately €220,000 to €250,000 (US$245,000 to $278,500) annually.

According to Orcan, payback period for its efficiency PACK is between two and four years. Although, due to the low temperature of waste heat, it can be challenging to harness and power output can fluctuate as a consequence of varying waste heat availability. "Whether an efficiency PACK offers an attractive return on investment, depends not only on the available waste heat, but also on the amount of operating hours", says Flipse. "If a ship barely operates its engines at a significant load factor, the fuel savings will also be limited."

Of course, one of the biggest drivers for installing an WHRS today is EEDI and the tightening emission control requirements. "I would say that a typical case is where we install four units and save around of 350 to 400tonnes of fuel annually and reduce CO_2 emissions by 1,000 to 1,200tonnes", says Flipse. Therefore, even if just one unit is fully utilised throughout an entire year, a vessel's CO_2 emissions could be cut by up to 450tonnes.

Orcan has sold 32 units in the marine sector to date, with efficiency PACK orders for both retrofits and newbuild projects lined up. One of the company's most significant installations this year is for two new environmentally sensitive LNG-fuelled catamaran ferries, owned by Rederij Doeksen. *NA*

From bow to stern: hydrodynamic measures for increased hull performance

The Hamburg Ship Model Basin (HSVA) gives an overview of some of its past and current work to improve ship-hull performance and explains why physical testing continues to play a vital role

Authors

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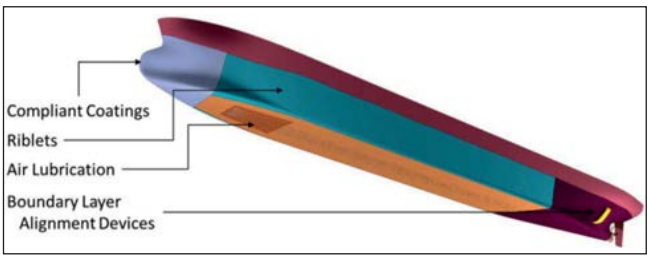

Fig. 1: From bow to stern: different concepts of drag reduction for improved hull performance (J. Marzi, HSVA)

IMO emission targets will require a fundamental change in seaborne trade patterns. Given the substantially higher price of alternative fuels investment into efficiency improvements will become more attractive. The hydrodynamic performance of the merchant fleet, in particular ship-hull resistance and propulsive efficiency, are key factors in this. The hull resistance of large, slow-speed vessels such as bulk carriers, tankers and general cargo ships is dominated by the viscous resistance components; the friction between the hull surface and the water – including three-dimensional effects – and the friction-induced pressure resistance caused by head loss along the streamlines past the hull.

The frictional forces on the ship hull are confined to the boundary layer, which changes its state along the hull: at the bow, the initially laminar flow quickly transitions to the turbulent regime associated with higher skin friction. Towards the stern, the boundary-layer flow decelerates, loses energy and may even separate from the hull surface. All these phenomena cause increased drag.

This article considers four different technologies studied at HSVA, of which three directly act on the hull surface and inside the boundary layer to provide reduced skin friction and thus improved hydrodynamic performance. The fourth technology also modifies the boundary layer but focusses on an improved interaction between the hull-wake flow and the propeller. These four hull-performance enhancement technologies are tailor-made for different hull zones (Fig. 1) as outlined below.

Compliant coatings

The FLIPPER project (2014-2017) saw HSVA join forces with the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (Fraunhofer IFAM), the Hamburg University of Technology (TUHH) and the chemicals manufacturer ARKEMA to investigate the potential of compliant hull coatings to increase the hydrodynamic performance.

Softer, responsive hull coatings are able to interact more favourably with the boundary layer along the ship hull (fluid-structure interaction). Two principal physical mechanisms are at play: (i) a delay of laminar-turbulent boundary-layer transition and (ii) an attenuation of coherent flow structures in fully turbulent flow. FLIPPER focussed on the former mechanism, drawing inspiration from dolphins and their soft, pliable skin (Fig. 3a).

The goal was to develop an 'artificial dolphin skin' for ship hulls capable of postponing the boundary-layer transition to turbulence at the bow of the vessel. Numerical calculations of the interaction between the laminar boundary layer at the bow and the compliant coating were conducted using a mechanical model of dolphin skin (Fig. 3b, see also Carpenter and Garrad (1985)) which was coupled with a numerical solver of the Orr-Sommerfeld equation governing the development of the so-called Tollmien-Schlichting (TS) waves (Schmid and Henningson (2001)).

TS waves are minute flow disturbances inside the laminar boundary layer which grow in amplitude when travelling downstream, eventually breaking down into a fully turbulent state. By attenuating the

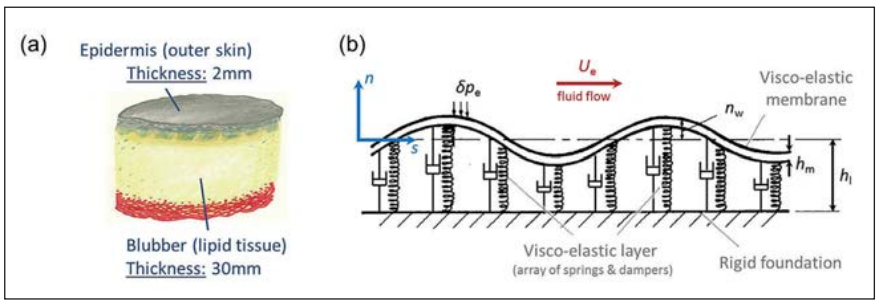

Fig. 2: (a) Schematic and (b) mechanical model of dolphin skin (reproduced after Carpenter and Garrad (1985))

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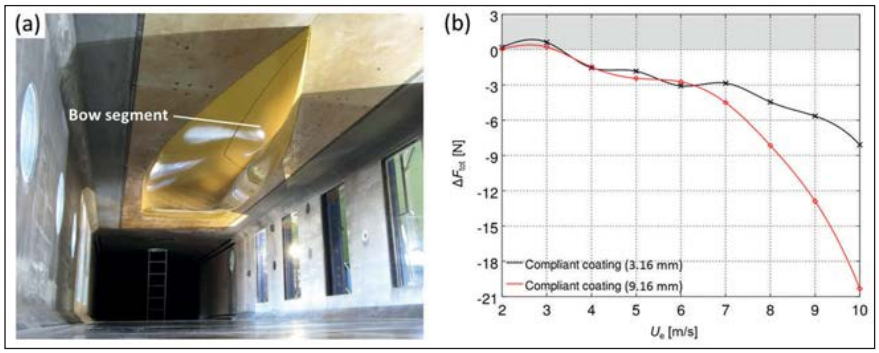

Fig.3: (a) HAI-TECH riblet structure (© Fraunhofer IFAM). (b) Development and testing of the ribleted foils in the HYKAT water tunnel using a cylindrical test body

growth rate of these TS waves the laminar state can be maintained along a longer stretch of the boundary layer, thereby reducing hull resistance. The compliant-coating model and the Orr-Sommerfeld solver were used to identify suitable coating parameters – layer thickness, stiffness (Young's modulus) and damping – for effective transition delay.

The FLIPPER project culminated in coating tests for proof of concept in HSVA's Hydrodynamics and Cavitation Tunnel (HYKAT). A wooden 1:3.2-scale model of the SAR-ship hull was used, featuring a removable bow segment with an integrated load cell for drag-force measurement. At a tunnel speed of 10m/s (design speed used in the calculations), the 9.16mm-thick coating led to a drag reduction by almost 21 N.

FLIPPER successfully demonstrated the functionality of compliant coatings as a means of frictional drag reduction in marine applications. The physical mechanism behind these coatings is a passive boundary-layer control via delayed laminar-turbulent transition, which renders this artificial skin particularly attractive because no energy is needed to operate the system – in contrast to active technologies such as air lubrication (see below). However, it is best-suited to small vessels as the relative savings through the technology decrease with size (Gad-el-Hak (1996)).

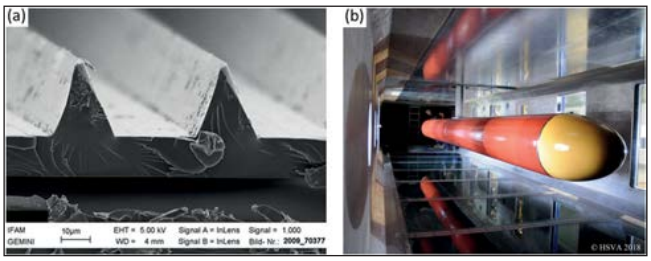

Fig. 4: (a) Air lubrication model in the HYKAT. (b) Bubble carpet during testing

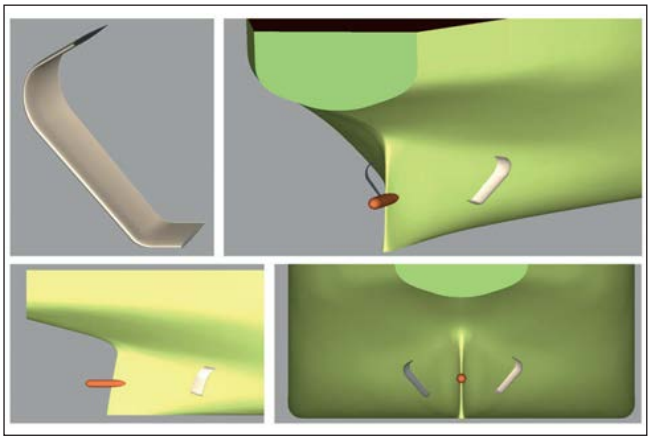

Fig. 5: BLAD deflector and position on the aft ship of a Capesize bulk carrier

Riblet surfaces

Inspired by the skin of fast-swimming sharks ("shark skin"), riblets are micro-textured surface protrusions aligned with the flow. They impose an anisotropic roughness distribution on a surface and were first applied in the aerospace, automotive and energy industries. Extensive experimental investigations on various geometries have been made in a limited range of Reynolds numbers (Bechert et al. (1997)) indicating a drag reduction of up to 10% for plane micro-textured surfaces compared to hydraulically smooth flat surfaces.

In the German research project HAI-TECH (2009-2011, Wilke et al. (2010)), a consortium made up of Fahrion Engineering, Blohm+Voss Naval, Beluga Shipping, LimnoMar and HSVA, and led by Fraunhofer IFAM, developed a coating technique which combined paint application with micro-texturing in a single continuous production process ("Dual-Cure-Paint") for ship hull applications (Fig. 3a). The trials were carried out on an 8m-long torpedo-shaped body in the HYKAT water tunnel at HSVA (Fig. 3b). A comparison of riblet-structured and smooth surfaces revealed a reduction of frictional resistance by more than 5% at near-operational test conditions at about 20knots flow speed.

For the eSHaRk research project (2015-2019), PPG (hull paint supplier, coordinator), Mactac (adhesive-film manufacturer), ND Coating/Meyer Werft (hull coating and anti-corrosion services), VertiDrive (robotic solutions for ship hull treatment) and HSVA cooperated to develop and manufacture a self-adhesive, non-toxic fouling release foil, produced by applying a state-of-the-art fouling release coating on top of a self-adhesive plastic film.

Three test campaigns in the HYKAT water tunnel demonstrated a friction reduction of about 4% compared to standard fouling-release paint; moreover, a sufficient strength of the film system and appropriate adhesion forces of the self-adhesive layer could be verified.

Active air lubrication

For the last eight years, HSVA has been investigating air lubrication systems in the HYKAT water tunnel (partial model in full scale) for application to the flat-bottom area of ships. These studies have been

conducted on behalf of a company which has since equipped several newbuildings with air lubrication systems.

The system generates small air bubbles and introduces them into the turbulent water boundary layer on the ship hull, producing a fluid-gas mixture of lower viscosity than pure water. These bubbles reduce the wetted hull surface and may also favourably interact with the turbulent flow structures in the boundary layer.

Although the effect of skin friction reduction of air-lubricated plane surfaces – often referred to as micro-bubble drag reduction (MBDR) – has been tested on a laboratory scale by various researchers for about 40 years (e.g. Madavan et al. (1984)), HSVA was among the first to investigate the system in full scale, using partial models (Fig. 4a) connected to a force balance to measure the friction force at the top of the HYKAT test section.

Apart from different geometries of the air-release openings, ship draughts of 2-13m, air flow rates up to 120m³/h and water flow speeds (ship speeds) up to 18knots were tested with focus on the bubble creation and carpet behaviour (Fig. 4b). For the partial model of the air lubrication system a friction reduction of 40% was achieved compared to a flat plate of the same dimensions. Since the air lubrication system is an active system the total power balance needs to include the necessary power for providing the required compressed air.

Boundary-layer alignment

The wake flow behind a ship plays a crucial role for the propulsive efficiency. The bulky hull forms of full-block vessels suffer in particular from massive axial-momentum losses above the propeller shaft; in addition, rotational losses occur in the propeller slipstream. To address this, the research project TARGETS (2010-2014) developed the boundary-layer alignment device (BLAD) consisting of a pair of flow deflectors (Fig. 5). The purpose of the BLAD is to deflect the streamlines towards the hull surface in order to accelerate the wake flow locally and reduce the boundary-layer thickness for a more homogeneous flow through the propeller.

Moreover, the BLAD deflectors are intended to create a swirling flow against the propeller rotation for diminished rotational losses in the slipstream along with extra thrust at a given engine power. This swirl is accomplished by different profile shapes and an asymmetric arrangement of the two deflectors.

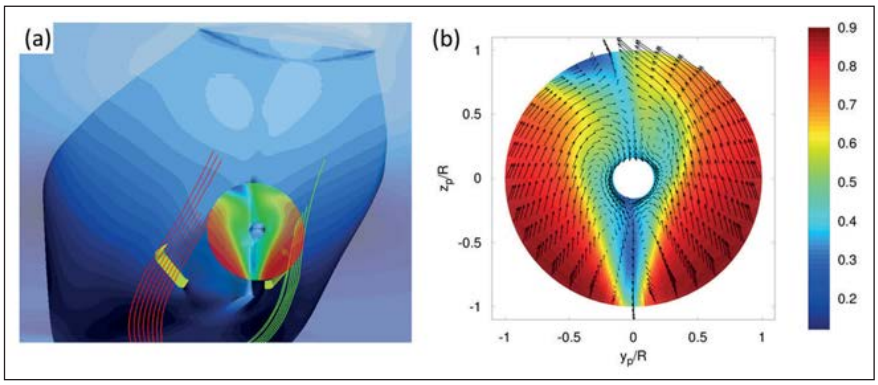

Fig.6: (a) The BLAD deflectors "in action" at 14knots speed: improvement of wake homogeneity and swirl generation. (b) Nominal wake in the propeller plane

The BLAD was developed and tested for a Capesize bulk carrier at 14knots speed with an 8.5m-diameter four-bladed propeller, using CFD simulations with HSVA's in-house codes FreSCo+ and QCM. Thanks to the asymmetric deflection of the port and starboard sided streamlines towards the propeller (Fig. 6a), a nominal wake with increased homogeneity and a swirling flow component could be achieved (Fig. 6b). The flow acceleration into the propeller plane led to an increased advance number at which the propeller could be operated more efficiently, which in combination with diminished rotational slipstream losses allowed for a lower required power to obtain the same ship speed.

Apart from a power reduction, the BLAD deflectors also led to a more symmetric distribution of the mean propeller-thrust force with a reduced peak value. This is expected to yield lower propeller-blade loads along with reduced cavitation risks as well as a better course stability of the vessel.

Conclusions

For many years ship designers have focussed their efforts on the wave-making resistance when optimising the efficiency of their hull designs. In pre-CFD times, wave-making resistance was the only component that could be studied in detail by visual observation, while measurements delivered integral values for the total resistance only. Today's simulations allow for a more straightforward decomposition of hull resistance and make it possible to include these aspects into the optimisation process.

Growing ship sizes, slow steaming and the focus on hull lines excessively optimised for minimum wave-making resistance have increased the relative contribution of the viscous drag components to the total hull resistance, giving rise to improved paint products and new technologies that reduce frictional resistance.

Experimental model testing plays an important role in these research studies. Model basins provide the large-scale experimental facilities needed to conduct hydrodynamic investigations at Reynolds numbers with practical relevance for the shipping industry. Numerical studies are certainly an attractive alternative at low to medium Reynolds numbers; however, fully turbulent boundary layers are mostly beyond the scope of industrial CFD and therefore still rely on physical testing.

An important aspect is to identify which technology fits to which type of ship. Take for example the boundary-layer alignment device, the effect will be most prominent in the case of blunt full-block vessels like tankers and bulkers while the impact will be limited in the case of slender hulls such as ro-ro or passenger vessels – at least with respect to resistance reduction. Air bubble injection, on the other hand, can only be placed in regions with fairly horizontal, large surfaces.

The previous example also demonstrates another crucial aspect: to make best use of the measures they need to be placed at the right position on the ship's hull. The transition-

delaying compliant coatings, for instance, need to be located in the bow region and would not make much sense in the aftbody region. Hence, the ship designers' task and their know-how do not only manifest in a mature, reliable and resilient technical solutions but also in developing hull designs that allow for a beneficial placement and combination of these technologies.

It shows that the main market barrier for these technologies is often the durability under service conditions. In order to generate trust into these new approaches, continued research and – even more important – prototype installations are needed to demonstrate their practical feasibility. The overall realistic savings based on the currently available data on the total resistance reduction of ship hulls could amount to 10% or more in total.

Outlook

HSVA is involved in – or is currently setting up – additional research projects dealing with passive and active boundary-layer flow control. The EU project AIRCOAT (May 2018-April 2021) also deals with a bionic principle of drag reduction: a team of 10 European science and industry experts led by the Fraunhofer Centre of Maritime Logistics and Services (Fraunhofer CML) is currently developing a passive air lubrication technology that utilises the biomimetic Salvinia effect (Barthlott et al. (2010)).

Nature has developed this effect through evolution, which allows the Salvinia plant – a floating fern – to breathe when submerged under water by maintaining a permanent layer of air. This ability builds on a complex surface composed of super-hydrophobic and hydrophilic structures. A ship equipped with such an AIRCOAT foil will produce a thin permanent air layer, reducing the overall frictional resistance significantly while, at the same time, acting as a physical antifouling barrier between the water and the hull surface.

The potentials of the AIRCOAT project are enormous: initial estimates indicate the technology may reduce the main-engine fuel oil consumption and exhaust gas emission by at least 25%. The major advantage over existing air lubrication technologies is that the ship hull is passively lubricated, i.e. no energy for operation is needed. Also, if successful the AIRCOAT refit technology will be immediately applicable to the entire fleet in the form of a foil system.

Passive and active boundary-layer separation control is another path of research and development in HSVA's focus. Nature again provides inspiration: the flippers of humpback whales feature a wavy leading edge formed by so-called tubercles (Aftab et al. (2016)). These enhance the whales' manoeuvrability through a postponement of flow separation to larger angles of attack. This passive principle can be transferred to ship rudders, stabiliser fins or highly loaded propeller blades in order to increase the lift and the lift-to-drag ratio. Even larger gains in lift at almost no drag penalty can be expected from active separation control. The focus is here on fluidic oscillators for boundary-layer momentum enhancement and energisation (Kim et al (2017)). The main benefit of fluidic-oscillator based active flow control lies in the possibility of turning off the system when not needed – a clear advantage over vortex-generator fins which permanently create drag.

Apart from a continued development of the present and of novel friction-reducing technologies, the assessment and validation tools need further attention. Although established EFD and CFD procedures for the flow analysis around ship hulls are available, including the determination of the various resistance components, the incorporation of friction-reducing measures into these procedures is not at all straightforward: the theoretical challenges ahead include the lack of scaling laws – e.g. for model tests with micro-bubbles – and the incorrect boundary-layer thickness owing to the violation of Reynold's similarity. Numerical hurdles consist in a lack of boundary-layer resolution in practical CFD models or in the challenges associated with fluid-structure interaction and many more multi-physics aspects.

Acknowledgements

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The end of the model test era?

Have ship-scale hydrodynamics supplanted towing tank models? Operator Seatrade Shipmanagement put it to the test in the design and development of its latest newbuildings. Jarek Cisek shares the results of its investigations

Seatrade Groningen has finalised a program of 10 newbuilding vessels (completed in April 2019), delivered from different Chinese yards during the past 2½ years. Based upon its experiences, the ship management company would like to share some of the findings which are part of a wider aspect covered by in-house analyses and related to the fleet performance monitoring program. This article is intended as a comparison between available results from the Computational Fluid Dynamics (CFD) stage, model test and sea trials for recently delivered newbuilding vessels, which are a part of four newbuilding projects.

In a Standard Shipbuilding Contract, there is a paragraph describing the vessel's guarantee speed (value obtained by the model test). A tank towing facility, agreed upon by the owner and the shipyard, performs model tests in line with their own experience and the guidelines set by the International Towing Tank Conference (ITTC). The final guarantee speed result under particular vessel loading conditions is verified during the sea trial. Nowadays, this procedure is relatively typical and standardised to establish the guarantee speed. Nevertheless, the origin of this process is based on the William Froude formula, where results of model tests are used to predict the behaviour of a full-scale vessel (Berry, 1924).

Alternatively, a model test of the vessel's guarantee speed can also be derived from the CFD calculations. The development of CFD in the current century allows for hull shape optimisation at an early stage (i.e., before the model test). Official standards for CFD calculations in shipbuilding practice has not yet been established. A number of workshops were held in Gothenburg, (Larsson, Stern, Visonneau, 2010), Tokyo (Larsson et al., 2015) and Southampton (Ponkratov, 2016) to discuss the numerical methods in the flow of model scale ship and ship scale hydrodynamics. The most advanced investigation was related to the comparison of results from numerical methods with details from sea trials measurements.

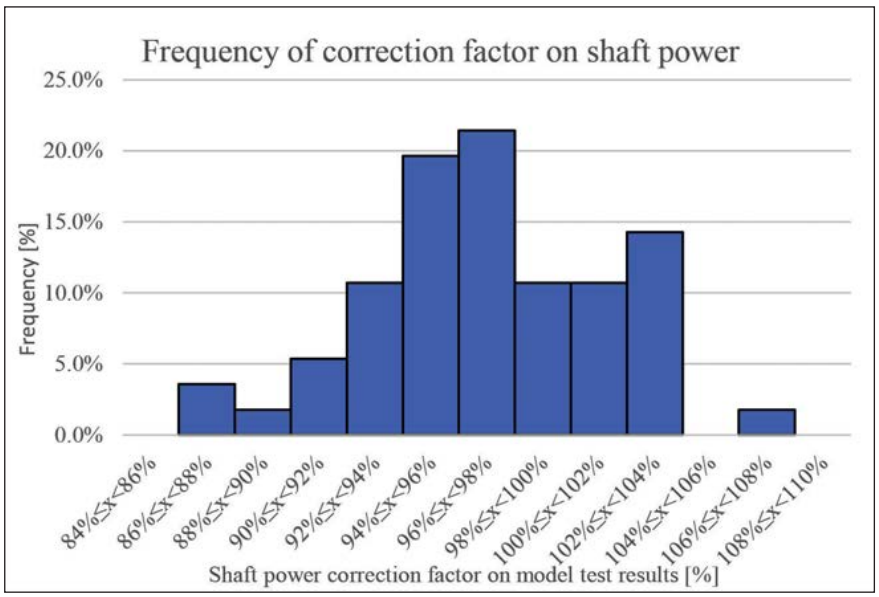
Figure 1: *Juice Express* – an NFC (Not From Concentrate)/ FCOJ (Frozen Concentrate Orange Juice) tanker after completion of its sea trial. The vessel was delivered to the owner on 12 March 2018

In this article, Seatrade Groningen would also like to share some available and gathered results of their investigation in this area. All the presented details and calculations are based on the following documents: final calm water model tests with design propeller delivered from tank towing facilities, sea trial analysis of power sea trial data (the same details which were the bases used by classification societies in issuing the International Energy Efficiency Certificates (IEEC)), and power-speed prediction with use of CFD – delivered from tank towing facility.

Model tests

The model test aspect covers a comparison of the model test results for ballast draft in calm water, with the recalculated (to

Figure 2: Histogram with frequency of correction factor on shaft power for ballast draft



calm water/weather condition) sea trial results also at the ballast condition. In this comparison, power-speed curves are compared for the same loading condition in calm water (ideal weather condition) in line with the agreed standard (ISO 15016:2015).

As a final result, the shaft power for particular recalculated speed is compared between the sea trial result and model test. The result for each measured point is a correction factor on shaft power represented by the formula of C_{SP}:

$$C_{SP} = \left[1 - \left(\frac{Pm - Pt}{Pm}\right)\right] \cdot 100\%$$, where:

- C_{SP} – shaft power correction factor on model test results in [%]
- Pm – shaft power from model test results (ideal weather condition) in [kW]
- Pt – shaft power from sea trial (ideal weather condition) in [kW]

Note: shaft powers (Pt and Pm) are compared for the same value of speed in ideal weather condition.

The sea trial data used in this research consist of results from 56 double runs of the vessels where the ultimate results are power and speed values recalculated to ideal weather conditions. The same speed values as received from the sea trails are input to the model test results where Pm is obtained by the interpolation of the model test points. The results of 56 sea trial measuring points compared with the model test results by formula of C_{SP} are presented on the histogram in Figure 2. A value of 100% represents exactly the same shaft power value during the sea trial as during the model test. Therefore, values below 100% shows overestimated model test results and values above 100% reflect underestimated model test results.

Figure 2 indicates that in 73.2% of the cases, the vessels during sea trial (and after recalculations of the results to calm weather condition) performed better than expected according to the model test results (those are values with correction factors on shaft power below 100%). However, there is also a noticeable number of cases (26.8%) wherein the performance of the vessels is worse than expected according to the model test results.

Furthermore, average value of C_{SP}– shaft power correction factor on model test results is equal to 97.0% and the mean absolute deviation around the average point defined by a set {x1, x2, ..., xn} is calculated as follows:

$$\frac{1}{n}\Sigma_{i=1}^{n}\left|xi - m(X)\right|$$

The mean absolute deviation around the average point is equal to 3.36%. Those results also support a theory related to additional but rational "safety" margin used by the tank towing facilities in prediction of the power-speed curves.

Figure 3: The 2,250 TEU Reefer Container vessel *Seatrade Green* before sea trials. The vessel was delivered to the owner on 15 January 2019

CFD comparison

This part of the article is concerned with the comparison of the CFD results for design draft in calm water with the recalculated (to ideal weather condition) sea trial results for design draft by using model test results – all those recalculations are performed in line with ISO 15016:2015.

The hull form CFD optimisation is based on both potential flow calculations and viscous flow calculations. The power-speed prediction result is based on the calculated resistance and assuming propeller-hull interaction, which in turn, is based on statistical data from tank towing facility database for similar vessels.

Firstly, the sea trial power-speed results are corrected to calm weather condition for ballast loading condition (the same condition as for the model test). After this step, the results are converted from the ballast loading condition towards the design

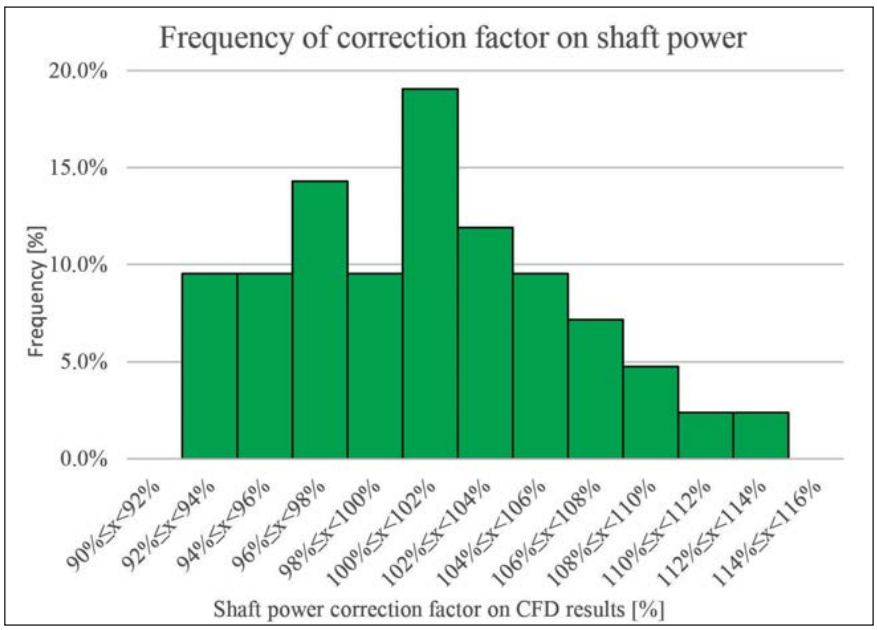
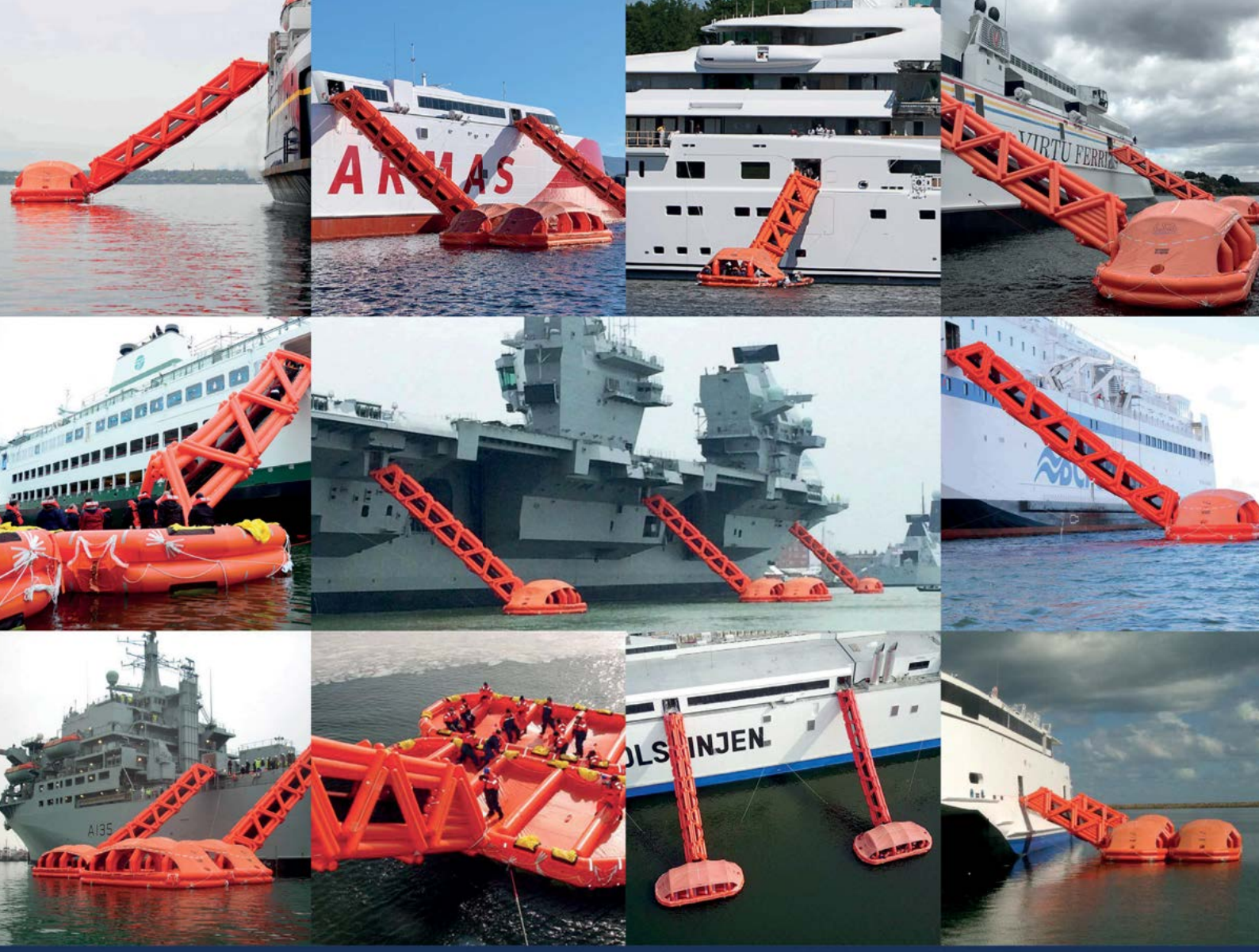


Figure 4. Histogram with frequency of CFD correction factor on shaft power for design draft



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loading condition with the use of the model test details. Received power-speed results for design draft are compared with all available CFD results (the result for each measured point is a CFD correction factor on shaft power represented by the formula of CFD_{SP}):

$$CFD_{SP} = \left[1 - \left(\frac{Pc - Ptd}{Ptd}\right)\right] \cdot 100\% \quad \text{, where:}$$

- CFD_{SP} – shaft power correction factor on CFD test results in [%]
- Pc – shaft power from CFD results (ideal weather condition) for design draft in [kW]
- Ptd – shaft power from sea trial (ideal weather condition) recalculated with the use of the model test data to design draft in [kW]

Note: shaft powers (Pt and Pm) are compared for the same value of speed in ideal weather condition.

The results of 42 compared points are presented in Figure 4. A value of 100% represents exactly the same shaft power value for both methods in design loading condition. Values below 100% shows overestimated CFD results and values above 100% underestimated CFD test results compared to sea trial measurements recalculated with the use of model test data.

Figure 4 also indicates that in 42.0% of the cases, the vessels during sea trial (with values recalculated by model test data) perform better than expected according to the CFD test results (values with correction factors on shaft power below 100%). However, in 57.1% of the cases, the performance of the vessel is worse than expected according to the CFD test results. The average value of the shaft power CFD correction factor on CFD test results equals 100.9%. The mean absolute deviation around the average point is equal to 4.21%. Consequently, those results are substantially less reliable compared to model test details, but they can give a reasonable indication of power-speed curve at the early stage of a vessel's design.

Conclusions and future developments

The International Organization for Standardization indicated that ISO 15016:2015 intends to achieve the anticipated accuracy target of within 2% in shaft power and 0.1[knots] in speed. Taking into consideration the details presented in this article, the maximum accuracy represented by only shaft power (for the same speed) should be within about 4%. Consequently, we can conclude that the average shaft power correction factor on model test results and average shaft power correction factor on CFD test results are already within ISO accuracy.

However, it must also be concluded that there is a relatively small number (1.8%) of cases wherein the accuracy settled by ISO standard is exceeded for shaft power correction factor on model test results. In case of CFD correction factor on shaft power, the number of the cases is substantially larger and equal to 26.2%. This number shows that further refinement of CFD is needed in order to become the an internationally accepted standard for guarantee speed verification of vessels.

Within analysed results, tank towing facilities on average achieved the C_{SP}– shaft power correction factor on model test results on the level of 97.0% and the mean absolute deviation around the average point equal to 3.36%. These results show the safe but also very rational approach of the tank towing facilities for prediction of the power-speed curves. Aside from that, we can assume that CFD calculations will only be seriously considered as the new and reliable worldwide standard if the CFD results achieve a similar level to those of model test results. Until then, it is probable that we will still observe model tests as standard practice to indicate the vessel's guarantee speed.

The most straightforward approach for the continuation of the research would be to compare the CFD calculations and sea trial data for the same ballast condition in ideal weather condition. At the moment, Seatrade Groningen is not in possession of CFD calculations for ballast condition of those presented cases, but that could be covered by future research and development projects.

For future newbuilding projects, there would be an advantage in gathering a full set of the ship performance data (model test results, CFD calculations and sea trials measurements) for the same ballast loading condition. This process would be a step forward in understanding and increasing in-house confidence in CFD calculations as a future maritime industry standard for the verification of a vessel's guarantee speed.

The development of CFD is in continuous progress and even now, there have been improvements which cover the effect of propeller and appendages. Those improvements should increase the accuracy of CFD calculations even more compared to those results presented in this article (CFD results represent a level from 2016, which has been compared with the sea trial details obtained between 2017-2019).

About the author

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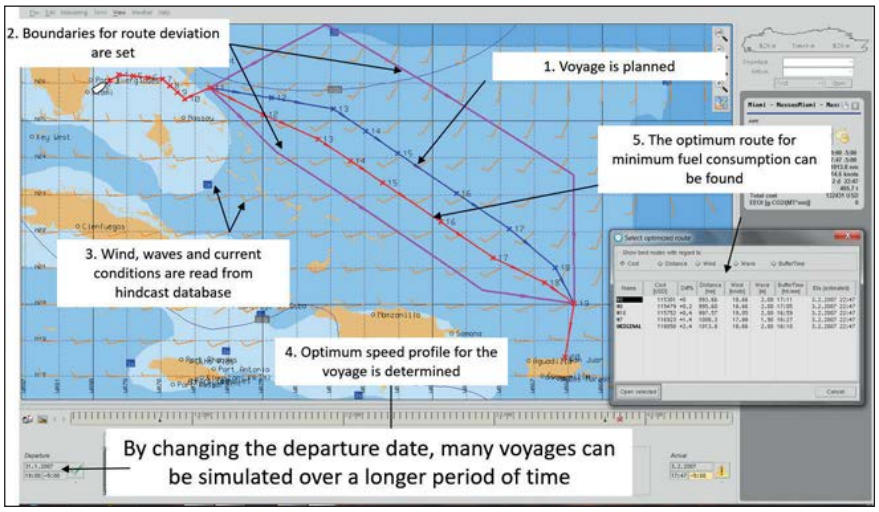
Foreship applies performance monitoring to ship design

Performance monitoring has become a routine part of managing and enhancing vessel operating efficiency. The data collected can also contribute to ship design decisions, writes Matthew Patey, senior specialist for ship dynamics at Foreship

In voyage planning software, systems installed on ships contain a baseline performance model used to make recommendations about planned speed and weather routing. This model is adjusted over time using measured data from the performance monitoring system itself, in a learning process that brings continuous improvements to an individual ship's voyage planning capability.

For the last three years, Foreship has been building the capability to use hindcast weather and reference ship performance databases to support realistic voyage simulations for new ship designs. Measured operational data is used to tune the analytical models being applied at the ship design stage.



The voyage simulation process – a sample voyage in an older version of NAPA Voyage Optimisation software used for voyage planning

One familiar focus when it comes to optimising propulsion power is the standard procedure to evaluate the performance of the hull using reference data from previous design, RANS CFD methods to optimise the hull form, with findings later validated by self-propulsion tests in a model basin.

These are tried and tested ship design methods, but they leave room for uncertainty: CFD procedures may not capture the flow in sufficient detail; again, model test procedures suffer from scale effects. While the methods can certainly establish "this hull is better than that one", there is uncertainty regarding by how much.

Ultimately, the designer estimates the required propulsion power based on standard model test procedures at constant speed in calm water and then adds a 15% 'sea margin' to account for the weather, making an educated guess on wind resistance. It is up to the hydrodynamicist to balance the propulsion power estimate with commercial pressures to optimise hull shape for minimum engine power.

In reality, a ship's propulsion solution, engine arrangement and related systems must take account of many more factors, including (for example) marine growth on the hull; hotel load needs; planned and unplanned engine maintenance; energy saving devices (waste heat recovery, air lubrication system, etc.) and of course the actual logistics of the shipping operation. Assessing electrical power demand for a diesel electric-powered ship is therefore no simple task.

Recently, we were offered the opportunity to take advantage of full scale operational data, after we approached an owner with a new way of calculating fuel consumption as part of a newbuilding project. The subsequent work supported the decision to make a significant change in the ship's powering solution.

Our suggestion was to use the full scale performance data available from the owner's ships, calibrate fuel consumption and propulsion power models by measuring specific voyages using their reference vessel and then apply the correction factors to the new design. In the case being assessed, contributions made by energy efficiency devices needed to be considered as well.

We were primarily interested in the required propulsion power and fuel consumption. Using operational data covering a six month period, it was possible to establish actual measured fuel consumption and develop a daily average power profile of the service load for the reference ship in operation.

Deriving correction factors started with simulating a section of the measured voyages during which the speed was more or less constant using hindcast weather data over a defined timespan, with sections of 36 individual port-to-port voyages simulated. The Specific Fuel Oil Consumption curves were corrected by a factor provided by the owner based on its own experience and marine growth rates applied based on the

owner's own data. Propulsion power was calibrated through an iterative process where the baseline speed-power curve was adjusted to maximise the correlation between the measured average propulsion power on each voyage and the simulated propulsion power. This approach achieved a 98% correlation between predicted and measured total fuel consumption and 96% between predicted and measured average propulsion power (considered 'close enough').

The tweaked 'operational' speed-power curve was then compared to the most recent 'design' speed-power curve for the reference vessel to develop a set of correction factors to apply to the new vessel.

The final step in making the scenario realistic involved incorporating the owner's statistics on engine availability. Planned maintenance was reflected by removing one engine from consideration on a regular basis for a single port-to-port voyage; unplanned maintenance was simulated using a random number generator and giving the probability of failure to remove an engine for a port-to-port voyage.

The reference vessel in operation and the new design were then run through a series of voyage simulations covering four round-trip itineraries in four different sea areas. Simulations were run over a 25 year period for which hindcast weather data was available. The information generated from simulations included: speed, engine mode and power profiles; voyage buffer times and late arrivals; fuel/energy consumption, CO_2 emissions/EEOI; passenger comfort and seasickness experienced; weather conditions; wind, wave and current contributions to power demand.

One of the main conclusions from the process was that the proposed engines for the new vessel would feature insufficient total installed power, if the current drydocking and hull cleaning schedule were to be used. The simulations resulted in several late arrivals on one of the itineraries (but not for the reference vessel) in circumstances where high levels of marine growth were factored in or when one or more engines were out of service and marine growth was moderate or high. This was despite the fact that the installed engine power was well in excess of the required power according to the 'design' speed-power curve, the expected service load and the traditional 15% sea margin.

In addition, the engines proposed appeared to offer less potential to optimise fuel consumption because all the engines were the same in the new ship. Meanwhile, the reference vessel featured two engine sizes, allowing for more flexibility to adapt to variations in the power demand encountered. Further simulations of the new vessel with half of the engines replaced with larger engines showed improved fuel efficiency, lower EEOI values and fewer late arrivals.

Ultimately, the analysis proved influential in the decision to increase the installed power and change the size and configuration of the engines used. Most significantly, it demonstrated the importance in the design stage of considering operational data from performance monitoring systems and the usefulness of voyage simulations to reflect real future operations of the vessel. *NA*

Siemens Simcenter solutions enhance education and research

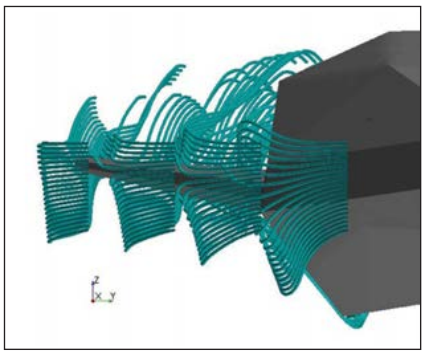
Simcenter STAR-CCM+ has become the major CFD tool for simulation of fluid flow at Gdańsk University of Technology

Established in 1904, Gdańsk University of Technology (GTU) is one of the oldest autonomous national universities and the oldest technical university in Poland. Today it reinforces its position among the best technical universities, certified by national rankings and international authorities.

The Faculty of Ocean Engineering and Ship Technology at the university offers a PhD degree program that tailors the course of study according to the interests of both the student and industrial partners, preparing students for teaching, research and commercial careers in ocean engineering, marine engineering and naval architecture.

The university makes extensive use of computational fluid dynamics (CFD) simulation in its education and research activities, and the tool of choice is Simcenter STAR-CCM+ software from Siemens PLM Software. The cooperation of Gdańsk University of Technology with Siemens began during the 'No engineer left behind' program, launched by CD-Adapco at the onset of the economic crisis in 2008. The support scheme initiated by CD-Adapco enabled engineers who had lost their jobs, or were at risk of losing them, to retrain in CFD simulation and change professions by providing free-of-charge access to software licenses and training. After CD-Adapco was acquired by Siemens and included in the Simcenter software family, the name of the package was changed to Simcenter STAR-CCM+; since then, it has been playing a major role in Gdańsk University of Technology's teaching programs.

"Simcenter STAR-CCM+ is perfect for teaching and for work with students, as well as for advanced education in the field of CAD/CAM/CAE," says Cezary Żrodowski of the Department of Ship Design and Subsea Robotics at the university. "At present, it is one of the primary CFD tools of our PhD students. Both the licensing method and the culture of its use make this software the preferred solution at our university. Among other things, students may use the licenses on a 'power on demand' basis not only at the university, but also on their private PCs at home."



Visualisation techniques are used to present the calculations results as current lines

The CFD process

The CFD simulation process is typically long, and the time required depends on the accuracy of calculations adopted by the engineer. "Depending on the particular research center, simulation procedures may differ significantly," Żrodowski says. "Usually, the process consists of three to four stages. First, the so-called geometry is prepared, then the computational domain is defined, added to the model in the form of a grid, embracing water and air around the examined body."

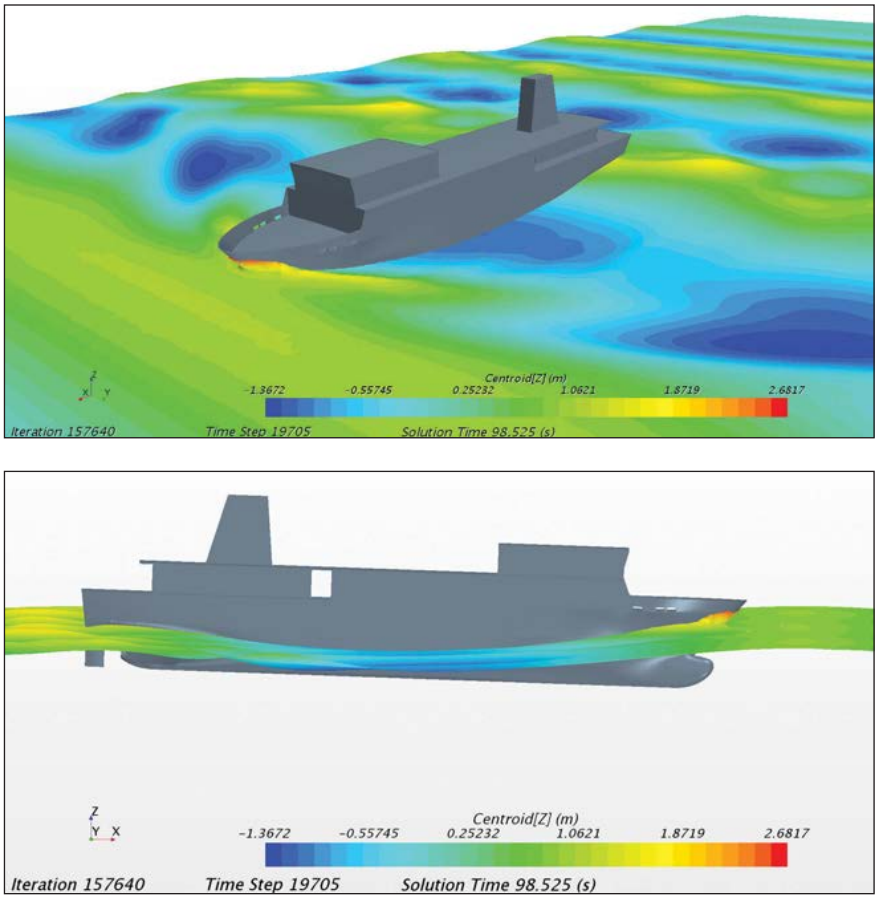
Finite element and finite volume simulation methods are based on discretization of space: the test area is divided into a mesh. It is an arduous process that requires experience and has a significant impact on the value of results. Increasing the density of the simulation mesh enables more accurate results that closely reflect real-world behaviour, but simultaneously makes the simulation time longer. It is easy to generate a model so large that waiting for the results would take decades. Engineering assumptions are always a compromise between accuracy and the calculation time. The simulations enable solving of various types of flow-related problems – from those in micro scale associated with chemical reactions, to those in macro scale, such as water flows around a ship hull or in a river bed.

Simcenter STAR-CCM+ enables users of the software to develop custom macros to automate the activities required during a normal ship design procedure and during model tests. "Not so long ago, the primary method of testing the water flow around ship hulls was testing in a model pool, usually at scales from 1:20 to 1:50," Żrodowski says. "Next, the results of such tests were applied to the behavior of actual ships. At present, we complement and most often replace these cost- and time-intensive tests with CFD simulations." Simcenter STAR-CCM+ also offers specific simulation tools and procedures to meet the needs of the marine industry. The Estimating Hull Performance (EHP) module provides naval architects with a streamlined process to simulate powered hull performance, reducing reliance on scaled-model testing in pools. Engineers can simply prepare the appropriate shape of the analysed model and enter the data to the software. Results from the simulation are consistent with those of pool testing.

Model calibration

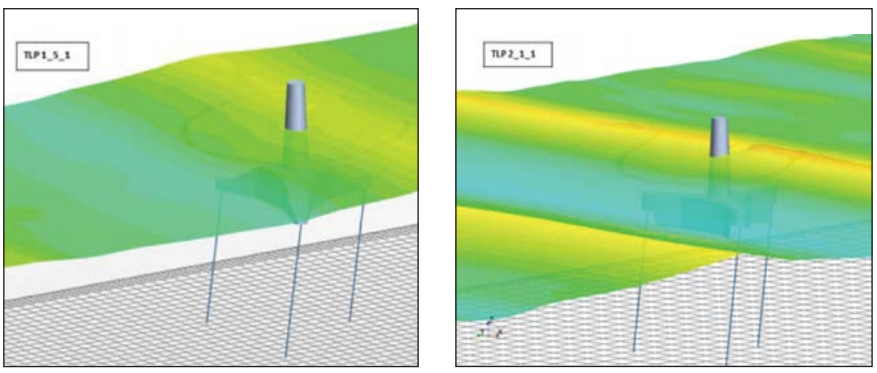
Even with the advancements in simulation technology, tank tests are still needed and even necessary in order to properly prepare the computational model. To obtain results that correspond to real-world behaviour, it is necessary to properly calibrate the model by adjusting its equation coefficients. With these adjustments, such models can be used to simulate hundreds of modified body shape variants, with high reliability of the results obtained. The percentage of physical tests performed is gradually getting lower in favour of CFD simulations. Many believe that the use of tank tests will soon be limited exclusively to those necessary to calibrate the computational model.

"The object of simulation is rather the medium in which it moves, instead of the



Simulation of hull behaviour on the wave. Source: Niklas K., Pruszko H., Żrodowski C., Selected results from 'SmartPS - Smart Propulsion System'; project no ERA-NET MARTECII/ SmartPS/4/2016; Gdansk Univ of Techn, Gdansk 2018

ship itself, and in case of sailing vessels, it is also the wind. A ship, the coast or a bridge are in fact obstacles for the fluid, and during the simulation we deal with what happens to a fluid or gas after it encounters either static, moving or deformable obstacles," Żrodowski says. "Our job is to find out what happens to the fluid after such an encounter. Sometimes flows are laminar, but in ship technology most often turbulent. Usually, the result of a simulation performed by an engineer is the distribution of pressure generated by a given flow. Entering the correct fluid characteristics to the model allows us to determine the hull behaviour under the influence of waves, and to detect any irregularities, such as the possibility of water getting on board the ship, or the risk of capsizing."



The waves-induced movement of anchored objects

Usually, the object target parameters are assumed so that the model simulation results are clearly on the safe side in relation to the requirements. This results from the limitations associated with the model accuracy and the quality of available data, which requires the adoption of significant safety margins.

Supporting engineering specialties

Pressure calculations made using CFD tools are carried out independently from strength calculations. However, more and more often thanks to the tools like Simcenter STAR-CCM+, the university can include the interaction of structure and fluid (FSI – fluid structure interaction). This allows for the study of the behaviour and strength of the structure based on hydrodynamic loads that approximate real ones, instead of the traditionally oversized regulatory loads.

The tests performed using Simcenter STAR-CCM+ may relate both to the behaviour of fluid on the ship hull surface and in the area of the screw propeller. The engineers designing a ship's shell plating perform the hull simulations, while the propulsion experts are interested in what happens in the propeller area in terms of vortexes and vibration.

On the other hand, engineers dealing with the ship's steering perform simulations for the rudder area. Simcenter STAR-CCM+ also enables engineers to predict the spread of fire on a ship, and the software can be used to simulate behaviour with respect to fire safety.

"When designing the ship, we want to know where such negative phenomena – the detachment of the flow from the hull, and in the case of propellers, cavitation – occur," Żrodowski says. "Traditionally we focus on estimating resistance, which has a direct impact on fuel consumption, but modern software also allows you to simulate manoeuvrability, seakeeping or stability. When testing a model, we try to find answers to the following questions: Should we add extra keels to minimise the ship rolling and pitching, or should we add some elements modifying the flow near the propeller to increase the propulsion efficiency, or to minimise vibration generated by this type of part in order to improve the comfort of work?"

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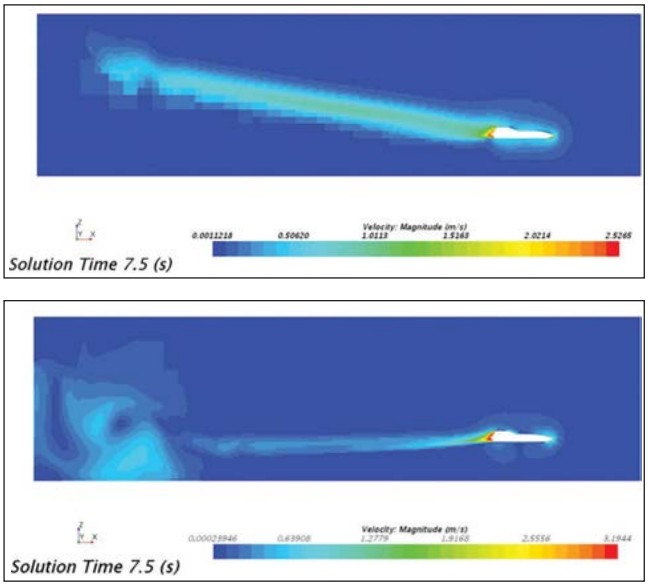
Simcenter STAR-CCM+ for students

The software is also used for professional scientific projects, including the design of ships or offshore drilling rigs. Approximately 50 students use tools integrated with CFD to perform the simulations of individual geometries. Some of them perform more advanced fluid mechanics simulations.

The tools are also used by PhD students working on commercial research projects concerning offshore platforms and sea wind farms. "Simcenter STAR-CCM+ is oriented for use by engineers," says Żrodowski. "It does not require highly specialised knowledge to start calculations, but simultaneously, it includes many advanced features that support complex research projects. The integration with the system during modelling of the geometry is important. The software accurately simulates fluid mechanics.

"The ability to purchase the so-called core hours is very convenient and results in significant reduction of research costs. At the same time, the data generated by the educational and the commercial versions are fully compatible with each other. The compatibility allows users to continue the work started as student exercises during later research at master or doctoral studies." *NA*



Calculations of the forces acting on an object moving along a given trajectory

Estonian maritime duo team up to optimise ferry loading

Tallink and TalTech are working together to develop a 'Smart Car Deck' that uses digital solutions to automate vehicle traffic flow and efficiently position passenger cars on a ship's deck

Tallink Grupp will test their 'Smart Car Deck' on its shuttle ferry, *Megastar*

Two years ago, Tallink Grupp activated its 'Smart Port' solution at the Port of Tallinn in efforts to automate and speed up the process of loading and unloading vehicles onto ferries. Now, the Baltic Sea shipping company has set out to push such smart solutions even further.

Early this year, it announced a collaborative project with TalTech's Estonian Maritime Academy to develop a 'Smart Car Deck'. The goal of the two-year €100,000 (US$110,000) project is to reduce waiting times for passengers with vehicles embarking and disembarking ships, improve operations of ships' car decks and provide more support for cargo officers.

Like many ferry lines across Europe, Tallink has seen an increasing number of passengers year-on-year. The company, which operates between Estonia, Finland, Sweden and Latvia, set a new record in July for transporting the highest number of passengers – 1,238,871 – in one month throughout its history.

And just as passenger numbers have grown, so too has the size of the ferries. The market growth has persuaded ferry operators to invest in bigger passenger and ro-pax vessels, yet, ports have remained virtually the same size due to physical space limitations. This imbalance has exacerbated the potential for traffic jams, long waiting times and unpleasant queues during boarding.

With its Smart Car Deck and Smart Port solutions, Tallink and TalTech hope to overcome these challenges by making the everyday routine work required when loading ferries more automated.

Machine-based boarding

Through scientific collaboration, the partners – who have worked together previously – plan on using the latest sensor technology and machine learning to develop the Smart Car Deck. They will look at combining well-known sensors and systems, such as cargo and vehicle registration, the ship's loading and stability software, and the ship's hydrodynamic sensors, with new custom-made ones.

Using these technologies, the ship will effectively be able to both identify the vehicles being loaded and establish the best place for them on the ship's deck. This means that the ship's loading plan will no longer need to be generated by a cargo officer, but instead will be produced automatically by machine learning software. The cargo officer will only have to approve the plan and can spend additional time on more specialised tasks.

"The introduction of this kind of new technology will enable us to automatically create the most efficient digital loading

plans, all aimed at the best positioning of all the vehicles on the car deck," says Captain Tarvi-Carlos Tuulik, head of ship management at Tallink. This way "they help achieve the best stability, cargo space utilisation and fuel efficiency for the trip."

Obtaining information about the passenger vehicles being loaded and determining how to arrange the best loading conditions are among the greatest difficulties in relation to cargo stowage on ro-ro vessels, according to IMO. The Smart Car Deck, however, would help eliminate these obstacles, which often slow down the embarking process.

Once the vehicles have been identified and directed onboard, they will be guided to the optimum parking slot by digital screens. The location of all vehicles or cargo units will be automatically detected when parked and secured. In addition to automating vehicle traffic flow and improving the use of deck space, passengers' access to their vehicles will be enhanced as well.

Tallink and TalTech are currently focused on developing the initial solutions for Tallink's Tallinn-Helsinki route and will eventually test the Smart Car Deck on the company's shuttle vessel, *Megastar*. If it proves successful, the system has the potential to work on all kinds of ro-ro ships visiting ports equipped with Smart Port solutions, says Tuulik.

Pairing digital port and ship solutions

Ultimately, the Smart Car Deck will act as an extension of the company's Smart Port solution. The vehicle traffic-flow management software, which was developed by multinational tech giant Nortal, minimises the time spent in the harbour by using an automatic check-in system with license plate recognition. In the Port of Tallinn, the €10.5 (US$11.75) million Smart Port technology directs passengers with vehicles through the port via digital screens into the correct lanes in the waiting areas.

"In the future, if digital fully automated loading plans are used, it will be possible to automatically pre-sort the vehicles in the most optimal way to prepare for the fastest possible loading process already from the moment the vehicles enter the port area," explains Tuulik.

The company has also recently been testing their 'Smart Lanes', which gives passengers who are travelling by car the option to board the ship through automatic gates if they have already checked-in online. When the Smart Car Deck is paired with Smart Port and Lane solutions, Tuulik says the team hopes that passengers will be able to embark vessels without having to wait unnecessarily at all. Though, he admits, this will take time to achieve. *NA*

Easing the burden of hazardous materials regulations

With the EU SRR effectively making IMO's Hong Kong Convention a reality for many shipowners, third-party auditor Verifavia has successfully branched out into ensuring vessels are HazMat compliant

On 31 December 2018, the European Union's Ship Recycling Regulation (EU SRR) entered into force, prohibiting or restricting the use of hazardous materials onboard EU-flagged newbuildings and EU-flagged vessels heading for demolition at recycling yards. Two years after that date it will be further extended to cover all other EU-flagged ships, as well as ships trading under the flag of a third country that call at an EU port of anchorage.

It is estimated that some 35,000 ships will be affected by the legislation, which in effect represents a localised phasing in of IMO's Hong Kong Convention (HKC) for the Safe and Environmentally Sound recycling of Ships. For shipowners it represents further administrative burden on top of the EU Monitoring, Reporting and Verification of CO_2 emissions (EU MRV), IMO's parallel Data Collection Scheme (IMO DCS) for fuel consumption and, of course, the pending sulphur cap.

However, as reported in June's *TNA*, there is a growing acceptance within the industry of the HKC's importance in both environmental protection and improving the often-appalling health and safety standards endured by workers at recycling facilities in South Asia, where 90% of vessels are scrapped.

One company that could be said to have a foot in both camps is Verifavia, a third-party consultancy with a presence in both Europe and Asia, that provides independent environmental verification, certification and auditing services for commercial transportation. Verifavia Shipping initially focused its activities on assisting companies with EU MRV and IMO DCS compliance, and says it is now the world's largest independent (non-class) verifier of carbon emissions for shipping companies. But more recently it has extended its auditing services to include verification of the Inventory of Hazardous Materials (IHM) that must be held by ships as part of EU SRR.

Representatives of Verifavia Shipping ahead of an IHM inspection of the bulk carrier *E.R. Borneo*

In May, it was announced that Zeaborn Ship Management had contracted Verifavia to conduct IHM surveys for its fleet of more than 100 vessels, apropos the issuance of Statements of Compliance (SoC) by the Korean Register (KR). Verifavia has now been approved as a HazMat Expert Company by most of the major classification societies.

Gap in the market

Yuvraj Thakur, commercial director of Verifavia Shipping and its lead IHM expert, explains that the company first became aware of a gap in the market for EU SRR services through its EU MRV work. "The regulation is prepared by the EC but has guidelines which are provided by the European Maritime Safety Agency (EMSA), so we were working in much the same domain. Being marine engineers and naval architects, we quickly caught up, particularly because ship recycling was a subject close to us," he says.

"So, from last year we started to research it. But it's not just a case of going onboard a ship and becoming an IHM inspector. I was the first one in the company to attend a four-day training course held by DNV GL, which involves going onboard vessels and learning how to take samples to check for substances such as asbestos [as detailed in the Annex for EU SRR 1257/2013].

"These samples are then sent to an independent ISO certified lab and they generate a report that is submitted to the class society. Of course, the class may have a few additional queries but if these are resolved then eventually they will issue a Statement of Compliance to the ship."

Verifavia now has a 15-strong team of trained HazMat experts based out of its Indian office, including a quality controller who has been working in IHM since 2009. "We wanted the service to have the same DNA as for our EU MRV services, so invested a lot into the training of our people," says Thakur. "Our inspectors are already familiar with vessels; they will normally have four or five years' experience of sailing onboard ships and, as most of them are from India, they know why it so important."

For Verifavia, the IHM audit will typically begin with a presentation to the management company about EU SRR, IHM and what to expect from the process. Key documentation will already have been requested in advance from the shipowners, such as the Fire control & Safety Plan, Insulation plan, General Arrangement and International Air Pollution Prevention certificate. These will be used to prepare the Visual / Sampling Check Plan (VSCP), which identifies areas of the ship from which samples will need to be taken, as creating a location diagram for these.

A minimum port or anchorage stay of at least 12 hours is required for sample collection. Verifavia will also request a short meeting with key crew members, such as the Captain, First Officer and Chief

Engineer, to explain why they are onboard, the scope of the exercise and the areas of the ship they would like to visit. Typically, the accommodation area, bridge, engine room and deck are key inspection sites.

"For example, boiler insulation would be sampled for asbestos, while paint would be tested for Polychlorinated Biphenyls (PCBs). It's a pretty labour-intensive job and normally we have at least two or three people onboard, sometimes three or four if we have people being trained.

"Because of our marine background, safety is always foremost in our minds, whereas other test service providers use chemists or chemical engineers who don't have the same mindset. We will have a crew member accompanying us throughout the vessel and once our job is finished, we will have a closing meeting with the crew," explains Thakur.

IHM ignorance

Verifavia is predominantly consulted for vessels in service, with close to 230 vessels having been signed for conducting IHM audits by the company so far. Thakur says there remains widespread ignorance about the nature of EU SRR and HKC, and this is contributing to conflicting information and application of standards. "The purpose of IHM is not just to have a document onboard but that 10 years down the line, at the end of a vessel's life, is that the ship recycler has this document and understands that before touching a particular segment of the vessel, he should take precautions for handling those hazardous materials."

India remains one of the world's major recycling hubs, with data published in July by the NGO Shipbreaking Platform indicating that 116 vessels were sent for breaking there in the first half of 2019 (second only to Bangladesh, with 156 vessels). But no Indian yards have yet been included on the European List of approved recycling facilities. Although many Indian yards have been issued Statements of Compliance (SOCs) by classification societies indicating that they meet HKC requirements, the consistency of these standards has been widely questioned.

Thakur says that Verifavia, with a team that includes experience of handling recycling projects, is keen to lend its support to the relevant authorities. "What has happened, particularly with regard to India, is that there has been no voice on the ground from the country of origin. I've discussed it with a local class society and told them they should really be at the forefront of backing these regulations… At the end of the day it should be about making the lives of shipyard workers better."

For the present, however, he says the emphasis is on consolidating the early success of the IHM verification service which, given it is applicable to all vessels over 500gt, is considerable. "One of our strengths is that we have people in all parts of the world and in terms of IHM survey we cover the region from China and Hong Kong, to Singapore and India, through to Dubai and Europe, which is pretty good for a company only founded a few years ago.

"I understand that, at the moment, the major preoccupation for shipowners is scrubbers, but as an industry it's time to push shipping companies, particularly the smaller players who aren't onboard yet, towards IHM." *NA*

ABS joins the carbon race

The US class society's response to IMO's CO_2 mandate is a considered and realistic assessment of current technologies and the challenges ahead

Ever since MEPC 73's momentous agreement in April 2018 to target a 50% reduction in shipping's overall carbon output by the middle of the century, the maritime industry has been fretting over its readiness to achieve such a goal. Inevitably, many shipowners and operators are looking towards classification societies to provide guidance on the kind of future fuel and technological strategies they should consider.

Officially launched at Nor-Shipping in June, ABS's *Setting the Course to Low Carbon Shipping* is the latest attempt to seize the gauntlet and identify potential pathways for lowering GHG emissions. The study, which was commissioned from Maritime Strategies International (MSI), takes a pragmatic approach in assessing the main operational options available to shipping.

Pointedly, the report is described as an 'Outlook' for 2030 and a 'Vision' for 2050. Like many in the industry, ABS anticipate that the interim 2030 targets – a decline on 'carbon intensity' of 40% compared to 2008 levels – will be achieved through a use of existing technology and speed reduction. However, the 2050 goal requires a different breed of solutions that remains out of reach.

Setting the Course to Low Carbon Shipping was published in June

"The 2050 target is the most ambitious because it does not allow for trade growth," says Kirsi Tikka, executive vice president and senior maritime advisor at ABS. "We're obviously going to have some changes in ship design and operations but will probably also see changes in what cargoes will be moved."

Shipping, Tikka points out, is already a highly efficient form of transportation, accounting for just 3% of global CO_2 emissions. Moreover, significant progress has already been made since the 2008 levels of carbon intensity that serves as the baseline for the reduction targets. In 2008, emissions were calculated at 22g of CO_2 per tonne-mile, but had decreased to 15.2g (a drop of around 30%) by 2015, based on data published by IMO and the United Nations Conference on Trade and Development (UNCTAD).

While this can be attributed in part to a depressed market (compelling owners to adopt slow steaming), it means that 2030's 13.2g target is a comparatively modest goal. Emission caps are not expected to be formally imposed until the IMO's carbon strategy is finalised in 2023 and will draw upon data and trade growth predictions from the ongoing fourth *Greenhouse Gas Study*. However, there are already mandatory slow steaming proposals on the table at IMO, with separate delegations led by France and Greece advocating speed restrictions and fleet-wide annual emission caps.

As MSI's research director Niklas Carlén notes, from a bunkering perspective consuming less fuel is music to the ears of shipowners, notwithstanding the knock-on carbon reduction. "If it's combined with just-in-time port calls and increased efficiency landside then it's great because you're achieving it with the same level of fleet. The risk is that you don't see that and you're effectively taking capacity out of the market," he warns. This, of course, would lead to rising freight rates and newbuilding orders to plug the gap, leading to further CO_2 production.

Hydrocarbons trump alternatives

With its more onerous 6.6g per tonne-mile target, the 2050 mandate is another matter that carries with it the implication of new technologies still far from maturity. Tikka highlights the findings published in the *BP Energy Outlook 2019*, which states that by 2040 renewables will still only account for 15% of primary energy with hydrocarbons (coal, oil and gas) still representing around 75% of the energy mix (the remainder being made up by hydro and nuclear).

RINA-QINETIQ

Maritime Innovation Award

Innovation is key to success in all sectors of the maritime industry and such innovation will stem from the development of research carried out by engineers and scientists in universities and industry, pushing forward the boundaries of design, construction and operation of marine vessels and structures

The Maritime Innovation Award seeks to encourage such innovation by recognising outstanding scientific or technological research in the areas of hydrodynamics, propulsion, structures and material which has the potential to make a significant improvement in the design, construction and operation of marine vessels and structures

The Award is made annually to either an individual or an organisation, in any country. Nominations for the Award may be made by any member of the global maritime community, and are judged by a panel of members of the Institution and QinetiQ. The award will be announced at the Institution's Annual Dinner.

Nominations are now invited for the 2019 Maritime Innovation Award. Individuals may not nominate themselves, although employees may nominate their company or organisation.

QINETIQ

Nominations may be up to 750 words and should describe the research and its potential contribution to improving the design, construction and operation of maritime vessels and structures.

Nominations may be forwarded online at **www.rina.org.uk/maritimeinnovationaward**

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Nominations should arrive at RINA Headquarters by 31st December 2019.

Queries about the award should be forwarded to the Chief Executive at **hq@rina.org.uk**

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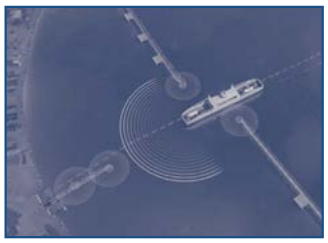

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Marine Design 2020 will return to provide a forum for reporting and discussing Marine Design practice and technical innovation, including Human Systems Integration. Marine Design is a holistic design process with a strong focus on the end users as well as stakeholders in the design process, based on the principles of Industrial Design.

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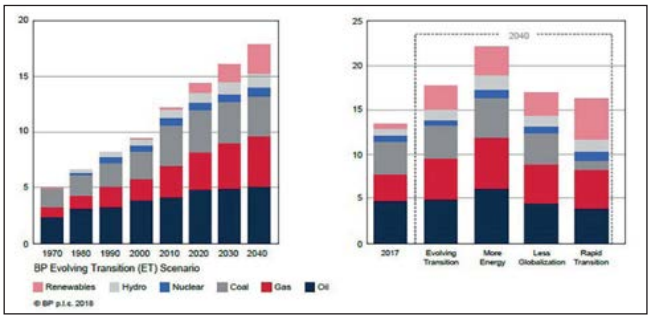
"It means that carbon capture is an important technology to consider and offers potential for synthetic fuels," says Tikka. "So, we looked at the alternatives and compared the infrastructure and emissions. One thing it's really highlighted is the superiority of hydrocarbons in terms of availability, safety of handling and energy density."

While it provides a palliative to SOx emissions, LNG does not make a major contribution to CO_2 reduction and is only seen as an intermediary solution. However, its progress as a marine fuel over the past decade is a useful indicator of the supply chain challenges that must be overcome by alternative fuels. "Ten years back many of us expected LNG to be a major source of fuel by now and it hasn't happened. I believe a big part of the reason is the capital cost required to have LNG, even on newbuildings, let alone retrofitting. It's very difficult for an owner to justify the economics of installing LNG power unless a charterer is asking for it," says Tikka.

The MSI/ABS report includes a detailed breakdown of the current alternative fuel options. It highlights their respective pros and cons and the likely expansion of regulations, including the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code), as experience of using them grows. But it is expected IMO will issue ad hoc interim guidelines as they are needed, as they did in September 2018 for ships using methyl or ethyl alcohol as fuel.

Additionally, it anticipates that many future vessels might use a combination of different fuel technologies, some of which may continue to be served by the traditional bunkering process while others will entail special requirements. Moreover, it suggests that operational requirements and restrictions may necessitate that some fleets adopt fuel technology that is only available in a dedicated area. "We see alternative fuels as more of a regional case. It's easier for governments to incentivise that sort of implementation and it becomes more of a test-bed for implementation later on in the deep-sea trades," says Carlén.

With regard to ABS's own activities in the research and development of new technologies, Gurinder Singh, director of Global Sustainability, points to the launch of its Singapore-based Global Sustainability Centre. Launched in April, the centre serves as a hub for the study of alternative fuels and energy sources, analysing carbonisation pathways and the certification and validation of new technology. "Our goal is to bring all of these technologies to fruition in a more practical, commercially viable way to the industry," Singh says.



Data published in the *BP Energy Outlook 2019* suggests that even by 2040 fossil fuels will still dominate

Concept designs

As part of the report, ABS also worked with naval architects and consultancy Herbert Engineering Corporation on the concept designs for two containerships. The technology, operational profiles and (low-sulphur burning) propulsion systems for a state-of-the-art 2,000 TEU feeder ship and 14,000 TEU neo-Panamax were modified to create versions that might be capable of running on hydrogen fuel cells and liquid biofuels. Although not technically or commercial feasible today, these designs might be possible by 2030.

The study found that bio-fuelled version of the 2,000 TEU ship would offer a 6% improvement on hull efficiency compared to the baseline vessel, by utilising optimized hull and propeller designs and slower turning. Its design speed of 16knots was two knots slower than current feeder ships, but with overall propulsion power of less than 60% of the baseline ship. The 14,000 TEU design offered even bigger savings, with 80% less propulsion power and a design speed of 21.5knots (a knot slower than the baseline).

With the fully-electric hydrogen fuel cell variations, the report acknowledges it goes way beyond what can currently be achieved. For the 2,000 TEU vessel to achieve the same 16knot design speed of the biofuel version, power comes from four cells with an output of 2.5MW per cell. Propulsion power is provided by contra-rotating propellers, one of which is a contra-rotating shaft propeller (driven by a 3.8MW electric motor) and the other a 2.5MW steerable pod. 1,200m^3 of liquid hydrogen, enough for 2,000nm, would be stored in either membrane or cylindrical tanks. The propulsion power is 53% of the baseline.

In the case of the neo-Panamax design, the same technologies are scaled up, with 20 fuel cells delivering a power capacity of 58MW. Likewise, a contra-rotating propulsion configuration is assumed, with a 26MW electric motor and 17MW steerable pod. Up to 31,000m^3 of liquid hydrogen could be stored, with a design range of 12,000nm. Here the propulsion power stands at 75% of the baseline.

The designs are relatively conservative but according to Anders Backlund, business development manager at Herbert Engineering, it was important to keep things pragmatic. "We're seeing concepts such a fin-tailed propulsion at the moment, but if we're talking about 2030, and perhaps even 2050, they won't be there. There's a lot that can be done with fairly basic changes rather than flying too high. If we're looking towards 2030 we need to be realistic and can't start from scratch."

Tikka adds: "We didn't want to come up with concept designs that look interesting because they try to incorporate everything possible that you could imagine. These are what I would call aspirational realistic designs. They are aspirational in the sense that they are for the future, but realistic in that they were developed according to the same principles you would for any basic design. All the powering requirements were determined properly and advancements such as fuel cell capacity were established based on discussions with vendors." ***NA***

Tanker damage stability: proposed solutions

Concluding a trio of articles published during the last year, Keith Hutchinson, of Safinah Group, and Andrew Scott, of the Maritime and Coastguard Agency, discuss the United Kingdom's recently published Marine Guidance Note addressing the demonstration of an oil or gas tanker's compliance with the appropriate damage stability regulations

In a paper [1] presented at a RINA conference nearly a decade ago and subsequent articles [2 to 4] published in this journal during last year, the authors have discussed historical problems in demonstrating compliance with the damage stability regulations for both oil / products [5] and chemical [6 and 7] tankers and also gas carriers [8 to 10]. The guidelines [11] of the International Maritime Organization (IMO) and associated requirements [12] of the International Association of Classification Societies (IACS) were also outlined and presented.

As promised, this article introduces the United Kingdom's (UK) Maritime and Coastguard Agency's (MCA) new guidelines for verification of tanker's damage stability compliance by discussing its recently published Marine Guidance Note (MGN) on this subject, namely MGN 611 (M) Damage Stability: Alternative verification method for tankers – UK interpretations and procedures [13].

Oil tankers come under the scope of the new MGN

Requirement for MCA guidelines

Although publication of MSC.1/Circ.1461 Guidelines for Verification of Damage Stability Requirements for Tankers by the IMO in 2013 [11] has proved immensely useful in clarifying and interpreting the amendments to the various tanker codes [5 to 10] through requiring the use of stability instruments to verify the damage stability compliance of tankers prior to departure, the MCA found that there remained some areas where further guidance on the UK's policies was needed. Therefore, the MCA decided to produce a new MGN to try to clarify the UK's policies towards implementation of the amendments to the tanker codes and application of the associated guidelines [11]. It was felt that the new MGN should be addressed to all those involved with the tanker business, from owners and operators to shipbuilders, consultants and software designers, as well as those involved with system approval and regular inspection, such as surveyors and Port State Control Officers (PSCOs). It was also felt that the MGN should be comprehensive and therefore include as much of the relevant background information as possible in a single document to minimise the need for cross-referencing.

Development of MCA guidelines

The development of MGN 611 (M) [13] was instigated by the MCA in early 2016 at the request of several classification societies and stability instrument producers who desired guidance on how to apply IMO Circular MSC.1/Circ.1461 [11]. IMO requires 'new' tankers, constructed on or after 1 January 2016 to be fitted with approved Stability Instruments capable of verifying compliance with the appropriate, both intact and damage, stability regulations. Whereas for 'existing' tankers, constructed before 1 January 2016, some of which may have already been fitted with a stability instrument, the Administration must be satisfied that procedures are in place for demonstrating that the stability regulations were being fully complied with prior to departure. If so satisfied, the Administration or its appointed 'Recognised Organisation' (RO), typically a classification society, would issue a waiver from the requirement to fit a newly approved stability instrument. Existing MARPOL [5], IBC Code [6], BCH Code [7] or EGC Code [10] tankers must comply with these requirements at the first scheduled renewal survey on or after 1 January 2016 but not later than 1 January 2021. For GC Code [9] tankers the compliance dates are the same except that compliance is required at the first periodical (rather than renewal) survey after 1 January 2016, and for IGC Code [8] tankers the final compliance date is 1 July 2021.

Given the above due dates of compliance for existing tankers there was, and remains,

Requirements for chemical tankers are categorised according to their cargo

a degree of urgency as ships come up for their renewal or periodical surveys. Extensive meetings and discussions were held with representatives from the ROs and the industry and a list of the issues, which were causing difficulties, was drawn up. The MCA's policies towards each issue formed the basis for the MGN.

Description of MCA guidelines

MGN 611 (M) [13] is divided into three parts. The main part commences with an introduction followed by some background information on IMO Circular MSC.1/Circ.1461 [11]. This is followed by sections on the actions to be taken by all the various stakeholders in the tanker business involved with verifying that the ships meet the relevant intact and damage stability requirements. At the end of the main part is a summary and some conclusions.

There then follow two annexes:

- Annex A consists of extracts from MARPOL and the other tanker codes [5 to 10] relating to the obligation to fit approved stability instruments or demonstrate some other satisfactory means of verifying compliance with the relevant, intact and damage, stability requirements. As alluded to previously, the aim here is to keep the relevant amendments to the damage stability codes together within one document for easy reference;
- Annex B consists of eight Sections:
  - Section 1 gives an introduction and more detailed background to the IMO guidelines in Circular MSC.1/Circ.1461 [11];
  - Section 2 describes the characteristics of the various types of software which can be used to demonstrate compliance with the stability requirements, based on the IACS Unified Requirement (UR) L5 [12] published in June 2017;
  - Section 3 consists of a flow chart to assist stakeholders in the decision-making process as to whether an 'existing' tanker complies with the amended regulations and guidelines for fitting a stability instrument. It shows the three possible outcomes, namely: (1) Issuing a waiver from fitting a new approved stability instrument; (2) Approving an existing stability instrument; or (3) Fitting a new stability instrument and having it approved. In the latter case the stability instrument should utilise IACS UR L5 Type 3 software - which is also the MCA's strongly recommended preference for use on 'new' tankers constructed on or after 1 January 2016;
  - Section 4 expands on the flow chart and sets out in some detail the various options available for issuing waivers, which are ultimately issued by the MCA in liaison with the appointed RO;
  - Section 5 is designed to assist front line surveyors and PSCOs in deciding whether a tanker is fully compliant with all aspects of the stability regulations, both intact and damage, and outlines several checks which can be undertaken during surveys or inspections. A spreadsheet is included which summarises the documentary evidence needed to confirm the validity of the verification method being employed, including those ships where stability at departure is verified at shore-based stations rather than on board;
  - Section 6 explains how all the above should be integrated into an approved and certified International Safety Management (ISM) procedure for assessing risks, establishing appropriate safeguards and dealing with the issue of demonstrating compliance with the stability regulations, however that is achieved, to the satisfaction of the MCA / RO and PSCOs. This includes the important issue of ensuring that personnel are suitably qualified and trained to use the stability instrument and that there are always at least two such personnel available either on board or ashore whenever needed;

LNG carrier stability is dictated by IMO's IGC Code

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- It was decided to include a short section, Section 7, on the historical background of computing damage stability for tankers. It explains how the increased computational power of modern computers together with the associated enhanced ability of software has facilitated the possibility of performing complex 'direct' damage stability calculations within a reasonable time-scale once the actual loading conditions (departure, mid-voyage and arrival etc.) are known. Existing ships may have software systems onboard which do not fully conform to the latest requirements and so decisions may have to be taken as to whether such systems are permissible or whether they must be upgraded;
- Finally, Section 8 attempts to address some of the many issues and questions which have arisen during the application of the IMO guidelines in Circular MSC.1/Circ.1461 [11], fuller details of which are included in the following section of this article.

Application of MCA guidelines

Initial drafts [14] of MGN 611 (M) included a question and answer section in which the MCA attempted to resolve some of the difficult issues raised by those involved with applying the IMO guidelines in Circular MSC.1/Circ.1461 [11]. For the published version of MGN 611 (M) [13], it was decided to integrate these questions and answers into the main body of the text where appropriate; many of them are now included in Section 8 of Annex B. They are too numerous to include fully in this article but below are a couple of examples of the more difficult questions received during the consultation period and how the MCA is proposing they be dealt with:

Question 1: What if the approved damage stability information (such as the Damage Stability Book) or the Stability Information Booklet (SIB) (also termed the Trim and Stability (T&S) Book) produces results which are incompatible with those produced by the newly approved stability instrument? Does the stability information need to be revised and re-approved so that the results are fully compatible?

MCA Response 1: If the differences are attributable to modern and more accurate calculation methods being used in the approved stability instrument as opposed to, for example, the use of 'look-up' tables in the approved Damage Stability (calculation) Book and / or the SIB, then the stability instrument may be approved and the SIB will not require to be revised and re-approved. If, however, the differences are due to fundamental changes to the stability information for the ship (including, but not limited to, items such as down-flooding openings, arrangement, maximum draught etc.) then the original damage calculations and SIB must be revised and re-approved in conjunction with the approval of the stability instrument.

In general, the SIB includes loading conditions covering the intact situation which are aligned with those in the approved stability instrument. If the damage stability calculations have not been performed in accordance with IMO guidelines in Circular MSC.1/Circ.1461 [11] then the SIB is invalidated for evaluating any condition of loading and cannot be used. The results from the approved stability instrument take precedence. The SIB should be retained onboard and continue to be used for everything apart from validating the damage stability. This must be made clear to the owners, operators and PSCOs by endorsing the SIB accordingly and updating the Document of Compliance for the ISM Code.

Question 2: Is intermediate stage (IS) flooding to be analysed? If so, which of several methods should be used and for how many stages? Is there a danger that calculation time will be excessive, especially if changes are needed to the initial loading condition, resulting in possible delays to the departure of the tanker? Should new stability instruments being installed on existing tankers necessarily use the same analysis method for IS flooding as was used in the previously approved damage stability calculations.

MCA Response 2: Section 9 of IMO's Circular MSC.1/Circ.1461 [11] makes clear that IS flooding is to be analysed by the approved stability instrument. It is tempting to argue that the final stage of equilibrium is always the worst in terms of residual stability, but this is not always the

Previous research has found stability approvals for LPG (pictured) and chemical tankers omitted critical elements in their verification

case. It is therefore necessary for the stability instrument to have the capability of calculating IS flooding for five stages by any of the methods indicated in Section 9.3 of MSC.1/Circ.1461. However, the MCA is aware of the risk of over-burdening the stability instrument and so the MCA's position is that most of the IS analysis work should be undertaken at the design stage when it ought to be possible to identify and select those damage cases most likely to result in the ship being non-compliant with the regulations during IS flooding. Only these damage cases would then be analysed for IS flooding by the Stability Instrument. This selection of damage cases would occur in conjunction with the Administration or appointed RO during the approval process. A similar selection process should be applied to minor damages (see Annex B, Section 8.3.5 of MGN 611 (M) [13]) to reduce the number of damage cases and hence the computing time whilst ensuring that all damage cases which could result in non-compliance are automatically covered.

It is not essential that new stability instruments being installed on existing tankers follow the same procedure for undertaking IS analysis as was used in the existing approved documentation. Just as for Question 1, the results from the new approved Stability Instrument have precedence. Neither is it necessary for the old documentation to be revised and re-approved to align with the results from the new stability instrument.

Conclusions

This article is the fourth and final in a series [2 to 4] describing some of the problems relating to the complex issue of tanker damage stability which have eventually led to revisions to the tanker codes [5 to 10] and the introduction of guidelines by IMO [11] relating to the installation and use of stability instruments. The advent of ever-improving software and hardware has opened the possibility of such complex calculations being undertaken onboard (or at a shore station) within a reasonable period prior to the ship's departure using the actual loading condition, and if necessary, those to be encountered throughout a voyage.

It is hoped that publication by the MCA of MGN 611 (M) [13] will further assist stakeholders in applying the regulatory amendments and associated guidelines and, in this respect, we are most grateful to those who have contributed their own questions and experiences in applying them to their own individual cases. We would also like to thank all those who assisted with comments and suggestions during the extensive consultation period.

MGN 611 (M) is now available on the GOV.UK website [13] but should be regarded as a working document subject to regular review and improvement in the years ahead as further experience is gained and comments received. Relevant contact details are given in the MGN.

Disclaimer

The views expressed in this article are those of the authors and do not necessarily represent those of the organisations with which they are affiliated and the professional institutions of which they are members. *NA*

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Scrubbing up well

Pacific Green Technologies has reaped the rewards of the sulphur cap with its patented scrubbers, but questions why so many shipowners have failed to take action

With mere months left before the introduction of IMO's sulphur cap, refit yards are tackling a burgeoning number of scrubber installations. Meanwhile, many shipowners are left with little alternative but to wait and hope that their low-sulphur contingencies don't come unstuck. Perhaps unsurprisingly, some scrubber manufacturers believe their optimism is misguided.

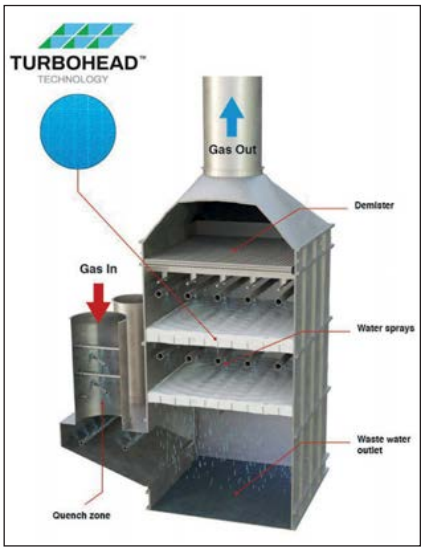
"There are 35-40,000 ships [suitable for scrubber installation] where the owners haven't made their decision," says Ken McClelland, technical director of Pacific Green Technologies (PGT), noting that the biggest surge of orders took place in the fall of 2018, when the more entrepreneurial shipowners took action.

"Every indication is there's going to be a real spread of fuels in 2020. A scrubber is capital outlay but – depending on the size of ship and type of scrubber – you can pay that back in 9-14 months. The other scenario is that every time you bunker you pay higher priced fuel," he adds.

Whether that's how the post-2020 bunkers market eventually plays out is a matter for debate. However, as Devon Smith, Pacific Green Marine's business development support manager, notes: "Scrubber-equipped vessels are currently attracting the premium charter rates and that's expected to continue. If you have a vessel that's scrubbed and one that's unscrubbed, the scrubbed vessel's going to command a bigger dollar figure per day."

PGT's marine scrubber business is currently almost entirely retrofit orders, but it's expecting a shift towards newbuilding orders as the market progresses post-2020. The Vancouver-headquartered company, which also builds land-based scrubbers, has enjoyed significant growth since 2017, when it signed a joint venture agreement with equipment manufacturer Power China.

McClelland says: "Power China is one of the biggest engineering, procurement and construction companies in China. Its engineering resources and knowledge of the Chinese market has allowed us to expand our whole scope and support it with experienced engineers. Being state-owned, it has a bit of a family relationship with other state-owned companies, so it's been very positive for us in terms of getting space in shipyards to do retrofits."



PGT's Envi-Marine system, with patented Turbohead technology

Patented system

PGT's marine scrubber, Envi-Marine, is based around a patented interface between the polluted combustion stream and the reagent solution that predominantly uses the natural alkalinity of seawater to remove the contaminants. "One of the major differences is that this is high, positive contact, not random. Our Turbohead process puts the flue gas into a very turbulent froth area, and because there are two heads it essentially takes out virtually all the sulphur," says McClelland.

The process doesn't use any media, meaning that less water needs to be run through the system, which creates back pressure. "It tends to make the scrubbers physically larger, or you have to reduce the media down to the point where operation is close to the threshold. So we operate only with our patented heads and get scrubbing results that are well within the 0.1% [as required in Emission Control Areas], while for the 0.5% [the 2020 global sulphur limit] we will tune the operating program to bring the reaction up and reduce the amount of energy."

Every PGT scrubber installation is a bespoke job, beginning with a thorough analysis of the ship's engines, volumes of gas that will need to be scrubbed and collaborating with the owner to develop a solution. Unlike some manufacturers, the tanks are rectangular, which usually makes it easier to fit them within confined spaces and allows for a more flexible footprint.

"We can put the scrubbers in two locations, either directly behind the funnel – which works well on tankers and bulk carriers where there is a winch deck directly after the funnel – or on the side of the ship, about three decks up," explains McClelland. "If the funnel is laid out with either boilers or auxiliary engines across the aft of the funnel it's a lot of work to get the largest duct through them. It's sometimes easier if it's right at the front of the funnel to go left and right to a side-mounted scrubber."

PGT offers its system as either a simple, open loop model or as a hybrid system. Surprisingly perhaps, given the recent concerns regarding bans on scrubber washwater discharge, open loop models remain the overwhelming preference of their customers.

But Smith says they offer a third option: open hybrid ready. "It's open loop but the engineering is done for the hybrid system. PGT's official policy is to recommend open hybrid ready, in case environmental regulations change. It also gives some flexibility if the vessel is taken under a charterer who wants a hybrid or closed system." *NA*

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