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A TRANSITIONAL FUEL WON'T LAST THE DISTANCE

By **Richard Halfhide**

During the latter stages of my conversation with Martin Holmgren of Swedish naval architects FKAB Marine Design (p39) I asked him whether he felt his company's shipowning clients were growing more confident about their options as IMO's decarbonisation goals – in particular the need to achieve a 40% reduction in carbon intensity by 2030 – draws ever closer.

"Not really, because the question we almost always get asked is 'what fuel should we choose for the future?'," he replied. "And there's no good answer to that because while most people agree LNG is a good transitional fuel it's only half good going forward. But all the others have a problem with availability."

It's both sobering and fascinating to think that when I took over as editor of *The Naval Architect* a little more than five years ago the widespread usage of LNG as a fuel was something still in its relative infancy. Even today there are still just over 250 such vessels in operation across all shiptypes (with a further 400 on order), according to classification society DNV.

In January, industry association SEA-LNG projected in its report *LNG – a fuel in transition* that by 2024 the number of vessels that were either LNG fuelled, LNG ready or on order would exceed 800. Moreover, with the European Union's Alternative Fuels Infrastructure Directive on track to ensure that all member states have introduced LNG bunkering facilities at their maritime ports by 2025, and similar initiatives elsewhere around the world, there's no question about the encouragement being applied to embrace gas propulsion.

So why does the uncertainty that Holmgren reported from FKAB clients feel so familiar? Conspicuously, the majority of the new orders being placed for LNG-fuelled vessels are coming from a small number of larger operators. SEA-LNG's report points to CMA CGM and MSC's commitments to gas-powered container ships; similar enthusiasm in the dry bulk sector from the Japanese triumvirate of MOL, NYK and K Line; with further familiar names committing to LNG for ro-ros and passenger ships.

Needless to say these companies are better protected should the higher capex (estimates put the figure at 15-30%) prove to be a poor long-term investment, in particular with regard to sell-on value. But the real concern is to be whether opting for an LNG-fuelled ship is a guaranteed means of achieving carbon compliance between now and 2050 or a white elephant with a sting in its tail. Even LNG's advocates appear to have adjusted their rhetoric in recent years, emphasising its importance as a transitional solution and asking owners to pin their hopes on bio and synthetic LNG being cheap and plentiful enough.

K-LINE'S LNG-POWERED CARRIER CARRIER *CENTURY HIGHWAY GREEN*

You probably wouldn't buy a house with the prospect that in 10-15 years it will require a costly refurbishment to meet drastic new efficiency regulations, or that you would only be allowed to inhabit it with reduced power, or with heavy taxes imposed. Given also that there's no certainty that IMO's ultimate climate goals won't be even stricter than presently outlined, or that other regulators such as the EU won't impose a harsher de facto standard, cynicism seems both rational and healthy.

'Waiting is not an option' declares SEA-LNG at the end of its report, while the other expression regularly regurgitated in this context is 'don't let perfect be the enemy of good'. But, as FKAB's hydrogen reforming MR tanker concept demonstrates (at least in principle) the technology exists to deploy LNG in a potentially cleaner, more efficient way than merely a gas-burning combustion engine. If not perfect it's at least a pathway towards a cleaner usage of methane, potentially supplemented by the implementation of carbon capture and storage infrastructure in the not-too-distant future.

I'd intended to write this column without making reference to the ongoing crisis in Ukraine and sanctions against Russia, however the implications of a prolonged Russian boycott, as now looks inevitable, can't be underestimated. As the world's second biggest gas supplier, and third biggest supplier of oil, the impact upon fuel costs is already being felt, with bunkering prices reported to have reached record highs by early March. Much as Covid-19 threatened to overshadow efforts to combat climate change, the hope must be that whatever adversity may be heading our way in the coming months and even years doesn't become a distraction from the search for less polluting solutions. ■

NEWS

TANKERS

CHINA DELIVERS WORLD'S FIRST DUAL-FUEL LNG-POWERED VLCC

Shipping major COSCO has taken delivery of the world's first LNG dual-fuel very large crude carrier (VLCC) from China's Dalian Shipbuilding Industry Company.

Yuan Rui Yang is classed by China Classification Society (CCS) and has a length of 333m, a moulded breadth of 60m and a moulded depth of 30.5m. Using LNG as its main fuel, it is equipped with the dual-fuel engine, power generators and boiler.

In gas mode, the ship's endurance can reach 12,000nm, with a combined endurance for fuel and gas of 24,000nm. It makes the design energy efficiency index (EEDI) approximately 39.3% lower than the baseline value.

The delivery is a significant milestone for CCS and China in developing vessels which cut CO_2 emissions as part of China's green energy drive across the shipping supply and logistics chain and demonstrates how LNG can be used as the main fuel for VLCCs, according to Yang Guang, deputy general manager of CCS Dalian Branch.

YUAN RUI YANG, THE WORLD'S FIRST DUAL-FUEL VLCC

CSS awarded class notations for *Yuan Rui Yang* include Natural Gas Fuel, i-Ship(E) for ship intelligent energy efficiency, Green Ship I and NEC (III) for NOx emission control. The vessel is designed with the C-type storage tanks, which are two 3,500m^3 LNG low-temperature storage tanks with completely independent intellectual property rights obtained for the vessel.

CONTAINER SHIPS

P&O MARITIME LOGISTICS ENTERS CONTAINER CARRYING MARKET

Dubai-based P&O Maritime Logistics, part of DP World, is helping to relieve stretched supply chains with its first-ever container fitting modification to the deck of a multi-carrying vessel (MCV), *Topaz Lena*, with five more vessels to come.

The containerised market entry marks a first for P&O Maritime Logistics and comes off the back of the maritime solutions provider working with customer Unifeeder on providing services on container routes with a low number of containers but a need for a fast turnaround due to logistics limitations.

The modifications will enable P&O Maritime Logistics' MCV fleet to carry 20ft, 40ft and 45ft containers when container capacity is most in need in addition to the original design to transport general and oversized project cargo.

Currently, several MCVs are delivering wind turbine blades, large process modules, reactors, and pressure vessels on short-sea routes and in the open season of the Volga Don Canal.

Martin Helweg, CEO of P&O Maritime Logistics, says: "As global supply chains have been stretched in recent years, we are entering the container carrying market to help provide additional capacity in the lower-volume, higher-frequency routes. With five more vessels slated to enter the containerised market, we'll soon be servicing niche trade lanes stretching from the Americas to Southeast Asia.

"We'll be working closely with our parent company DP World in rolling out of containerised service, beginning with fellow DP World-owned company short-sea feeder service provider, Unifeeder."

MCV *TOPAZ LENA*

DECARBONISATION

WÄRTSILÄ AND SOLSTAD OFFSHORE COLLABORATE ON FLEET DECARBONISATION AMBITIONS

WÄRTSILÄ AND SOLSTAD OFFSHORE WILL COLLABORATE TO IDENTIFY OPPORTUNITIES TO DECARBONISE THE OPERATOR'S FLEET

Solstad Offshore has partnered with technology company Wärtsilä in efforts to reduce the carbon footprint of its 90-vessel fleet.

Solstad Offshore aims to achieve a 50% reduction in CO_2 emissions by 2030 and sees the collaboration as being key to finding the right solutions.

The agreement aims to identify, evaluate, and implement solutions that will increase fuel efficiency and significantly reduce greenhouse gas (GHG) emissions from the company's offshore vessels. Each vessel will be assessed for appropriate solutions, possible operational improvements and life extension considerations.

"Cooperation is essential if we are to implement the solutions needed to succeed with the green shift that is underway. For this reason, we at Solstad are partnering with forward-looking companies such as Wärtsilä who have the expertise, experience and innovative technologies required," says Tor Inge Dale, head of sustainability at Solstad Offshore.

"It is too early to determine which solutions will prove to be the most appropriate for meeting the GHG emission reductions envisioned by Solstad. However, it is extremely likely that future propulsion solutions operating with new alternative fuels, such as ammonia and/or methanol, will be key enablers as these fuels become widely available for bunkering," says Roy Stavland, senior sales manager at Wärtsilä.

Wärtsilä will initially be an advisor and technical expert to Solstad Offshore. The agreement also allows the company to act as a possible supplier for the decarbonisation solutions selected.

NOISE POLLUTION

KR ISSUES UNDERWATER RADIATED NOISE GUIDANCE

Classification society Korean Register (KR) has developed new 'Guidance for Underwater Radiated Noise' to help protect marine ecosystems by reducing noise from ships.

With underwater radiated noise becoming a more serious issue as the size and speed of ships increases to handle high volumes of seaborne trade, IMO's Marine Environment Protection Committee (MEPC) is discussing measures to mitigate this growing challenge. As a result, new regulations are expected shortly which will determine sensitive areas to noise, where ships calling in that area will be required to meet appropriate standards for underwater radiated noise.

In support of this move, KR has developed a class notation for underwater radiated noise and Guidance, which is based on ISO 17208 (International standard of quantities and procedures for description and measurement of underwater sound from ships).

The Guidance covers the noise standard for two operating conditions: normal operation (transit) and quiet operation (quiet).

The class notation is given in the form of 'URN-T(20)', which indicates that when a ship operates at a speed equivalent to 20knots in still water, it meets the transit criteria for underwater radiated noise.

UNDERWATER RADIATED NOISE CAN CAUSE SIGNIFICANT DISRUPTION TO THE MARINE ECOSYSTEM

KR says: "Several countries and ports have already introduced regulations relating to underwater radiated noise, and some ports, such as the Port of Vancouver, are offering discounts on port user fees for vessels that meet the standards. If our customers' vessels have obtained KR's class notation for underwater radiated noise, they will also be able to benefit from these advantages while reducing their impact on the maritime environment."

IN BRIEF

LNG

BHP WELCOMES FIRST OF KIND LNG-FUELLED BULK CARRIER

Australia's BHP Group, the world's largest miner and shipper of dry bulk commodities, has taken delivery of M/V Mt. *Tourmaline*, a first of its kind Newcastlemax LNG-fuelled bulk carrier. The 299m-long, 290,000dwt vessel was built by Eastern Pacific Shipping (EPS) in China and is one of five LNG-fuelled bulk carriers scheduled for delivery to BHP Group in 2022 as part of its efforts to curb supply chain emissions.

AUTONOMOUS SHIPS

ABS PUBLISHES AUTONOMOUS VESSELS WHITEPAPER

Classification society ABS has published a new whitepaper proposing a goal-based framework for future rules to enable autonomous vessel operations. The 'ABS Autonomous Vessels Whitepaper' sets out 10 goals to create a framework for the design and operation of autonomous vessels and addresses key issues in implementation. Also included is an update on the outcome of IMO's Maritime Autonomous Surface Ships (MASS) Regulatory Scoping Exercise, an important step on the road toward the development of requirements governing autonomous operations.

CRUISE SHIPS

WORLD'S LARGEST CRUISE SHIP SETS SAIL

The world's largest cruise ship, Royal Caribbean International's 236,857gt *Wonder of the Seas*, has embarked on its maiden voyage, setting off from Port Everglades, Florida, to the Caribbean on 4 March. Built at France's Chantiers de l'Atlantique with construction starting in 2019, the 362m, 18-deck ship can accommodate 6,988 passengers and 2,300 crew and is the fifth vessel in Royal Caribbean's Oasis class.

ALTERNATIVE FUELS

CMA CGM LAUNCHES GLOBAL BIOFUEL TRIAL

CMA CGM has started biofuel bunkering in Singapore as part of its global trial to scale up the wider adoption of clean energy, with the support of the Maritime and Port Authority of Singapore (MPA).

The French shipping and logistics major's 10,640TEU vessel, *APL Paris*, is the first of the group's vessels on trial to be bunkered with biofuel.

Ship-to-containership biofuel bunkering was conducted alongside simultaneous container loading and discharging operations prior to the vessel's Asia-South America rotation of the Pacific East Coast 2 service.

The six-month global trial will involve up to 32 containerships running on different blends of biofuel to measure CO_2 and NOx emissions in order to obtain a trend analysis, which will be shared with the respective flag administration including MPA. Some of the vessels will be fuelled in Singapore with B24 biofuel, which comprises 24% used cooking oil methyl ester (UCOME) blended with conventional fuels.

Ranging from ship sizes between 2,200 and 10,640TEUs, the vessels on trial will serve several trade lanes including Asia-South America, Asia-Africa, Asia-Oceania, Asia-Mediterranean, North Europe–Oceania and North Europe-North America.

B24 can reduce carbon emissions by 21%. Compatible with modern ship engines, the 'drop-in' fuel can be run on all vessel types without requiring technical, safety or design adjustments, enabling ships to quickly start limiting their emissions, according to CMA CGM.

"With the use of biofuels being assessed over multiple key trade lanes and onboard ships of various sizes, we shall gather a comprehensive data set to verify the biofuel's performance as a marine fuel and gain insights into facilitating a wider adoption of biofuel as a clean fuel," says Stéphane Courquin, CEO of CMA CGM Asia Pacific.

APL PARIS LOADING BIOFUEL IN SINGAPORE. SOURCE: CMA CGM

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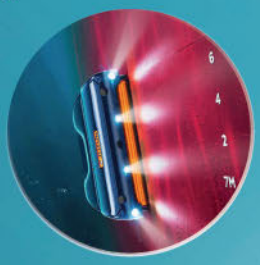

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NEWS ANALYSIS

RUSSIA'S WAR ON UKRAINE BEGINS TO IMPACT SHIPPING

By **Malcolm Latarche**, Correspondent

February could have been the month when car carriers occupied the headlines, not least because of the fire aboard the *Felicity Ace* and the vessel's subsequent sinking with the loss of some 4,000 cars onboard. However, the major news stories which are unfolding are all related to the fallout for shipping from the Russian incursions into Ukraine. This has been bubbling under for several weeks and has already been blamed for energy price rises that have caused problems around the globe.

Crude oil prices were already on their way up before Russian forces advanced into Ukraine on 24 February, since when crude prices have yo-yoed between US$95 and US$106 and the price of gas has also jumped by some 60%. Bunker prices have also risen and what the longer-term impact is likely to be is unclear.

THE BURNING *FELICITY ACE* CAR CARRIER. PRELIMINARY ESTIMATES INDICATE THAT MORE THAN US$550 MILLION WORTH OF VEHICLES WERE ONBOARD. SOURCE: PORTUGUESE NAVY

The rest of the world has mostly condemned the Russian action and applied some of the most stringent economic sanctions seen for a long time. Some institutions and individuals have become the subject of sanctions by the US, the EU and the UK among others. France has detained one Russian-owned vessel – *Baltic Leader* – which is owned (or at least financed) by a subsidiary of Promsvyazbank, one of the sanctioned organisations.

Sanctions banning several Russian banks from the SWIFT international payments network could make transmissions of funds for goods and services related to ships extremely difficult in some cases and likely to take much longer for those that do go ahead. That in turn could have a knock-on effect in ships being allowed to sail or carry out cargo operations if bills and freights have been delayed.

While not directly impacting shipping, both BP and Equinor have taken action to divest their interests in joint operations with Russian organisations. So far, no country has banned the import of Russian oil and gas although there is growing calls for this to happen. Germany however has suspended cooperation with Russia on the Nord Stream 2 pipeline and no gas is coming to Europe from Russia via that route. If there are embargoes imposed on some Russian exports, it can be certain that Russia will offer its products to friendly or neutral countries at prices below market levels and that may help dampen prices from other suppliers.

There have been reports that some merchant ships have been hit by shells or missiles from Russian forces in Ukrainian ports or waters and this may lead to insurers declaring the area a war risk and either refusing cover or requiring extra premiums. Some liner services have suspended calls as a consequence. Other ships have been advised to ensure that AIS signals make clear their intentions in the hope that this can avoid similar incidents.

There are growing calls for Russian-owned and flagged vessels to be prevented from calling at ports, with the UK government announcing on 1 March that it had become the first nation to pass a law involving a total ban of all ships with any Russian connection whatsoever from entering British ports. The impact on ports from such a ban could be significant. As an example, outside of the UK, some 15% of the transhipment in Rotterdam is Russia-related with 20% of coal handled coming from Russia, 20% of oil products, 25% of LNG and 30% of crude oil.

Even the threat of sanctions on ships could deter charterers from fixing such vessels. There will be an inevitable impact on chartering and freight rates as cargo interests seek to source alternatives for oil and gas exports from Russia and grain from Ukraine, probably increasing the tonne/miles involved and thereby hiking freights. Cruise lines appear to be suspending calls to Russian ports including ports such as St Petersburg well outside the conflict zone.

At the time of writing, diplomatic channels are still open and it could be that some small chance remains for a resolution, but it is difficult to even imagine what that could be short of Ukraine ceding territory and giving an undertaking to limit its aspirations for links with the EU and NATO. ■

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NEWS EQUIPMENT

LNG

WÄRTSILÄ SOLUTIONS FOR POLAND'S FIRST LNG-FUELLED ROPAX VESSELS

Wärtsilä has been contracted by Remontowa shipyard in Poland to supply engines, fuel storage and supply systems for three new RoPax vessels, the first LNG-fuelled RoPax vessels to be built for the Polish maritime sector. The ships will be operated by ferry companies Unity Line and Polferries.

Each vessel will operate with four Wärtsilä 31DF dual-fuel engines. The LNG-fuelled engines can use bio-LNG, either on its own or blended with conventional LNG, to further reduce their carbon footprint. The operators intend to run the vessels entirely on bio-LNG by 2025.

Wärtsilä will also deliver its LNGPac fuel storage, supply, and control system.

"High efficiency and sustainability are essential in today's operating environment, especially in the Baltic Sea which is an Emissions Control Area. The Wärtsilä 31 engine represents the latest engine technology available and this, coupled with Wärtsilä's vast experience in LNG solutions, made the choice easy for us," says Grzegorz Wardzyński, technical director of Polsteam, the parent company of Unity Line.

The vessels will have an overall length of 195m and will be capable of carrying 400 passengers, with 4,100 lane metres for vehicles. They will operate between Swinoujscie in Poland and the Swedish ports of Ystad and Trelleborg.

THE NEW ROPAX VESSELS WILL OPERATE ON LNG FUEL WITH WÄRTSILÄ 31DF DUAL-FUEL ENGINES

FUEL CELLS

KOREAN REGISTER SIGNS MOU TO DEVELOP SOLID OXIDE FUEL CELLS

The Korean Register (KR) has signed a memorandum of understanding (MoU) with STX Energy Solutions (STX ES) and Daewoo Shipbuilding & Marine Engineering (DSME) to collaborate on the development of solid oxide fuel cell (SOFC) technologies for ships.

KR says the agreement was signed to facilitate the development of a future power generation system through the sharing and application of technology and research resources to meet the International Maritime Organization's (IMO) increasingly rigorous environmental regulations.

THE MOU SIGNING CEREMONY

SOFC is a new low-carbon, high-efficiency renewable energy power generation facility that produces electricity through the electrochemical reaction of oxygen and hydrocarbons from oxidising LNG. KR notes that technology will be included in ship designs as a power generation facility and is being evaluated as means to reduce greenhouse gases.

"Under the MoU agreement, each company plans to apply their expertise and strengths, for example by enacting and revising the technical standards to fit SOFC on ships, and by deriving and performing joint research tasks," KR says.

STX ES will be in charge of developing and supplying SOFC systems for ships while DSME will manage the onshore testing and evaluation of SOFC systems for ships as well as the SOFC ship application concept research and demonstration project planning and execution.

"The aim of the three companies' joint cooperation is to successfully standardise the technology and thereby commercialise SOFCs for ships, allowing the technology to be applied to different types of ships in the future," says KR.

ENGINES

MAN PRIMESERV RETROFITS SCR SYSTEM FOR GERMAN CRUISE SHIP

MAN Energy Solutions' after-sales division MAN PrimeServ has completed the retrofitting of dual SCR systems aboard the cruise ship *Amadea*, operated by Germany's Phoenix Reisen GmbH and managed by BSM Cruise Services.

The retrofit developed by MAN PrimeServ integrated an SCR system into both of the *Amadea*'s four-stroke MAN 7L58/64 propulsion-engines to ensure optimal performance.

The work reflects Phoenix Reisen's desire to enhance its environmental friendliness and, more immediately, enables the vessel to meet emission standards in the key Norwegian Heritage Fjord market, according to MAN Energy Solutions.

For the project, MAN PrimeServ prioritised keeping hazardous emissions to a minimum while maintaining engine performance and propulsion efficiency.

Bernd Siebert, head of Retrofits & Upgrades, MAN PrimeServ, says: "This has been an important pilot project for MAN PrimeServ that ultimately proceeded smoothly despite the restrictions imposed by the Covid-19 pandemic. Notably, we also successfully delivered the SCR systems pre-equipped with honeycombs in order to maintain the tight schedule."

Besides some minor technical adjustments post-installation, the required exhaust-gas temperatures for SCR operation and regeneration of the honeycombs in testing was easily reached, according to Siebert.

"We still need to determine the exact urea consumption required to achieve the necessary NOx reduction, but, fortunately, the engines have been more recently equipped with new MAN turbochargers such that safe operation of the SCR systems is guaranteed," he adds.

The project required steel work to free space for installation of the SCR systems and ancillary units; the modular SCR system typically installed aboard newbuildings was not 100% transferable to a retrofit and required some adjustments in the case of the *Amadea*.

SYSTEM INTEGRATION

CEMRE SHIPYARD SELECTS NES TO EQUIP ZERO EMISSION FERRY

Cemre Shipyard in Turkey has awarded Norwegian Electric Systems (NES) a contract to supply the battery and control systems for the zero-emission ferry the shipyard is building for Scandlines.

The company will also act as the system integrator for the ferry's power systems and smart control set-up, taking charge of the complete energy design, electric power and distribution including energy storage system (battery).

Under the contract, NES will supply the ESS (energy storage system) pack, DC switchboard, generators and AC switchboards that allow two sailing modes: fully electric and hybrid electric mode (battery and biodiesel for auxiliary engines).

NES will also deliver its Raven integrated navigation system to the vessel, bridge consoles, integrated alarm system (IAS) and a data collection system to monitor vessel equipment performance. The data can be used in predictive maintenance programmes.

Scandlines' new ferry will have a length of 147.4m, breadth of 25.4m, design draught of 5.3m and a capacity of 66 freight units. It will accommodate 140 passengers and will be able to carry trucks on both the upper and lower decks. Expected to commence services in 2024, the ferry will operate the route between Puttgarden, Germany, and Rødby, Denmark.

"This is the largest contract NES has ever been awarded. It will be a high-tech ferry that on completion will sail the world's longest zero emission ferry crossing. We look forward to applying our competence and technologies to help Scandlines towards their zero emission ambitions," says Geir Larsen, managing director of NES.

THE NEW FERRY WILL SAIL THE WORLD'S LONGEST ZERO EMISSION FERRY CROSSING

HELSINKI SHIPYARD DELIVERED EXPEDITION CRUISE SHIP *SH MINERVA* TO SWAN HUNTER LAST YEAR

FINLAND

SKIES START TO CLEAR FOR FINNISH YARDS

By **Kari Reinikainen**, Correspondent

The Finnish shipbuilding sector expects strong demand for icebreakers and sees transition to greener shipping as a driver for innovation and hopefully also for new orders, while it might take some time before orders for major cruise ships are placed.

"The European Union's 'Fit for 55' programme, unveiled by the European Commission in July 2021, is likely to drive the shipping industry's switch to greener fuels, which in turn should mean markedly increased investment in R&D to make these technologies viable," according to Elina Andersson, secretary general at Finnish Marine Industries.

Consequently, the Finnish shipbuilding cluster is looking for funding from initiatives such as Horizon Europe. In addition, the European maritime cluster has also launched Zero Emission Waterborne Transport partnership, which entails about 100 companies in all, she notes.

Meanwhile, 2022 started well for Helsinki Shipyard as it received an order for a large LNG-powered diesel electric icebreaker from Norilsk Nickel, a Russian mining company. In light of current events in Ukraine, the yard is monitoring the situation, but for the time being its operations continue as normal, board member Carl Gustaf Rotkirch tells *TNA*. Helsinki Shipyard is owned by a Cyprus-based holding company in which a Belgian citizen has a stake of 80% and a Russian citizen 20%, according to Rotkirch.

Icebreakers, together with expedition type cruise ships and megayachts, are the kinds of vessels the yard is focusing on (see also p18-20).

Although there are still quite a few ships built in the 1980s on the expedition cruise market, their remaining lifespan is limited: they do not meet the forthcoming environmental rules and it would be too costly to upgrade them. There is every reason to believe that the expedition market will recover after the Covid-19 pandemic and the outlook for new orders in this area is encouraging, believes Rotkirch.

More IT needed onboard

While complex decisions regarding fuels to be used on new ships are an obvious challenge that owners face, the role of information technology (IT) is also growing.

This involves several areas – entertainment and communication, safety, navigation and the monitoring of onboard systems. "This is an area where Finland can do very well: the question is about integrating various onboard systems and it requires high levels of knowledge," Rotkirch says.

The approx. 10,000gt *SH Minerva*, delivered by that Helsinki Shipyard to Swan Hellenic on Cyprus just before Christmas had a price tag of about €135 million, of which various IT systems accounted for about €3 million. Despite the cost, Rotkirch points out that one should remember that the price of these systems is trending lower at the same time as the systems are becoming more powerful.

The Finnish shipbuilding cluster, including suppliers and contractors that also serve shipyards in other countries, have an annual turnover in the region of €9 billion and it employs 30,000 people.

Rotkirch believes that its importance is well understood by the government and a national shipbuilding strategy is under preparation at the Ministry of Economic Affairs and Employment.

"To obtain funding from the EU's Covid recovery package, projects should include sustainability, decarbonisation and IT within an 'ecosystem' meaning involvement from different industry segments. This is not always the case in R&D projects in shipbuilding," he says, adding that this acted as the starting point for the national shipbuilding strategy.

Back to normal after Covid-19 disruptions

The outlook is also positive at Rauma Marine Constructions (RMC), following an order for two 48,000gt ro-pax ferries from TT Line in Australia. These are scheduled for delivery in 2023 and 2024, respectively. In addition, the yard is building three 3,900 displacement tonne corvettes for the Finnish Navy. RMC is also a contender to build some or all of the five projected icebreakers for Finland and Sweden, although neither government has placed an order yet.

The largest shipbuilder in Finland in terms of output is the Meyer Turku shipyard that has focused on cruise ships and has orders from both the Carnival and Royal Caribbean Groups for large, LNG-powered ships.

However, in October 2021 it signed a letter of intent to build offshore patrol vessels for the Finnish government, a considerable departure from its key area of business.

Ideally, the industry should have the design office, steel production and fitting out functions all at a good level of employment and as the delivery dates for some cruise ships have been postponed, such a departure can be used to fill gaps that might otherwise open in the workload.

The Covid-19 pandemic caused quite serious operational challenges in the Finnish shipbuilding industry as the companies utilise large numbers of suppliers and contractors in addition to their own staff.

There were a number of outbreaks at the yards, some of which affected hundreds of people. However, with the pandemic now receding, life is returning to normal and Finnish shipbuilders can start to look to the future from a reasonably comfortable position. ■

RMC RECEIVED A BRACE OF RO-PAX ORDERS FROM AUSTRALIAN OPERATOR TT LINE

STARS REALIGN TO FAVOUR FINNISH SUPPLIERS AND CONTRACTORS

By **Kari Reinikainen**, Correspondent

The fortunes of the suppliers and contractors that form an important part of the Finnish shipbuilding cluster have started to brighten in the aftermath of the Covid-19 pandemic and the recovery is felt in many parts of the cluster.

While all three domestic yards have secured new business in the past 12 months, "there are positive vibes coming from other sources as well," asserts Elina Andersson, secretary general at Finnish Marine Industries.

Naval architects and equipment suppliers alike have been reporting an upturn in enquiries and orders, with the transition to green fuels changing the business landscape for companies such as Deltamarin, the Turku-based consultant naval architect firm.

Considering the many open questions related to the decarbonisation, owners are best served by building ships that can be relatively easily adopted to use other fuels over their lifespan, thinks Kristian Knaapi, sales manager. He references the pure car and truck carriers Deltamarin has designed for Höegh Autoliners in Norway, to be built in China. These will run initially on LNG, but can adapt for methanol later on.

There is a growing demand for solutions like this across all shiptypes – including those such as bulk carriers that have not been traditionally designed in Finland – albeit the focus has been on higher ticket price items, such as cruise ships and ferries.

"These are really exciting times: the Covid-19 pandemic meant that we were all working from home, but we have experienced an exponential increase in enquiries from owners," Knaapi enthuses.

Plethora of options

The plethora of new technologies on the marketplace – and new ones are likely to be introduced as time passes – to make shipping greener means that even an owner planning to contract a dry bulk carrier now has several choices to make to reach his green goals.

In addition to new fuels, owners are also interested in emerging technologies such as wind power and Knaapi says Deltamarin is involved in pilot projects to test a new product in this field – details of which will be disclosed in due course.

Given the transition to greener shipping is only likely to accelerate ordering of newbuildings, the outlook for companies such as Deltamarin seems highly encouraging. Indeed, an ongoing question is the extent to which existing vessels will be retrofitted with green technologies or whether they will be replaced with newbuildings that have such features included from the outset, notes Andersson.

ELINA ANDERSSON

Although the recovery of cruise business has been hampered by the Omicron variant, the sector remains vital for Finnish shipyards and numerous suppliers and contractors. On a positive note, no orders have been cancelled for cruise ships, albeit the delivery schedules for some have been postponed, with downstream implications for the supply chains concerned.

There has been some bad news as well, however. The recent collapse of MV Werften, the German cruise ship builder owned by Genting Hong Kong, which has also become insolvent, has been felt in Finland.

A total of 16 Finnish companies had contracts worth €500 million for the two 208,000gt Global class ships that were planned to be built at MV Werften. The second ship was, however, cancelled before the collapse of the yard and its owner.

Finnvera plc, the Finnish export credit agency, has an exposure of €365 million related to the two ships. The exact amount of risk exposure to the agency remains yet to be determined, says Jussi Haarasilta, EVP Large Corporates at Finnvera.

Startups in digitalisation

While some companies had to make redundancies and lay off staff during the pandemic, people with the right skills find employment in the cluster now, Andersson points out.

Quite a few new companies have also been set up in recent times and many of them are involved in the digitalisation of the shipping business. This again also has links to green technologies and the outlook for the startups that have emerged, and ones that may yet be established, are encouraging.

Many of these businesses also serve other industries and one of the trends Andersson expects to see in the future is a blurring of the lines between shipping and other businesses: technologies that can be used at sea may also be used elsewhere. In addition, onshore developments in areas such as green fuel production could well prove to benefit the maritime industry, she concludes. ■

LEVIS STORE COULD BE THE RIGHT FIT FOR FINNISH SHIPBUILDING

By **Kari Reinikainen**, Correspondent

There are many good reasons to feel good about the state of the Finnish shipbuilding cluster and although the Covid-19 pandemic has hurt the demand for cruise ships, one of the key focus areas of the cluster, it has risen from crises in the past, summarises Vesa Marttinen, senior advisor at MarineCycles, the Finnish consultancy.

"The government supports the cluster and Finnvera is an important enabler," he says, referring to the state-owned report credit agency.

However, there is one field where a gap has opened up in the past. There is nobody in the country at the moment that would act as an innovator on a broad scale in the important passenger ship building sector in general and the cruise ship sector in particular.

"Shipyards see themselves as integrators that put together inputs from various parties and they do not invest a lot in R&D; various suppliers and contractors focus on their particular areas and consultant naval architects that have a lot of competence concentrate on work for which they get paid," Marttinen comments.

The situation is, fortunately, much better in the icebreaker and ice-strengthened tonnage sector that forms the other cornerstone in the Finnish shipbuilding cluster. Here the expertise is concentrated in Helsinki-based Aker Arctic, which has strong industrial owners and in which the Finnish government holds a stake. Consequently, this company is involved in R&D in its area of the industry.

A man called Levis

As far as the passenger shipping sector is concerned, things were different in the past. The R&D team of Wärtsilä published a number of concept designs under its leader Kai Levander – who was locally known by the nickname Levis (without the apostrophe) – in the 1980s and 1990s.

One paper that Levander published in 1982 covered a sail-powered cruise vessel, a top end of the market ship that would today be called cruise yacht, a catamaran cruise ship with a large open courtyard facing the stern and a concept Levander called All Outside Cabin (AOC).

Although all the other concepts in Levander's 1982 paper were built over time, it was AOC that revolutionised cruise shipbuilding.

By placing passenger cabins in the superstructure and most public rooms on the uppermost deck in the hull – a reversal of what had been done before – it was possible to greatly increase the number of balcony cabins. This arrangement, with variations, remains the template for most cruise ships on the drawing board today.

VESA MARTTINEN

Levander continued to publish several concept designs, not all of which were implemented, but the work of him and his team meant that there was a bird's-eye view on passenger ship design. But for several years now, the Finnish shipbuilding cluster has lacked such an approach. "It's the time to set up a new Levis store," Marttinen suggests.

Icebreaker tonnage development in good shape

While the outlook for the Finnish shipbuilding cluster is encouraging in general, there are differences in the business cycle for cruise ships on one side and icebreakers on the other, both being key products of the industry in Finland.

A recent order for a large diesel-electric icebreaker from Norilsk Nickel in Russia that Helsinki Shipyard recently won could be the first one in a number of new orders.

Another Russian company plans to order an even larger icebreaker, while the Finnish and Swedish governments are planning to replace the total of five mid-1970s' built 22,000bhp Urho class icebreakers with newbuildings. The Russian order would go to Helsinki, whereas Rauma Marine Constructions is competing for the Finnish-Swedish order – or at least some of it, says Pentti Kujala, professor of marine technology at Aalto University in Finland.

"Aker Arctic is hiring more staff as there is a lot of activity in their field. They have a lot of competence and they also benefit from icebreaker projects in Canada and the US," Kujala explains. Aker's drawing office designed the 20,000ton displacement vessel that Norilsk Nickel has ordered.

Decarbonisation is a powerful driver for matters in the maritime sector and it is quite possible that this could serve as the starting point for new concept designs. It will probably also mean that there will be a strong demand for newbuildings in the years to come as it

will probably not be economically viable to retrofit all existing ships to meet the environmental requirements that will come up during their planned lifespan.

However, Kujala admits that there is no corresponding developer of new designs of passenger ships for what Aker Arctic is doing in the icebreaker sector. "Aalto (University) has strong foundations when it comes to architecture. However, it is the ship design side that brings its own complications to the picture and one has to look at it from a cross disciplinary point of view," he explains.

Aalto University is aware of the fact that a bird's-eye view of passenger ship design would benefit the Finnish shipbuilding cluster and it is working towards filling the gap that has emerged over the years here. But the picture is rather mixed also outside Finland, Kujala points out.

New concept designs mostly come from international architect companies that work on cruise ship interior design. While they master this area very well, they do not have the expertise in shipbuilding that would be needed to include technical dimensions to their designs. "The competition is intense and there are no architect firms in Finland that would design cruise ships," Kujala says.

At the moment, the Finnish shipbuilding cluster focuses on passenger ships, with both cruise vessels and ferries on the menu, while icebreakers form the second pillar on which the industry stands. Kujala thinks it remains to be seen if the cluster will have to take a more flexible approach to what it focuses on: as the Covid-19 pandemic recedes, the worst for the badly hit cruise sector is over.

Although the immediate impact of the pandemic has been significant, there is every reason to believe that strong demand will gradually build up for cruises, which will eventually lead to demand for new tonnage, he noted.

New generation passengers value different things

Tapio Karvonen, senior lecturer of Maritime Studies at the University of Turku, agrees that innovation would need to continue in the key passenger ship building sector. The cruise industry needs to attract younger people onboard ships and their ideas of what should be available onboard often differs significantly from the ideas of baby boomers, who provided the backbone of the business of the industry when it took off in a large scale in the 1980s and the 1990s.

Work has started on the first unit of Royal Caribbean Group's new Icon class at Meyer Turku but Karvonen observes that almost nothing has been disclosed about what the class will actually offer. "The later you publish any details, the longer it will take your competitors to create their own versions of your innovation," he says.

Marjo Keiramo, who is in charge of R&D at Meyer Turku concurs that younger customers have different ideas of what should be onboard than the middle-aged and older cohorts.

One such element is accommodation: they often travel in groups, but do not necessarily have the money to book a large suite that could accommodate them all. A solution to this could be a communal lounge that can only be accessed by occupiers of rather inexpensive accommodation.

Another sector that will gain momentum in the future will be e.g. spa and retail services as passengers' preferences move away from wining and dining towards more experience-based activities, she adds.

In conclusion, the cruise industry is much more mature now than it was four decades ago, when Levander presented many of his sometimes revolutionary ideas. There are few low-hanging fruit to pick in this respect.

Many of the ships currently on order form part of a long series of vessels based on the same design and

BUILT BY HELSINKI SHIPYARD, P&O'S *ROYAL PRINCESS* (1984) WAS THE FIRST CRUISE SHIP TO THE 'LEVIS' AOC CONCEPT. THE SHIP REMAINS IN SERVICE TODAY, NOW KNOWN AS *ARTANIA*. SOURCE: PJOTR MAHHONIN/ CREATIVE COMMONS

IN JANUARY 2022, NORILSK NICKEL AND HELSINKI SHIPYARD ANNOUNCED PLANS FOR AN ENVIRONMENTALLY FRIENDLY ICEBREAKER, TO BE DESIGNED BY AKER ARCTIC

given the long-term planning that's required, there may be limited opportunities to include major changes to them. However, Karvonen notes that experience from previous units of a class is often used to fine tune later units.

The Covid-19 pandemic has hurt the cruise industry quite badly and it will probably take a few years before new orders start to flow in any significant way. This should give designers time to create new ideas and even new concepts.

Generally speaking, the cruise shipping industry prefers evolution to revolution – a failed design can become a costly mistake indeed. But as the case of AOC showed, from time to time, a successful new concept can revolutionise the industry and to develop these would probably benefit from a new Levis store. ■

REALITY CHECK FOR FUEL CELL USE IN CRUISE SHIP PROPULSION

By **Jan-Erik Räsänen**, chief technology officer, & **Veikko Ahola**, project engineer, Foreship

The IMO's aim to halve marine greenhouse gas emissions by 2050 when compared to 2008 levels looks beyond the reach of even the most energy-efficient combustion engines. Supplementary or replacement ship-propulsion technologies are therefore required, and while battery energy storage systems (BESS) are proving beneficial on short-sea routes and in meeting peak power needs, they alone are not capable of propelling large vessels over long distances.

Against this background, fuel cell technology, which converts hydrogen-rich fuel into electrical and thermal energy by electrochemical oxidation, represents a promising alternative, especially if supported by BESS for peak loads. In the maritime context, the technology takes one of two forms: the polymer electrolyte membrane fuel cell (PEMFC) and the solid oxide fuel cell (SOFC).

The PEMFC is the more mature of the two, offering lower pricing and higher power density than the SOFC. However, using liquid hydrogen (LH) as fuel, a PEM system requires fuel space roughly equivalent to four times that needed for marine gas oil (MGO), and no supporting infrastructure currently exists for bunkering hydrogen. One solution is to use fuel reformers to convert an original fuel such as liquefied natural gas (LNG) or methanol (MeOH) into hydrogen-rich fuel, but for the PEMFC, this requires a sizeable external reformer alongside complex and potentially short-lived water management systems.

In the case of the SOFC, original fuels may be reformed internally. SOFCs are also more efficient at converting hydrogen into electricity, with an electrical efficiency of 60–65% – around 10–20% greater than that of PEMFCs. In addition, the technology's high operating temperature (750°C) makes it possible to increase efficiency further by exploiting waste heat recovery.

For all the benefits of SOFCs, their smaller power density, higher price and slow load-response, start-up and shut-down times are likely to see their use aboard ships restricted in the short to medium term. However, although Foreship sees PEMFCs making a valuable contribution to vessel propulsion in the years ahead, we believe their potential will be most fully realised in shorter transits where onboard fuel storage of pure hydrogen is not an issue.

Fuel cell facts of life

Where larger ships sailing longer distances – namely cruise ships – are concerned, questions remain regarding the suitability of fuel cell technology. Shipowners need to know whether it is feasible to replace internal combustion

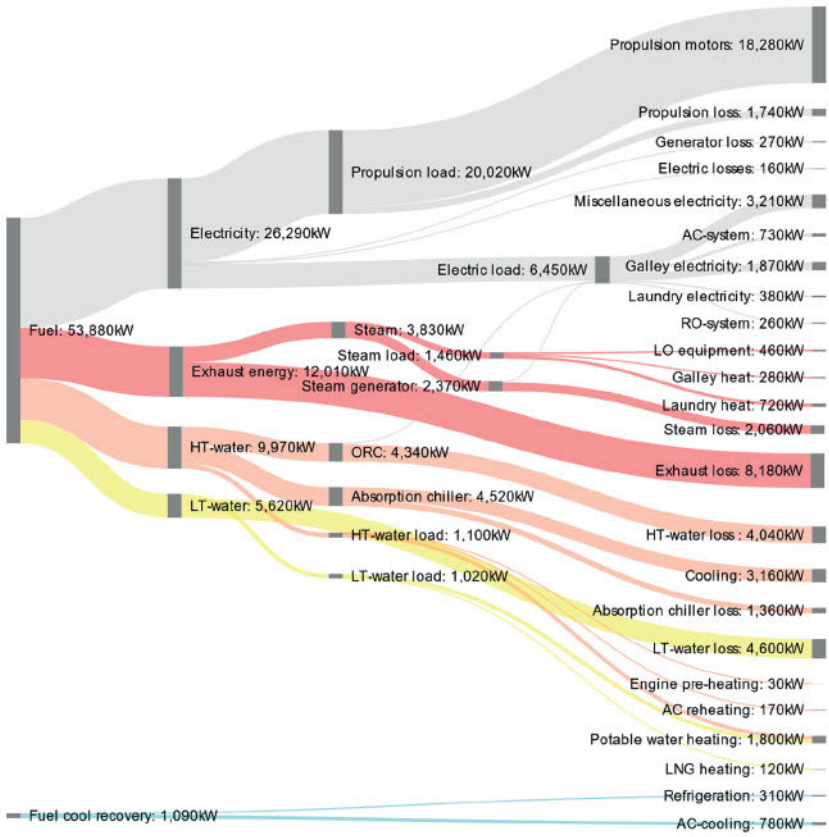


FIG 1: SANKEY DIAGRAM FOR REFERENCE CRUISE SHIP'S ENERGY CONSUMPTION

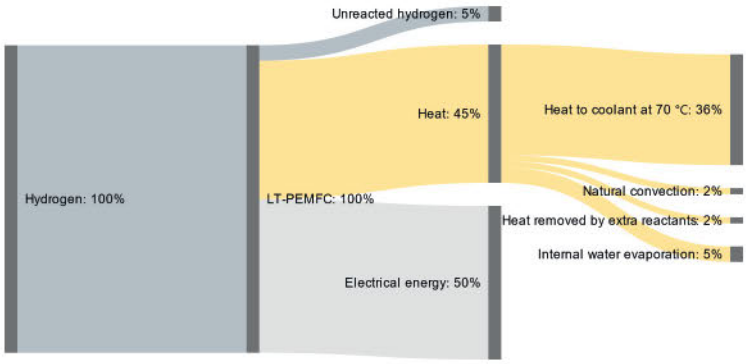


FIG 2: CASE 3 FOR A LOW TEMPERATURE PROTON EXCHANGE MEMBRANE HYDROGEN FUEL

engines (ICE) on a cruise vessel with fuel cells in their current form. They also require insight into the heat and energy balance for a fuel cell-powered ship as well as the space needs of a fuel cell system.

To answer these questions, Foreship used a state-of-the-art reference cruise ship, assessing the impact of three fuel cell solutions – a low-temperature (LT)PEMFC using LH, an LTPEMFC using MeOH and an SOFC/LTPEMFC using LNG – on the vessel's performance.

The reference vessel is a 77,000gt cruise ship with 900 cabins and 12,300m² of public space. It has a total installed engine power of 46,000kW from six LNG-MGO dual-fuel engine-generator sets that deliver all the electricity and heat the ship needs. Propulsion is provided by two 15,000kW electrically driven podded units, and the service speed is 21knots. Furthermore, two auxiliary boilers provide additional steam and heat when the heat production from main-engine waste flows is not sufficient to cover the demand.

According to Foreship's findings, all three fuel cell solutions would offer greater electrical efficiency in this set-up than the ICE. In summary:

- The LNG+SOFC/LTPEMFC solution (Case 3) is the most efficient, at 52% (2% more efficient than its PEMFC counterparts and 11% more efficient than the ICE).
- Case 3's required fuel volume capacity is the lowest of the four options in terms of m³ per week (1,119).
- Case 3 also has the lowest heat energy demand of the three fuel cell solutions, at 447,480MJ. Its total energy demand is the second lowest.
- Case 3 is the second lowest in terms of tonnes/week, behind Case 1 (LH+LTPEMFC) consuming 471m³ compared to 177m³ for Case 1).
- Case 1 has the lowest overall energy demand, at 21,340,348MJ, and while its required fuel volume capacity is the highest in terms of m³/w (2,496), it is the lowest in terms of t/w.
- Case 1 is also the most environmentally friendly of the power production types, being the only solution to cause zero emissions in the form of tank-to-wake carbon dioxide or methane slip.

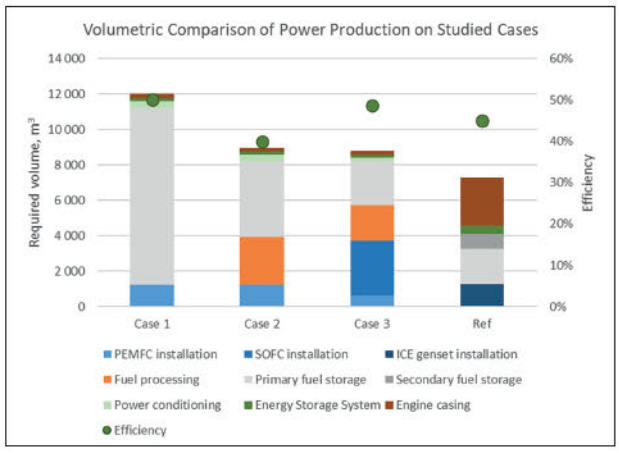


FIG 3: VOLUMETRIC COMPARISON

It should be noted that all values refer to the tank-to-wake process, rather than being based on a well-to-wake evaluation which could take account of the broader impact of renewable energy sources.

Total energy demand realities

However, Case 3 suffers significant reformation losses – 1,792,614MJ – while its steam reformer consumes 860,455MJ. With neither the ICE nor Case 1 requiring reformation, only MeOH+LTPEMFC (Case 2) has higher reformation losses and steam reformer consumption, at 5,195,983MJ and 2,494,076MJ respectively. These figures contribute to a total energy demand for Case 2 of 29,030,407MJ, which is the highest among the four options. In addition, Case 2 has by far the greatest required fuel capacity in terms of t/w and, while it matches the other fuel cell solutions in causing 0 tons per week of methane slip, it emits the most tank-to-wake.

As the least efficient fuel cell option in absolute terms, Case 2 nonetheless offers benefits for ship design. Its ability to use structural fuel tanks in the double bottom instead of large cylindrical pressure vessels saves enough space for 31 extra double occupancy passenger cabins and allows for 12,400m² of public space. In contrast, Cases 1 and 3 would reduce public space to 11,700m².

With several pros and cons to each fuel cell type, deciding which to deploy onboard a cruise vessel requires research and reflection. What is clear is that the conventional ICE will not lead shipping to a more sustainable future in line with IMO targets – and in this context, fuel cells are well-placed to be among the industry's favoured power production solutions in the coming years. The more shipowners invest in the technology now, the faster it will mature and the more evident its benefits will become.

ECO SHIP TECHNOLOGY

WIND POWER SOLUTIONS TO PROPEL DECARBONISATION EFFORTS

By **Daniel Johnson**

As the shipping industry journeys towards IMO's 2050 decarbonisation targets, much of its focus is on future fuels. But mounting pressure for a rapid reduction in carbon emissions and the imminent implementation of new energy-efficiency standards are driving a growing interest in solutions available today that can help make vessels cleaner and greener in the near-term, one of which is wind-assisted propulsion.

"The momentum in wind propulsion is continuing to grow and there are the early signs that investment, installations and production lines are starting to ramp up," says Gavin Allwright, secretary-general of the International Windship Association (IWSA). "There is significant interest in these technologies to deliver benefits when it comes to EEDI/EEXI calculations and as a clear and increasingly affordable part of the solution for CII."

Recoginising the importance of wind propulsion technology in the push to decarbonise, IMO has granted IWSA full consultative status (see *TNA* Feb 2022, p8). However, Allwright believes there is still a perception gap when it comes to the uptake of wind propulsion. "Currently, we have more large commercial vessels in operation using wind propulsion systems than all zero-emission fuel options combined," he explains. Allwright expects to see a doubling of installations on large vessels by the end of 2022.

Kite takes to the skies

Kites, rotors and rigid sails are amongst the wind-powered solutions, and the start of 2022 has seen a burst of activity in this emerging sector. Following formal approval from Bureau Veritas to begin operations at sea, France-based Airseas' automated kite Seawing has embarked on its first transatlantic voyage. The parafoil, which can be deployed, operated and stored at the push of a button, flies at an altitude of around 300m, capturing the strength of the wind to propel the vessel. The system has been installed on the ro-ro ship *Ville de Bordeaux*, which will deploy a half-size 500m² Seawing on its journeys transporting aircraft components between France and the US, conducting six months of sea trials and testing. Airseas estimates that the system will enable an average 20% reduction in fuel consumption and greenhouse gas (GHG) emissions.

M/V *COPENHAGEN* HAS BEEN SAILING WITH A NORSEPOWER ROTOR SAIL INSTALLED SINCE 2020. SOURCE: SCANDLINES

Rotor sail recognition

Classification society RINa has granted Finland's Norsepower Approval in Principle (AiP) for its rotor sail technology solution. The sail is a modernised version of the Flettner rotor – a spinning cylinder that uses the Magnus effect to harness wind energy to propel a ship, allowing the main engine to be throttled back to improve fuel efficiency and to obtain a reduction of GHG emissions. According to Norsepower, the current savings that can be achieved with rotor sail installation range between 5-25%.

The technology will be installed on Scandlines' hybrid ferry M/V *Berlin* later this year, following its successful installation on sister ferry M/V *Copenhagen* in 2020, and a year of demonstrated results.

Hard sail system ready

Mitsui OSK Lines (MOL) and Oshima Shipbuilding in Japan have announced the completion of a hard sail system jointly developed under the 'Wind Challenger' project. MOL estimates the additional propulsion power will reduce a vessel's GHG emissions by 5-8%. The system will be installed on a bulk carrier currently under construction at Oshima Shipbuilding and slated for delivery this autumn.

Also starting the year with the wind in its sails is Michelin's WISAMO project, which is centred on an automated, telescopic, inflatable wing sail system. The French tire maker has partnered with Compagnie Maritime Nantaise to test the system on a merchant ship for the first time – a prototype with a surface area of 100m² is to be installed on Compagnie Maritime Nantaise's ro-ro cargo vessel *MN Pélican* in the second half of 2022. Chartered by Brittany Ferries, the ship makes two weekly rotations between Poole in the UK and Bilbao in Spain and Michelin says WISAMO could help save up to 20% in fuel consumption.

"As we enter the crucial 2022/23 period, wind propulsion may not be making as many waves as alternative fuels, but the outlook is bright with a stiffening breeze," says Allwright. ■

SPOTLIGHT ON SUSTAINABLE FUTURE-PROOF SOLUTIONS

By **Vincenzo Severino**, technical sales engineer, Anemoi

VLOC WITH FOLDING SYSTEM IN PORT (CLOSE UP)

Late last year, amid a backdrop of increased media coverage about the climate emergency, the International Chamber of Shipping (ICS) unveiled plans to the International Maritime Organization (IMO). The ambitious blueprint detailed urgent measures they believed governments had to take to help the industry achieve net zero CO_2 emissions by 2050.

In the submission, shipping accepted the vital need to accelerate decarbonisation timelines. However, it stated that a net-zero target by 2050 will only be plausible if governments and stakeholders take the necessary actions. Anemoi, an award-winning provider of proven wind technology, believes installing rotor sails as retrofit or newbuild could be part of the ideal solution for the maritime community as it looks to reduce carbon emissions and costs.

Rotor sails, originally known as Flettner rotors, were first installed on a vessel over 100 years ago. But through careful research and innovation, they have been successfully reimagined by Anemoi engineers for modern use.

Rotor sails make use of the aerodynamic phenomenon known as the 'Magnus effect'. As the cylinder rotates within an airflow, a forward thrust force perpendicular to the apparent wind direction is created, which delivers additional thrust to the vessel. The thrust generated can either provide additional vessel speed or maintain vessel speed by reducing power from the main engine. The tall cylindrical sails can be installed on the main deck, bow or elsewhere with sufficient space.

Four key data sets

Anemoi has developed a Fuel Saving Assessment Model (FSAM) to accurately predict fuel and emissions savings from various sizes and classes of vessel. Central to FSAM are four key data sets which are: rotor sail performance data (harvested from Anemoi's full-scale UK test facility), vessel performance data, route data and wind data. FSAM utilises this data to simulate thousands of historic voyages over a five-year period to ensure the results accurately reflect the wind conditions experienced on the chosen route. Any additional drag and increased generator usage are also included so that the net results are fair and transparent.

For a 310,000dwt VLCC trading the Bonny-Ningbo route and fitted with six rotor sails, FSAM predicts an annual fuel and emission saving of 15.8% which equates to 1,903tonnes of fuel and 5,918tonnes of carbon saved each year.

Savings attributed to an 210,000dwt Newcastlemax bulker with four rotor sails plying a Qingdao-

Tubarao route could save up to 14.6% on fuel and emissions, which equates to 1,307tonnes of fuel and 4,065tonnes of carbon saved each year. In turn, this reduces the Energy Efficiency Existing Ship Index [EEXI] score by 19.64%.

Simplicity in mind

Installing Anemoi technology can be an uncomplicated process because wholesale changes to the vessel structure, or dry docking, is not necessary. Rotor sails and all associated equipment are delivered to the dockside, ready for installation. Our specialist and highly trained team then supervise the full equipment installation. Each rotor is installed in a single crane lift and connected to the foundation on the ship's deck once the vessel integration work is complete.

Prior to this taking place, a feasibility study – which is unique to each vessel – will have been conducted to determine the optimal rotor sail positioning. This is to maximise performance within the vessel constraints and the required deployment system for the vessel.

The vessel integration stage is crucial to the process and we constantly support clients at every stage, including the design and installation of the structural foundations and the electrical cabling from the vessel main switchboard to each rotor sail. The vessel integration can be completed during the construction phase of a newbuild vessel, or during a survey at a shipyard for a retrofit vessel. Once the rotor sails are installed and all cables are connected, we complete final commissioning of the system prior to handover. This crucial stage ensures safe operation and compliance with Class requirements through rigorous testing.

Future-proof

Shipowners already have to carefully consider the options currently available to achieve compliance. Debate still surrounds the realistic timeline, availability and eco nature of alternative fuels. As a result, many shipowners are ready to take the plunge and install wind technologies.

Anemoi confidently believe rotor sails as retrofit or newbuild could be the ideal answer for vessel owners across an array of segments as the world increasingly turns to sustainable solutions. ■

BULK CARRIER M/V *AFROSBECAME* THE FIRST VESSEL TO BE EQUIPPED WITH ANEMOI ROTOR SAILS IN 2018

SAFE STORAGE OF NEW FUELS REQUIRES CLEAR GUIDANCE ON GAS CARGO/FUEL TANKS

By **Dr Bo Wang**, ABS

New fuels are set to play an important role in reducing shipping's contribution to greenhouse gas production, but as these new energy sources are considered, it is important to maintain a focus on safety. Designers, owners and manufacturers must ensure that the chosen containment systems specified meet all applicable standards for new fuels.

The potential to use independent Type C liquefied gas cargo tanks to carry ammonia and hydrogen in a liquid state is seen as a promising solution for transporting these fuels. For example, vacuum-insulated Type C tanks with double shells can contribute flexibility in fuel choices with the most popular design for gas fuel containment.

With cleaner energy demand increasing, there has already been a commensurate increase in the demand for gas carriers capable of carrying LNG, LPG and liquefied ethane gas. Market demand has been strong for small and medium sized gas carriers and bunker barges in both short/medium distance trades.

Growing fuel demand has been met with independent Type C tanks; typically in a cylindrical or bi-lobe configuration, each with two end saddle supports for gas carriers. On gas-fuelled ships, vacuum-insulated Type C gas fuel tanks with double shells are the most popular design for the gas fuel containment system.

One end is fixed (all degrees of freedom are restrained) and the other end is designed to be able to slide in a longitudinal direction to compensate for the effect of thermal contraction/expansion caused by the temperature change of the tanks.

The design of independent Type C liquefied gas cargo tanks must meet the requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). Type C fuel tanks must satisfy the International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code) requirements.

In general, independent Type C tanks – also known as pressure vessels – are designed and built to meet the requirements of recognised pressure vessel standards such as the ASME Boiler and Pressure Vessel Code (BPVC), as well as additional classification society requirements and statutory regulations.

Guidance notes

To support the safety of the energy transition, ABS has developed Guidance Notes to provide procedures for determining design loads on Type C tanks and performing the strength evaluation of the tank and supporting structures.

BO WANG

Liquefied gas cargo/fuel tanks must be designed to sustain all static and dynamic loads such as weight, wave-induced loads and sloshing loads during their service life. This includes liquefied gas cargo tanks on gas carriers, barges or offshore terminals and liquefied gas fuel tanks on gas fuelled ships. The technical approach adopted in these procedures is based on the direct calculation method using the Finite Element (FE) analysis to assess tank and supporting structures subject to static and dynamic loads.

Design load cases including standard, accidental and test load conditions are defined for yielding, buckling and fatigue evaluation. Finally, a strength assessment procedure for different failure modes is provided for tank and supporting structures.

In the ABS Guide for Building and Classing Liquefied Gas Carriers with Independent Tanks (LGC Guide), the procedure for the strength evaluation of hull, tank, and support structures has been developed for gas carriers with independent type gas tanks.

The new Guidance Notes provide a procedure for the structural assessment of Type C independent cargo/fuel tank and supporting structures under static and dynamic loads to supplement the LGC Guide and the ABS Marine Vessel Rules.

The notes consider design load cases including wave-induced high cycle fatigue load and cargo/fuel loading/unloading induced low cycle fatigue load conditions for fatigue assessment. ■

A copy of the Guidance Notes can be downloaded here:

ww2.eagle.org/content/dam/eagle/rules-and-guides/current/design_and_analysis/327_gn_type_C_tanks_2022/type-c-tanks-gn-jan22.pdf

REGULATIONS

CII MAY BECOME A MAJOR DECIDING FACTOR FOR CHARTERING

By **Daniel Johnson**

CII MAY ACT AS A MARKET MEASUREMENT FOR CHARTERERS WHEN CHOOSING THE MOST EFFICIENT VESSELS. SOURCE: KEES TORN/ CREATIVE COMMONS

The requirement to demonstrate operational carbon intensity reduction through the Carbon Intensity Indicator (CII) enters into force alongside the introduction of the Energy Efficiency Existing Ships Index (EEXI) in January 2023 and will have a profound impact on vessel operations in the years ahead, not least the marketability of vessels – CII will effectively provide a means for charterers to rank vessels.

That was one of the take aways from a recent webinar hosted by vessel inspections specialist IDWAL covering the fundamentals around the requirements of CII.

Although not the intended reason behind CII, it is clear that it would be a mistake to disregard the attained grade as a possible requirement for chartering. "The nature of these new regulations means that all emission information for vessels becomes significantly more public, and it's likely the public will have a new or renewed interest in the emissions that have been produced to receive their goods," stated IDWAL sales executive Ben Thomas. "This will be especially relevant for stock listed companies who have significant environmental commitments and just as important for smaller vessel owners and operators whose stakeholders require greener and faster transit."

What is CII?

Whereas EEXI is a measure of the energy efficiency of the technology and design of a vessel, CII is a measure of the vessel's operational efficiency, or how efficiently it is being operated based on the amount of fuel consumed in a year. The units of the score are grams of CO_2 per tonne nautical mile ($gCO_2/t.Nm$) and measure the amount of CO_2 created per unit of cargo carried a certain distance. Its basic formula is:

$$CII = \frac{\text{Annual } CO_2 \text{ mass}}{\text{Distance x DWT}}$$

CII will assign all vessels above 5,000gt a performance band between A and E. As well as being the likely beneficiaries of positive green investment, ships in the higher performing bands of A and B may receive some

TABLE 1. HOW CAN THE CII BE CHANGED. SOURCE: IDWAL

Measure	Cost	Potential commercial impact	Effect on CII
Slowing down	Low	High	High
Change fuel type	High	Low	Medium
Fuel measurement	High	Medium	Low
Social measures	Low	Low	Very Low
Engine room power management	Low	Low	Medium

incentives, such as reduced port fees. Band C represents the Required Annual Operational CII, and is essentially the acceptable baseline of the regulation. Vessels in the D and E bands will have to show annual improvement so as to move towards band C. Ships that spend three consecutive years in band D, or one year in band E, will be subject to a mandatory plan of corrective actions that must be made to achieve the Required Annual Operational CII.

The goal of IMO is to continually push vessels to keep improving their CII score and therefore reduce their carbon emissions.

IDWAL is currently conducting an analysis of over 3,000 bulk carriers, tankers, container vessels and general cargo vessels. Initial analysis of the bulk carriers shows that on their present trajectory, come next January 33% would sit in bands D or E, 30% would sit in band C and 37% in bands A or B, indicating that more than 30% of bulk carriers will require operational interventions to reduce and improve their CII score by 2023.

Reducing the score

So how can a vessel reduce its CII score? "A major part of CII compliance will be achieved through the reduction of the speed the vessels operate," stated Steffan Henry, head of marine standards and IDWAL technical lead on sustainability initiatives. However, there are a number of issues that companies will be thinking about when they consider slowing their fleet down. Primarily, this will be the reduction in tonne miles that vessels will be able to achieve and as such a reduction in the number of charters that a vessel will be able to undertake.

Other options listed by Henry included: a change to a less polluting fuel type; fuel measurement measures (such as the installation of a fuel mass flow meter to more accurately measure fuel consumption); social energy measures (e.g. turning off lights, reducing the air conditioning or heating, etc.); and engine room power management measures - all of which will have varying impacts on operational costs and the CII score (see Table 1).

Another challenge that ship owners face as they move to modernise their fleets could be current yard availability. "The reality of being able to install new technologies into older tonnage is that they will require major refit which will most likely mean dry docking, or at a minimum time out of the market, and as yard availability declines the price to modernise will significantly increase," according to Thomas.

Regardless of the approach taken to comply with CII, the threat of potential sanctions, stakeholder pressure to be more sustainable and reputational damage for non-compliance are reasons to take it seriously. ■

The IDWAL webinar 'What is CII?' is available to watch at https://www.youtube.com/watch?v=mRW8tqIp4z0

ENGINES

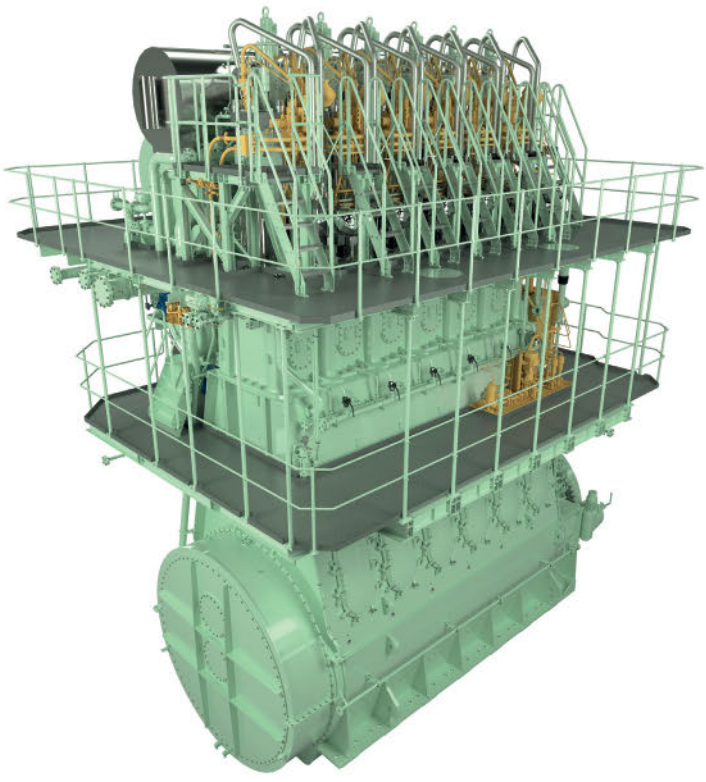
MAN'S METHANOL ADDITION

By **David Tinsley**, Correspondent

Choice of deep-sea vessel propulsion machinery capable of primary operation on methanol has recently been extended by the addition of an 800mm-bore model to the ME-LGIM two-stroke series, developed and licensed by MAN Energy Solutions.

Designated the G80ME-C10.5-LGIM, the engine is of dual-fuel type, and has been released in six-, seven-, eight, and nine-cylinder configurations. The addition to the range is a response to rising interest, especially among the container ship community, in pragmatic methods of reducing the industry's carbon footprint as well as curbing noxious emissions. While mid-size boxships constitute a key target sector, the methanol-capable engine is suited to other vessel types, such as VLCCs and very large ore carriers (VLOCs). The immediate market reach is all the greater for the fact that LGIM technology can be retrofitted to existing G80ME-C installations.

In its 10.5 iteration, the G80ME-C class of super-long-stroke covers applications across the 17,160-42,390kW output band at rating points from 58 to 72rpm.



SIX-CYLINDER METHANOL DUAL-FUEL ENGINE OF THE G50ME-C-LGIM SERIES DEVELOPED BY MAN ENERGY SOLUTIONS AND FITTED IN A FLEET OF CHEMICAL/OIL PRODUCT CARRIERS

Utilising the diesel principle ensures the methanol-burning engine yields the same power and efficiency as the ME-C fuel oil engine. Moreover, power output is not affected by ambient conditions and is only slightly sensitive to the quality of methanol bunkered.

Although operation on methanol needs a pilot fuel, be it HFO, MDO or MGO, as an ignition enhancer, LGIM engine running on fossil fuel (natural gas)-based methanol can reduce CO_2 emissions by more than 10% compared to HFO, virtually eliminate SOx, and give a 30%-plus lower level of NOx. The only particulate matter (PM) emissions generated by methanol dual-fuel plant emanate from the use of pilot fuel, and are consequently minor. To ensure compliance with IMO Tier III NOx criteria in all operating modes, proprietary exhaust gas recirculation (EGR) technology is available.

Viable pathway

When derived from renewable energy sources, methanol offers a pathway to meeting the IMO's decarbonisation goals without further investment or compatibility issues using the current dual-fuel engine technology. To achieve fully CO_2-neutral operation, the pilot oil could feasibly be any renewable hydrocarbon fuel, such as biofuel or Power-to-X diesel.

The smallest engine in the new G80ME-C10.5-LGIM series, the six-cylinder model, can be ordered with reduced or external moment compensation, depending on rating and ship dynamics, if resonance is considered to be a potential issue. The inertia forces on engines with more than six cylinders tend to neutralise themselves.

LGIM dual-fuel technology was initially introduced at the 500mm-bore size, by way of the S50ME-C9.6 and G50ME-C9.6 types, and was ordered for a new generation of chemical/product tankers used by a major player in the global methanol trade, Waterfront Shipping of Canada. The scope for methanol-fuelled primary power was augmented last year with the release of LGIM versions of the most potent engine in MAN's low-speed, two-stroke programme, the 950mm-bore G95ME-C10.5 design. In its 12-cylinder layout, the engine has a nominal maximum rating of 82,400kW.

The development of the methanol version of the G95 type was quickly endorsed by A.P.Moller-Maersk for eight 16,000TEU boxship newbuilds contracted at Hyundai Heavy Industries. Each vessel has been specified with an eight-cylinder G95ME-C10.5-LGIM installation, which the shipowner intends to run primarily on methanol. The order came just one month

NYK BULKSHIPS' *SEYMOUR SUN*, A RECENT DELIVERY IN THE SERIES OF 49,999DWT METHANOL DUAL-FUEL POWERED TANKERS DEPLOYED BY WATERFRONT SHIPPING

after the Danish group had nominated a six-cylinder, G50ME-C.LGIM engine for a 2,100TEU container vessel booked with Hyundai Mipo Dockyard.

In the further evolution of the LGIM type, the company launched the ME-LGIM-W variant encapsulating a methanol-and-water blending concept. The addition of water to methanol lowers the combustion temperature and thereby the formation of NOx. The economic benefit of complying with Tier III NOx emission levels by adding water to the fuel arises from dispensation with the need for EGR or SCR. Using methanol as the main fuel, it is possible to bring NOx down to the Tier III ceiling by running on a mixture containing 25-40% water, depending on engine load, plus 5% pilot diesel oil to ensure stable ignition and combustion.

Burgeoning orders

At the time of the announcement of the G80ME-C10.5-LGIM model towards the end of December 2021, the company reported that LGIM sales had reached 55, with 110,000 service hours having accumulated running on methanol in 14 of the product tankers with 500mm-bore engines.

Shipowning companies which have nominated ME-LGIM engines for chemical/product carriers include leading lights such as Mitsui OSK Lines, NYK Line, Westfal-Larsen, Marinvest and Stena Bulk, with Vancouver-based Waterfront Shipping playing the central role as charterer and part-owner. Waterfront is a subsidiary of Methanex Corporation, the world's largest methanol producer. It has to date committed to methanol dual-fuel power in 19 tankers, each of just under 50,000dwt.

The initial series of seven vessels, built by Minaminippon Shipbuilding and Hyundai Mipo Dockyard (HMD), entered service in 2016, and was followed by a further quartet out of HMD in 2019. The second programme of eight tankers, also entrusted to the South Korean yard, was opened in 2021 by the delivery of two vessels, joined at the beginning of 2022 by a third ship, *Seymour Sun*. The five remaining newbuilds are set to be commissioned during 2022 and 2023.

The latest series of tankers has been specified with the engine in its ME-LGIM-W version. Although the water-in-fuel solution introduces the requirement for a water tank, there are evidently no miscibility issues concerning methanol and water, obviating the need for a separate, surfactant reservoir.

The engine type, the Tier III 6G50ME-C.9.6-LGIM-W, has also been nominated for six 49,900dwt medium-range tankers booked by European interests at Guangzhou Shipyard International for service entry during 2022 and 2023. The initial trio, led by the *Stena Pro Patria*, is to the account of a joint venture of Stena Bulk and Swiss-headquartered Proman, while the second batch of three ships has been ordered exclusively by energy company Proman, the world's second largest methanol producer.

Methanol is mainly produced from natural gas, and has been used for decades as a base chemical in many industries, such that there is widespread familiarity with its properties, storage and handling procedures, and an established supply infrastructure. It can be handled and transported under normal temperatures and pressures. Methanol is a clear, colourless liquid that quickly dissolves in water and biodegrades rapidly. The environmental effects of a large methanol spill would be very much lower than those from an equivalent oil spill.

Methanol's specific energy factor of 19,700kJ/kg is much lower than that of LNG and conventional liquid fuels. For the same energy content, it requires about two and a half times greater storage volume than conventional fuels.

Mixing methanols

MAN's ME-LGIM engine family offers scope for 'green' methanol to be mixed with more readily available methanol derived from natural gas or residual industry gases. "This means that vessel owners can gradually transition as prices for renewable methane come down and an infrastructure and supply are ready for use, making it safer for companies to invest in methanol engines without the risk of later suffering a fuel shortage," says Kjeld Aabo, MAN Energy Solutions' director of New Technology, Two-stroke Promotion.

Following the enterprise displayed by the tanker sector in opting for a methanol-based powering system, the orders implemented by Maersk provide a lead in the container shipping business. Aabo underscored how important it is that the shipping industry as customers are the ones pushing the development of new technology, affirming that: "Today, shipping companies are in contact with experts and producers in new and green fuels and then come to us technology providers to learn whether it is possible to build efficient engines that can run on these fuels. We're thinking green already, but we need the continued confidence and pressure from the industry to invest in new technology."

MAN Energy Solutions is also engaged in R&D work aimed at augmenting its four-stroke range with methanol-burning versions by 2024. ■

MEDIUM-SPEED GAME CHANGER?

By **David Tinsley**, Correspondent

Determination to keep pushing the envelope in medium-speed reciprocating engine design is exemplified in the development by Anglo Belgian Corporation (ABC) of a new class of power unit promising 'future proofing' through a design that lends itself to adaptation over time.

Fuel flexibility and ease of conversion to future fuels and technologies are pivotal to ABC's Evolve four-stroke engine platform. Citing the pressures induced by the energy transition, uncertain policy reforms and future fuels availability, volatile fuel prices and competing technologies, the company has developed and shaped Evolve to meet the manifold challenges and mitigate the risks faced by shipowners.

Conceived as a long-lasting workhorse, the Evolve generation has assumed first form as the compact 4EL23 model. Targeted in its initially offered, four-cylinder configuration at the widest range of small-ship applications, the 230mm-bore engine covers an output band up to 1,320kW across various speed settings. The power density achieved on a small footprint reflects the producer's experience in supplying machinery for space-constrained vessels such as short-sea cargo vessels, ferries, dredgers and tugs.

THE ABC EVOLVE 4EL23

Independent player

ABC Engines, a European bastion of four-stroke, medium-speed engine production and technology, and an independent player within a sector dominated by larger, more powerful groups, has consistently ploughed back revenues into R&D. Evolve is an innovative but pragmatic issue of a culture of continuous reinvestment. The development complements the firm's work on hydrogen marine engines within its BeHydro venture with compatriot shipowning organisation Compagnie Maritime Belge (CMB).

The 4EL23 offers a choice of ratings, from 749kW at 750rpm, an output which has a bearing on manning levels under certain flag administrations, through to a maximum 1,320kW at 1,200rpm. It has been engineered to facilitate, in a financially viable way, future changes or upgrading in accordance with fuel developments and technological advances.

The cylinder head assembly constitutes an exchangeable power unit, enabling conversion to other fuels or technologies without the necessity for complete engine re-build or replacement. The engine can thereby be readily adapted from operation on diesel or other liquid fuel to dual-fuel or spark-ignited gaseous fuel. The arrangements not only reduce the downtime and complexity associated with conversion or retrofitting, but also facilitate maintenance and overhaul routines.

The engine features a common rail (CR) system, variable valve timing and the Miller cycle, with a micro pilot fuel injection system for future dual-fuel functionality, plus the choice of a pump-line-nozzle (PLN) injection arrangement for liquid fuels. The retention of a PLN option acknowledges the varying wishes and needs of different markets.

So as to ensure IMO Tier III and EU Stage V compliance when running on diesel, until other, alternative fuels

TECHNICAL PARTICULARS					
ABC engine 4EL23 (Bore: 230mm; Stroke: 310mm; Cylinders: 4 in-line)					
Engine speed (rpm)	720	750	900	1,000	1,200
Power, MCR (kW)	749	820	1,000	1,100	1,320
Torque, nominal (kNm)	9,800	10,441	10,609	10,480	10,505

become a viable proposition, the 4EL23 installation incorporates proprietary exhaust aftertreatment system (EATS) technology to virtually eradicate NOx and particle emissions. The modular EATS equipment comprises a diesel particulate filter (DPF) and selective catalytic reduction (SCR) unit with an integrated mixing pipe.

Futuristic appearance

Promotional images depicting ABC's latest product in its optional protective shell accentuate the distinctiveness of the design. The shroud is composed of a number of removable panels that give access to different areas of the engine, and confers a smooth exterior and futuristic look. More importantly, the cover is integral to the Evolve platform's overarching concept of functionality. The shell is intended to protect the crew from injury and the engine from impact damage, reduce heat radiation and suppress noise transmission.

A circular LED (light emitting diode) interface at the top corner of the engine shell on each side provides an instant indication of engine health or status. The LED colour, which changes to provide a warning, can be assigned in accordance with different engine parameters. Furthermore, a slit in the upper mid-section of the cover, at eye level for a member of the engine room personnel standing on the bedplate grating, gives sight of the cylinder tops and fuel lines.

The more conservative client can specify the engine in its naked form, of course. However, the practical advantages offered by incorporating the special shroud and its smooth lines can be expected to arouse interest among others within the shipping community.

Last year, ABC became the first medium-speed engine manufacturer to receive EU Stage V certification, which was gained for its DZC series. Moreover, the proven DZC type has provided the technical basis for the initial DZD hydrogen dual-fuel engines and the nascent hydrogen monofuel(spark-ignited) engines, marketed under the BeHydro brand.

The introductory DZD hydrogen dual-fuel models encompass six- and eight-cylinder in-line and 12- and 16-cylinder vee-form versions spanning an MCR band from 1,000kW to approximately 2,700kW. In the hydrogen DF engine, diesel pilot fuel is used as the ignition source. The envisaged companion series of spark-ignited, hydrogen monofuel variants promise wholesale elimination of CO_2 emissions.

The extension of the product offering overall is complemented by the expansion of factory and workshop premises and manufacturing capacity at Ghent, following investment in new test facilities. ■

SK SHIPPING, WINGD AND LUBMARINE JOIN FORCES ON CYLINDER OIL

By **Serge Dal Farra**, global marketing manager, Lubmarine

Lubricants form a significant proportion of vessel operator expenditure, making the need for cost effective cylinder oils that perform well essential. This is likely to develop further as marine two-stroke cylinder oils will also have to work with future alternative gas and liquid fuels, while still providing their core lubrication, basicity (where needed) and cleaning functions to the piston running components of an engine.

To meet its future emissions goals, South Korean operator SK Shipping chose the dual-fuel X-DF engine manufactured under license for WinGD by Korean specialist HSD for *SK Audace* – the first vessel fitted with the dual-fuel X-DF engine – when it was built in 2017.

The switch to LNG to reduce CO_2 emissions, combined with the advanced X-DF engine capability operating a low-pressure Otto-Cycle combustion system, further reduces NOx emissions without the need for additional emission reduction technologies to achieve Tier III compliance.

To increase environmental performance and help drive further cost savings, SK Shipping required a superior cylinder oil to keep the engine and piston running components free from excess deposit build up to give a high level of engine protection and optimise engine performance, while aiming to reduce cylinder oil feed rates to significantly lower and sustainably safe levels.

Cylinder oils, while burning LNG as fuel (ie. in gas mode), undergo significantly more thermal stress than in liquid fuel mode. Working closely with engineers from SK Shipping and WinGD, Lubmarine trialled its Talusia Universal cylinder oil on the *SK Audace* for over 4,000 hours while operating mostly on LNG.

Lubmarine ran two separate liquid fuel trials including 2,000 hours on ULSFO and 2,000 hours on VLSFO, both on current WinGD X Generation engines, making it one of the most tested cylinder oils currently available on the market.

"What struck us was the level to which Lubmarine wanted to test. They wanted it to be rigorous. We ran three full validations – one on gas and two on different liquid fuels. It's certainly one of the most tested-on lubricants we have seen," says Frank Venter, WinGD's project engineer for tribology fuels and lubricants.

Talusia Universal is, as a result, fully validated and approved for unrestricted use on all these fuel grades. Crucially during the LNG trial, the *SK Audace* operated in a variety of sea and ambient conditions with the engines running almost 24/7. Trials onboard the vessel used two WinGD X-DF engines, allowing for simultaneous, direct comparison between Talusia Universal and another lubricant. Vessel inspections at port and drain-oil analysis samples from the sea trials, were then sent to Lubmarine's laboratory for analysis and interpretation. Findings were shared with all partners to help inform decisions and next steps.

SERGE DAL FARRA

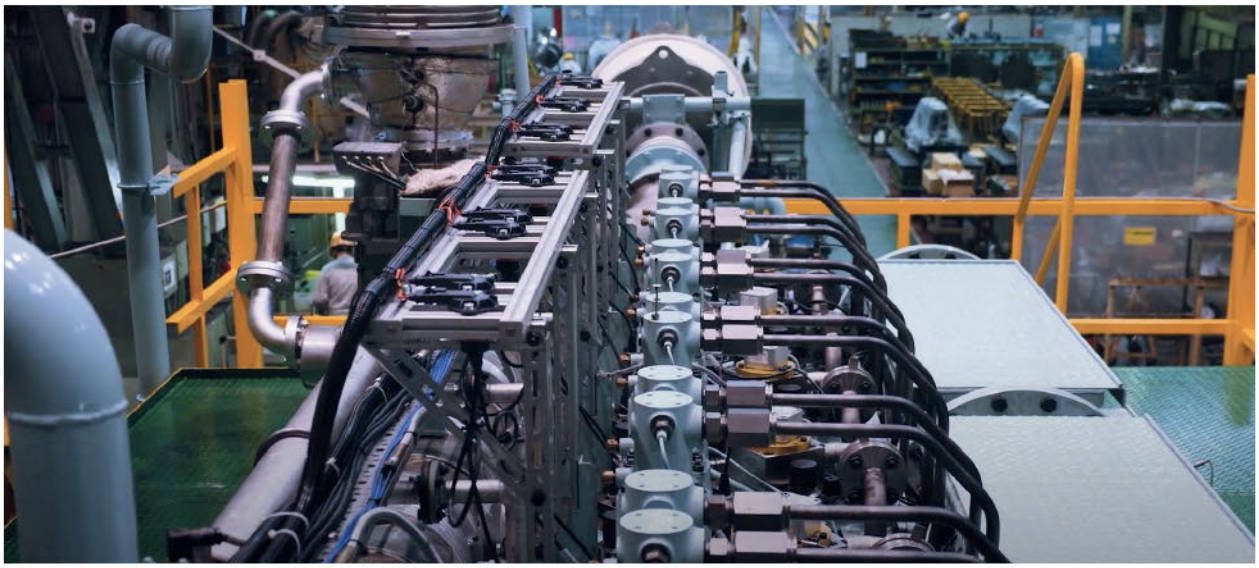
By the end of the *SK Audace* trial, the engine using Talusia Universal was able to operate at a feed rate 20% lower than the second engine running with an alternative lubricant, and with improved cleanliness levels. Talusia Universal showed significantly improved piston and component running performance as a result of greatly reduced, and in places negligible, carbon deposits found on engine components, including the piston and piston rings.

To date, Talusia Universal has proven a commercially viable option and is currently one of just two cylinder lubricants on the market to have passed WinGD's gas mode validation while using LNG as a marine fuel. Talusia Universal is 'DF' dual-fuel validated among other products. SK Shipping is now supplying all of its X-DF engine carriers with Talusia Universal from Lubmarine. ■

SK SHIPPING'S LNG TANKER *SK AUDACE*

GAS OPTION FOR LOW-SPEED, FOUR-STROKES

By **David Tinsley**, Correspondent



THE G30 GAS ENGINE OPENS A NEW CHAPTER FOR HANSHIN DIESEL

Japanese propensity for continuous improvement is exemplified across the maritime industries, with the commercial effectiveness of incremental gains in product performance sharpened by an unerring emphasis on productivity.

The marine engine manufacturing sector, a vital element of the industrial infrastructure, has demonstrated resilience in the face of unremitting regional competition, and one factor behind this is a commitment to a particular concept proven in meeting the domestic and wider markets' expectations as to reliability and economy. That concept is the low-speed, four-stroke trunk piston engine, widely favoured over medium-speed four-stroke and low-speed two-stroke power among Japanese and east Asian operators engaged in coastwise and short-sea trade.

While environmental standard has emerged as the essential and most pressing companion to fuel efficiency and operational performance for engine designers worldwide, a national drive towards a low-emission and an ultimately carbon-neutral future has given fresh impetus to R&D endeavours among the Japanese makers of the low-speed, four-stroke genre. Hanshin Diesel maintains a prolific output of such machinery of in-house design, mainly for applications below 5,000kW, and has now augmented its offering with a gas-only model, based on the low-speed, four-cycle concept.

The G30 engine opens a new chapter for the company embarking on a strategy aligned to pressing environmental goals and the expectations of legislators, business and society.

PRINCIPAL PARTICULARS	
Hanshin G30 gas engine	
Bore	300mm
Stroke	720mm
Cylinders	6
Cycle	4-stroke
Maximum output	1,422kW
Speed	290rpm

Six-cylinder setup

Six-cylinder in-line formats predominate in the low-speed, four-stroke stakes, and such is the G30's configuration. The 300mm cylinder bore relative to a 720mm stroke yields a stroke-to-bore ratio of 2.4, one of the largest worldwide in the trunk piston engine category. The engine achieves a maximum continuous output of 1,422kW at a crankshaft rotation of 290rpm, enabling direct coupling to the propeller.

Utilising the same basic structure as that of the existing family of low-speed, four-stroke diesels, with adaptation to 100% gas operation achieved only by changes to the combustion chamber section, the G30 is claimed by Hanshin to be the world's first gas monofuel reciprocating engine developed according to the low-speed, four-cycle principle. The G30 is a further string to Hanshin's bow in offering IMO Tier III-compliant power solutions. Its previous initiative in this respect had been the development of an SCR system that can be integrated with the LA32 diesel, one of the company's flagship products.

As well as fulfilling the Tier III regulatory standard for NOx and obviating the generation of soot and SOx emissions, the G30 is attributed with high thermal efficiency (TE). While the TE of the engine is higher in IMO Tier II mode than in Tier III, the G30 still attains a higher TE factor than the LA32 diesel when operating in Tier II mode. The G30's rating in this regard is significant from the perspective of one of Hanshin's principal markets, since the Tier III regulation is not applied in the coastal areas of Japan, where Tier II compliance is sufficient.

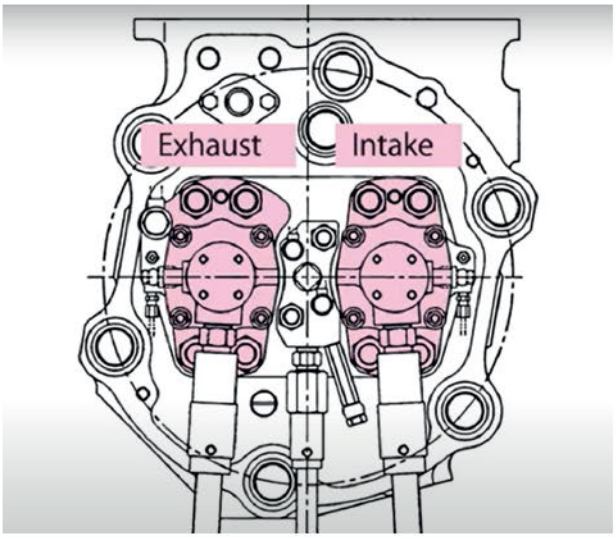
Simple arrangement

Since operators in the low-margin coastal transport sector represent a key market, the G30 has been designed with the aim of keeping acquisition cost to affordable levels. A comparatively simple structure and arrangement has been adopted. Gas is injected from a gas admission valve through a gas nozzle into the air intake passage upstream of the intake valve. Gas is mixed with the intake air before entering the cylinder. Electric ignition is effected by means of spark plugs. Two spark plugs are located in each cylinder to ensure continued firing in the event of failure of one of the plugs.

For stable combustion, both the fuel injection volume and the intake air volume have to be controlled in concert with engine load. Two types of valve are fitted to adjust air intake and achieve the required air/fuel ratio throughout the operating profile, one to bypass the exhaust and another to bypass the intake (supply) air point. Moreover, a supply air throttling valve is provided so as to regulate intake volume under extremely low load conditions. Pressure sensors in the cylinders provide for continuous analysis of combustion pressure in conjunction with ignition timing control.

The fuel is received and stored aboard in LNG form, then piped to an evaporator for conversion into a gaseous state and supply to the engine via a buffer tank.

The G30 is the product of a lengthy development programme conducted by a dedicated project team, and which included two years' work with a single-cylinder prototype and another four years using full-scale engines.



A TWO-VALVE SYSTEM IS USED FOR STABLE COMBUSTION

Besides the 'all-in-one' capability to meet NOx, SOx and particulate matter (PM) emission criteria, the rationale behind the investment in a gas engine included projections of future, greater abundance of natural gas compared to oil, and pointers to a future price advantage. The G30 constitutes the first step in the company's efforts to curtail CO_2. The engine achieves a 25% cut in greenhouse gas (GHG) emissions relative to diesels of comparable power.

Flow challenge

Certain areas of the R&D campaign posed particular challenges. Tests to optimise the air/fuel mixture flow into the chamber were repeated using both single-cylinder and full-scale engines, while tests relating to control during sudden load fluctuations were conducted numerous times during the four years' work with full-scale engines.

Company strategy accords with national objectives, as expressed in the Roadmap to Zero Emission from International Shipping drawn up by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) in collaboration with the maritime industries.

Hanshin's adherence to the low-speed, four-cycle principle in the pursuance of CO_2 reductions reflects operating experience and a certain confidence, albeit not complacency, garnered from having a 41% share of the domestic market.

Proponents of the low-speed, four-stroke concept, which allows direct coupling to the propeller, dispensing with a gearbox, point to its simpler construction and proven high reliability. Relative to a medium-speed, geared installation, lower through-life costs accrue due to a slower speed of the engine itself as well as the absence of interposing transmission, while higher thermal efficiency is obtained because of the longer stroke and larger combustion space. The absence of gearing also influences prime mover efficacy since a 'conventional' medium-speed plant is reckoned to incur a power loss typically of about 4%.

Hanjin recognises that hydrogen, ammonia, e-fuels such as e-methane, and biofuels are being ardently promoted in various quarters as candidates for realisation of decarbonisation goals. However, which fuel or fuels will become mainstream is still not clear, so that a circumspect approach has to be adopted. In the immediate term, up to 2025, the company will continue to aim to exact still higher efficiencies from diesel engines, but with an overlapping medium-term objective, over the period to 2030, of expanding the gas engine line-up. Beyond that, the strategy is directed at achieving carbon-neutral solutions by 2050.

The Hanshin portfolio also embraces the in-house MX series of medium-speed, four-stroke diesels plus small-bore (350mm) models made under licence from MAN. Furthermore, with production from three factories, at Akashi, Tamatsu and Harima, Hanshin has a broader business base than engines alone through its parallel activities as a manufacturer of controllable pitch propellers and side thrusters, shaftlines, engine monitoring and control systems, and purifiers. In the smaller ship ranges, it accordingly ranks as complete propulsion system designer and supplier. ■

THE MAGNETIC TOUCH

By **David Latimer**, CEO, Magnomatics

Electric motors for marine propulsion have traditionally been either synchronous, induction or more recently permanent magnet, and each has its benefits. The synchronous machine provides good efficiency at high powers, but is relatively complex requiring an exciter to create current and thus flux in the rotor of the motor.

Synchronous motors are used in the 22MW Roll-Royce Mermaids on the *Queen Mary 2* and in the larger ABB Azipod drives. Conversely, the induction machine is very simple and tends to translate into lower capital expenditure, but it has a lower efficiency particularly at high powers which brings further issue in terms of cooling the machine. This is critical as excessive temperatures in the winding can damage the insulation systems and reduce motor life.

More recently the benefits of permanent magnet (PM) motors have been appreciated. Rare earth magnets can be seen to provide 'free' flux in the rotor which means very low rotor losses and high efficiencies. In turn this results in very simple machines that are highly compact and maintain efficiency at high speeds. Whilst the capital expenditure of a PM machine may be slightly higher, the operating costs will be substantially lower. This is critical as the operating cost will be around 20 times the cost of buying the motor; a factor often missed when making purchasing decisions.

Shear stress

All electric machines operate by using magnetic flux to create a shear stress in the air gap between rotor and stator. For the mechanical engineer there is a great analogy with a drum brake on a car. The flux is analogous to the friction coefficient of the brake pad materials. The torque is the product of the friction and the area over which it is applied. Similarly, in the motor the shear stress acting on the cylindrical air gap between rotor and stator produces the torque.

So, there is a limit to the shear stress one can create. In a PM machine this is generally limited by two aspects: firstly, the strength of the magnets and secondly, the thermal limits of the stator which in turn limits the current you can inject into the windings. To create more torque (and power) one therefore needs to increase the area over which the shear stress acts. For the cylindrical air gap in our radial flux motors this means more diameter or more length.

Increasing diameter is the obvious way to go as area increases with the square of the radius. It's why one sees the very large direct drive wind turbines having very large diameters (~10m for a 12MW generator) and short length. These large diameters may be accommodated for shaft line propulsion, but they are not appropriate for a pod. If one assumes that pod diameter is restricted then if you want to double the power you have to double the length.

DAVID LATIMER

But building electric machines with very long unsupported rotors is challenging. Even if you can manage that, you will have a long pod with lots of friction drag. The alternative of an axial flux machine is also unsuitable for a pod as here torque increases with the cube of the radius.

Propeller limitations

Marine power brings further challenges in that propeller speeds have to be limited. The other way to increase the power from an electric machine is to increase the speed. Power increases linearly with speed, so twice the speed means twice the power. However, one is then faced with the need to introduce a gearbox to match a high-speed electric motor with a low-speed propeller. Gearboxes introduce losses, a potential source of failure, not to mention the need for maintenance. As a result, the use of a gearbox may be tolerated in a shaft line arrangement where access is good but using a gearbox in a pod is not particularly appealing.

This is where we believe magnetic gears offer a solution. They have already seen extended service driving pumps in oil wells continuously for over two years. The magnetic gear has three principle benefits. It is very efficient. It has no mating surfaces. In fact, it uses the same shear stress in an air gap that we discussed earlier for other electric machines.

Magnetic gears

Extremely compact, magnetic gears are made up of three elements (Figure 1). An outer array of magnets which performs just like a ring gear in a planetary gear.

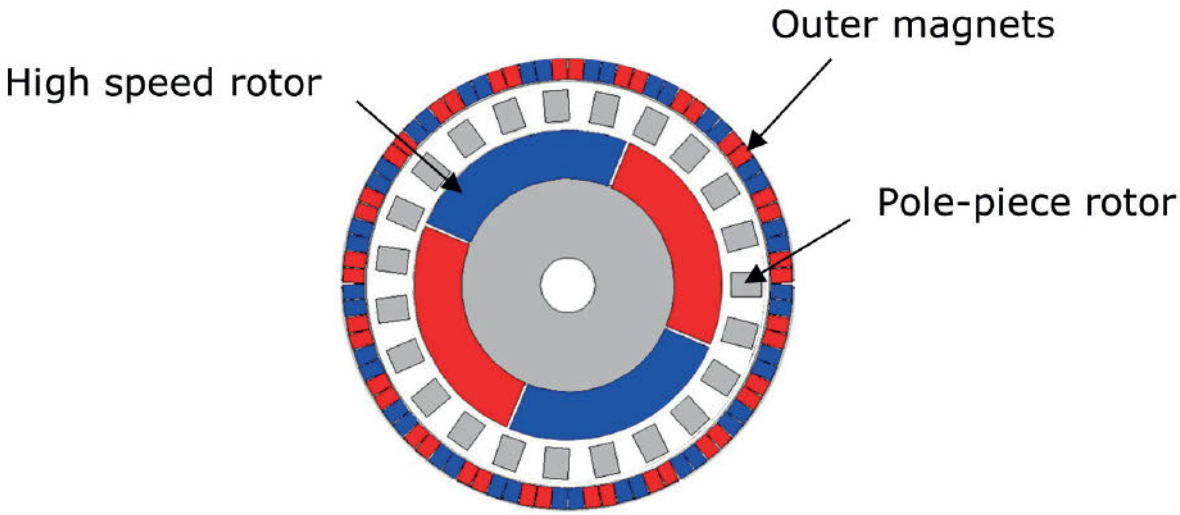


FIG 1

An inner array of magnets which acts just like a sun gear and is the high-speed rotor within the gear. The third element is the pole piece rotor (PPR) which is inserted between the two arrays of magnets. The PPR modulates the flux pattens from the two arrays so that they run synchronously but at different speeds.

The magnetic gear can easily be combined with a conventional stator to form a magnetically geared propulsion motor (Figure 2). This configuration of magnetically gear motor has been developed by Magnomatics and is called the Pseudo Direct Drive (PDD).

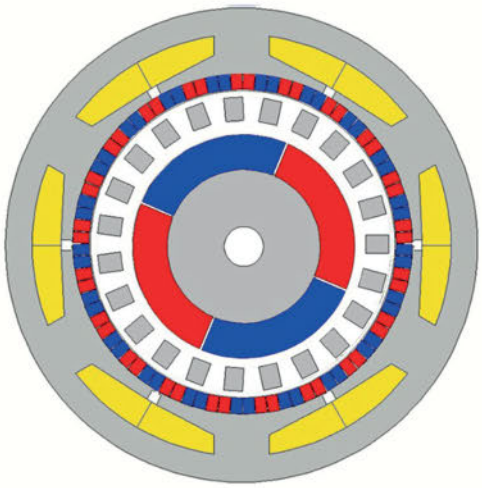


FIG 2

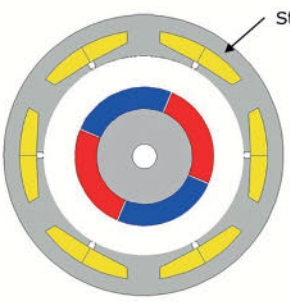


FIG 3

The outer array of magnets is fixed to the bore of the stator. The stator windings drive the inner high speed magnets of the gear controlled by a normal three phase inverter. This is effectively the same as a conventional PM motor but with a large air gap (Figure 3).

This high-speed inner magnet rotor has a dual function as it also forms the inner part of the magnetic gear. Its interaction with the outer array of magnets causes the pole piece rotor to rotate but at a lower speed and with a much higher torque. The magnet to magnet coupling in the outer air gap creates a very high shear stress (>130kPA, double that of a PM motor). The result is a very torque dense motor ideal for low-speed applications. Because these high levels of torque are achieved as a result of the magnetic gear, the stator current remains low, improving efficiency and extending stator life.

Size reduction

Simulations have shown that a PDD will be less than two thirds the size of an equivalent PM motor and half the length of an induction motor. Furthermore, it can be designed to be 2-3% more efficient without compromising the torque density. This makes the PDD ideal for marine pods – reducing operating costs and extending life. The motor itself may be marginally more expensive but remember the cost of operating an electric motor is typically 20x the cost of buying it.

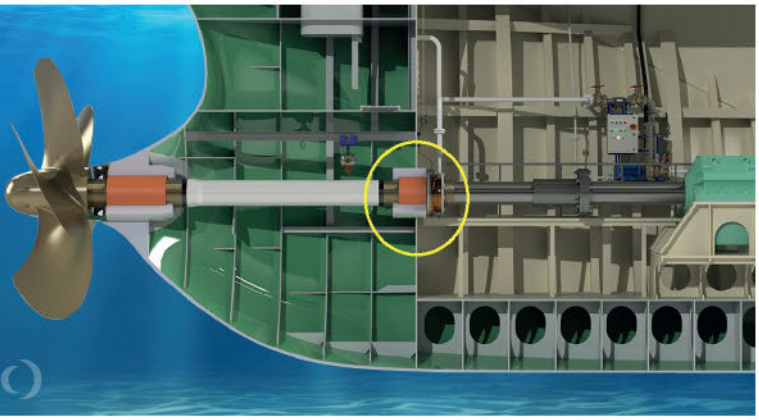
The PDD was invented at the University of Sheffield and is being commercialised by Magnomatics. It has been applied to diverse applications including electro-mechanical flight control surface actuators, traction motors, marine thrusters and for renewable energy. Magnomatics have provided a large global engineering company with exclusive access to the technology for use in offshore wind turbine generators. ■

For more information visit: www.magnomatics.com

SEALS & BEARINGS

SRTP FEATURE ADDS TO THE ECO BENEFITS OF THORDON'S NEW SHAFT SEAL

By **Richard Halfhide**



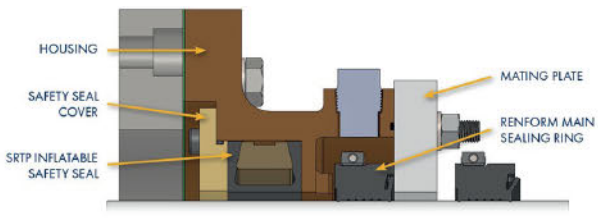
PROPELLER SHAFT ARRANGEMENT WITH THE THORDON BLUEWATER SEAL CIRCLED

Despite being a company with more than a century of history behind it, and a presence in more than 90 countries worldwide, Canadian-headquartered manufacturer Thordon Bearings prides itself both on remaining a family-owned business and its commitment to protecting the environment.

"Our mandate is to protect the environment," asserts Thordon CEO Anna Galoni, the fourth generation of the Thomson family to run the business. "We were the first to come up with the water-lubricated polymer bearings and had a vision of waters free from oil. Oil works, but it leaks and this pollutes our precious waters."

Although the company pioneered polymer alloy bearings in the late 1960s, its real breakthrough came with the development of its COMPAC water-lubricated propeller shaft bearings system and an order from the Royal Canadian Navy in 1992 to furnish a new series of frigates. Since then it has supplied more than 50 navies and coastguards around the world, not to mention finding success with commercial vessels.

It was with commercial shipping in mind that in February 2021 Thordon launched its latest product, the BlueWater Seal, a water-lubricated propeller shaft seal with a unique Safe Return to Port (SRtP) feature. Designed as low-maintenance and robust, the commercial-grade axial lip seal is manufactured from Thordon's proprietary polymer and suitable for vessels with shaft diameters between 300mm to 1,000mm.



CROSS-SECTIONAL VIEW OF THE BLUEWATER SEAL

Mark Fucic, senior project engineer at Thordon, says: "The only parts that rotate with the propeller shaft are the main sealing rings. All the other items are stationary. It's a very simple and effective seal with minimum moving parts and easy to install, operate and maintain.

"During normal operations seawater would be injected directly above the main sealing ring where it would lubricate the sealing lip and mating plate, then travel along the shaft to lubricate the bearings and then travel out back to the sea – hence the term Open COMPAC system. There's no additional seal."

Like any axial lip seal, its primary function is to prevent seawater from leaking into the ship's engine room, but with a couple of distinct differences. The first is its Renform (named after Thordon's chief research engineer, Gary Ren) main seal ring, which allows the facing elements of the seal to operate with almost no friction, making it better equipped for variable draught conditions and offering superior hydrodynamic efficiency.

The second innovation is the SRtP emergency seal; a bladder-like seal that can be inflated or deflated depending on the situation. Fucic explains: "If the main seal is damaged during operations, or worn out, and seawater is leaking excessively into the engine room, the SRtP seal can be inflated with compressed air and it will drastically reduce the amount of leakage and allow the ship to return to port under its own power."

While other rubber seals on the market can only be used as static seals, the SRtP seal has both static and dynamic seals modes. In static mode the shaft would need to be stopped completely, and the shaft inflated, to allow for repairs. The dynamic seal would require a reduction in propeller shaft speed but could continue travelling under its own volition, rather than wait to be towed.

The introduction of the BlueWater Seal means shipowners looking to adopt an open seawater lubricated shaft line arrangement as the entire propeller shaft line system can now source it entirely from Thordon's COMPAC range. With class approval now secured from ABS, LR, DNV, BV and CCS, the company is now offering the solution across the commercial marine sector. ■

TANKERS

FKAB'S HYDROGEN-POWERED MR COULD REFORM TANKERS

By **Richard Halfhide**

Much of the discussion concerning hydrogen as a carbon-free marine fuel has focused on supply chain considerations, but a concept for a medium-range (MR) tanker announced in February proposes to instead use LNG to fuel a gas reformer for the onboard production of hydrogen for propulsion, as well as the capture of CO_2.

Designed by Swedish naval architects FKAB Marine Design the MR Tanker, which has received Approval in Principal (AiP) by Italian classification society RINa, utilises currently viable technology developed by ABB and Helbio (a subsidiary of energy company Metacon AB). The idea is to offer shipowners a pragmatic way of IMO's goals of a 70% reduction in carbon emissions while accepting that a reliance on fossil fuels remains likely for the foreseeable future.

Martin Holmgren, senior structural analysis engineer at FKAB, tells *TNA* that the company became a partner in the project after being approached by RINa about the feasibility of onboard hydrogen reformation. He comments: "We've designed many LNG ships, both fuelled and cargoed, but nothing like this before. I guess nobody has because it's quite a novel concept."

By combining LNG with steam in a Helbio gas former, the LNG's methane molecules are split into hydrogen and CO_2, with hydrogen then being fed directly into the internal combustion engines and fuel cells in ABB's hybrid power system. Unlike conventional combustion however, the CO_2 is captured and stored rather than emitted as exhaust gas.

Holmgren says there are a number of reasons why MR tankers were a good fit for the project, not least that it's where FKAB has found the greatest demand for its services in recent years. "There's also the benefit that you can use the captured CO_2 to inert the tanks, which is an extra benefit that you don't have on dry cargo or pax ships. A tanker also needs a lot of power for unloading; an ordinary MR tanker has both a big propulsion engine and big auxiliaries, but in this case we can combine it so there's a lot less installed total power."

However, he adds that the concept is highly flexible, with the possibility that the LNG and CO_2 tanks could be incorporated within the hull rather than on deck, to improve stability for larger vessels. One major advantage is that the technology is intended to be scalable during the vessel's lifetime, so while the initial order from an owner might incorporate just a single CO_2 tank with the intention of running on 25% hydrogen (and the rest LNG) the decision could be taken later on to retrofit further CO_2 storage at some later date.

THE MR TANKER OFFERS A MEANS OF ACHIEVING 2050 TARGETS WHILE STILL USING FOSSIL FUELS

Although that might exceed a tanker's CO_2 needs for inerting purposes, it's generally anticipated that CO_2 discharging facilities will become available at major ports within the next decade. In other words any vessel built to the design should be future proofed against the rising bar of IMO's Carbon Intensity Index (CII) rating.

FKAB have held preliminary discussions with Wärtsilä as a potential engine supplier for the design. It was previously announced last year that the Finnish company had joined forces with Helbio, ABB and RINa on the project, not to mention its successful demonstration of running gas engines with a hydrogen blend of up to 25%. The fuel cells, which will be supplied by ABB's partner Ballard Power Systems, also raise the possibility of an entirely electrical propulsion system, albeit such a solution is likely to prove cost prohibitive in the short term.

Holmgren says that the initial response to the concept from both old and potential new clients has been highly positive, with meetings already taking place, although it's still too early to say whether that will coalesce into serious interest. In the meantime, FKAB is continuing to research how much potential there may be for energy recovery to further improve the gas reforming.

"Although this process is used on land they don't have all this excess heat of a ship, so we're just looking into how we take a more holistic approach. Theoretically we should be able to achieve lower consumption, but what happens when we put the hydrogen in? Besides all the benefits you might have a cargo that needs heating, for which we currently use a lot of the spare heat. So we have to check all these stages before we can say, but it looks really promising," he concludes. ■

JIANGNAN-BUILT VLEC IS 'BUILT FOR LIFE'

By **George Wang**, China Correspondent

PACIFIC INEOS BELSTAFF: THE WORLD'S LARGEST VLEC

Ethane and its derivative ethylene have become firmly established as a globally traded commodity, with around 200 million tonnes produced globally in 2020. In March last year, the US Energy Information Administration estimated that US ethane exports topped 370,000 barrels per day (bpd), of which 280,000bpd was for waterborne transportation.

So-called Very Large Ethane/Ethylene Carriers (VLECs) have been transporting ethane from the US since the 87,000m³ *Ethane Crystal*, built by Samsung Heavy Industries (SHI), took to the waters in 2016, and hitherto it's been a segment controlled by Korean yards.

However, December 2021 saw delivery of *Pacific Ineos Belstaff* which, at 99,000m³ capacity is not only the world's largest VLEC to date but also the first to be built by China Shipbuilding (CSSC) subsidiary Jiangnan Shipyard (Group) Co. Ltd (Jiangnan).

Pacific Ineos Belstaff is the first in a series of eight Panda gas ships being built by the yard, putting Jiangnan in first place in the current VLECs market share. It is owned by INEOS Shipping & Trading and will be operated by Pacific Gas under charter to the INEOS Group for the transportation of American liquified ethane to an ethylene cracker in Belgium, taking INEOS's current fleet of ethane carriers to 11, including three VLECs. Named after the iconic Belstaff clothing label, which is also owned by INEOS, the ship will also carry the brand's logo 'Built for Life' on its side.

Utilising four IMO Type B in four cargo tanks and two further Type C tanks on deck, the vessel is 230m long, 36.6m wide, and 22.5m deep. Classed with ABS and China Classification Society, the VLEC design meets the latest requirements of IMO, USCG, IGC Code, and other international regulations.

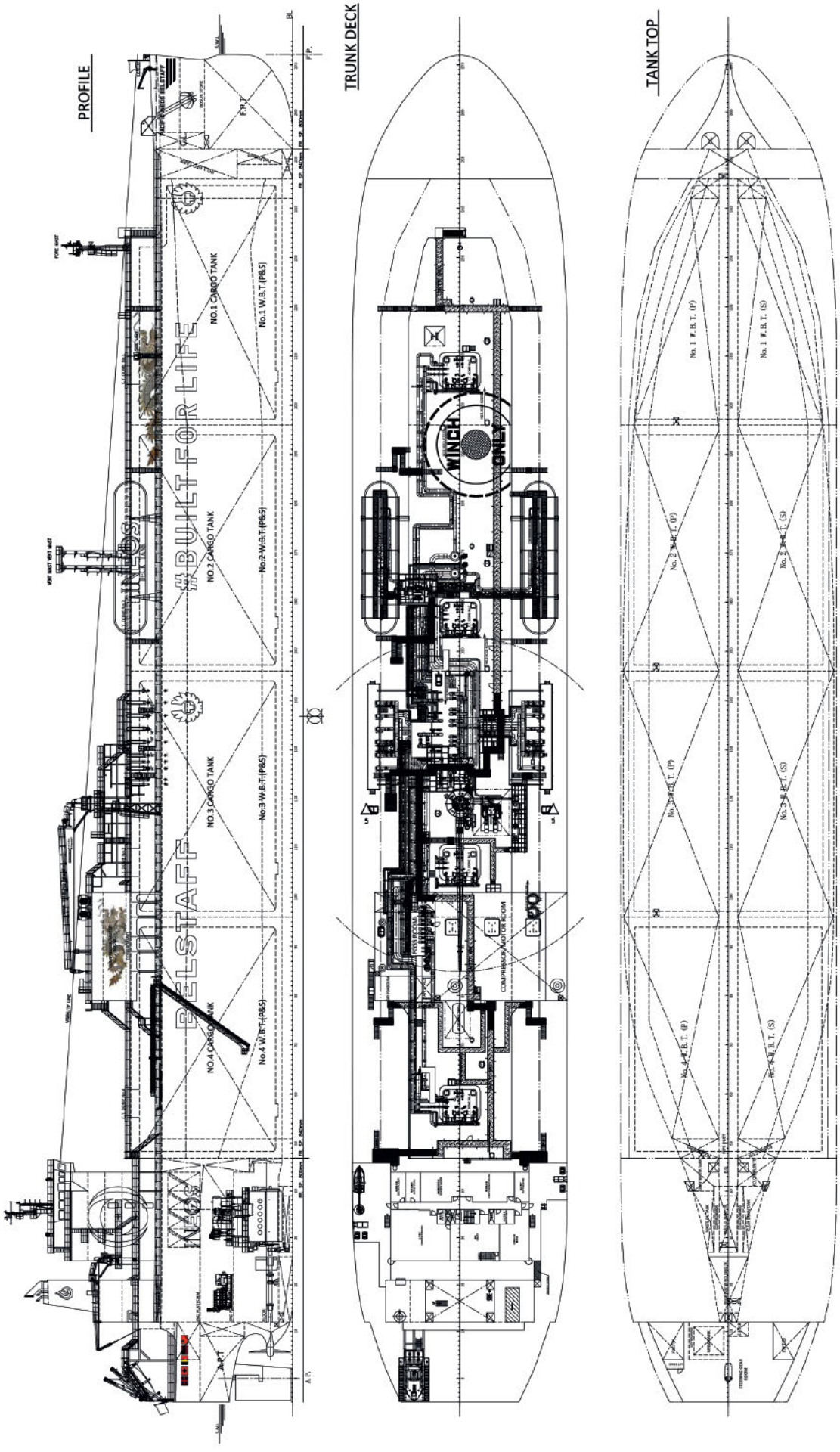
Jiangnan was quick to identify the rapidly emerging opportunities in shale gas commercialisation, and ethylene in particular. As early as 2017, the yard started its independent development of a brand new proprietary IMO Type B tank design, which is now branded as BrilliancE® CCS [cargo containment system]. The 'B' stands for IMO Type B cryogenic tanks and 'E' stands for the carried cargoes, which are ethane at –89°C and ethylene at –104°C.

This novel tank design also takes advantage of Type A's structures and supports, and the mature welding performance because of its 5%-nickel steel. Compared with other existing ethane/ethylene carriers, most of which use GTT's membrane CCS, BrilliancE® CCS is said to be high in safety, high in reliability, low in maintenance costs, and free from sloshing concerns. This new CCS does not have restriction to cargo filling, and is known to have less cargo discharging residuals.

Pacific Ineos Belstaff's 99,000m³ cargo-carrying capacity is the largest for any vessel that can enter the Houston Ship Channel. The two deck cargo/fuel buffer tanks provide some flexibility for carrying LPG or ethylene as alternative fuels. It is powered by MAN's latest ethane duel-fuel GIE engine with an in-line shaft generator, cutting the SOx emission by 99% and CO_2 emissions by 18%.

The vessel has excellent energy efficiency, achieving Phase III of EEDI. This innovative design applies Jiangnan's patents of VS-BOW® (hull form at the bow), CAPRO® (propeller reaction fin), and many other energy-saving technologies. Jiangnan's design team carried out extensive numerical studies using the advanced computational fluid mechanics (CFD) tools; striving for the optimum balances among many competing demands, considering both the laden and ballast conditions, and hull performance in calm and wave conditions. The predicted hull propulsive performance was validated in SSSRI model test basin, and eventually verified by sea trials. ■

PRINCIPAL PARTICULARS	
Shipbuilder	Jiangnan Shipyard (Group) Co., Ltd., China
Vessel's name	*Pacific Ineos Belstaff*
Hull No.	H2624
Owner/Operator	Pacific Gas
Charterer	INEOS
Flag	Hong Kong
IMO number	9901398
Designer	Jiangnan Shipyard (Group) Co., Ltd.
Energy efficiency features	Optimised hull form, V-BOW, fin-CAPRO®
EEDI	Phase III
Model Basin Test	SSSRI, Shanghai
Total number of sister ships on order	7


PROFILE
TRUNK DECK
TANK TOP
BUILT FOR LIFE
BELSTAFF
NO.1 CARGO TANK
No.1 W.B.T.(P&S)
NO.2 CARGO TANK
No.2 W.B.T.(P&S)
NO.3 CARGO TANK
No.3 W.B.T.(P&S)
NO.4 CARGO TANK
No.4 W.B.T.(P&S)
WINCH
ENGINE
COMPRESSOR/MOTOR ROOM
No. 1 W. B. T. (P)
No. 1 W. B. T. (S)
No. 2 W. B. T. (P)
No. 2 W. B. T. (S)
No. 3 W. B. T. (P)
No. 3 W. B. T. (S)
No. 4 W. B. T. (P)
No. 4 W. B. T. (S)

KAWASAKI'S PIONEERING LIQUEFIED HYDROGEN CARRIER FINALLY ENTERS SERVICE

By **Richard Halfhide**

THE SHAPE OF THINGS TO COME: KHI'S *SUISO FRONTIER*

Few countries have embraced hydrogen as the carbon-free solution to its energy needs with quite the same alacrity as Japan, which plans to expand its hydrogen market from around two million tons in 2020 to around 20 million tons by 2050, but as an island nation with immediate limited natural resources, not to mention space, it was faced with a quandary.

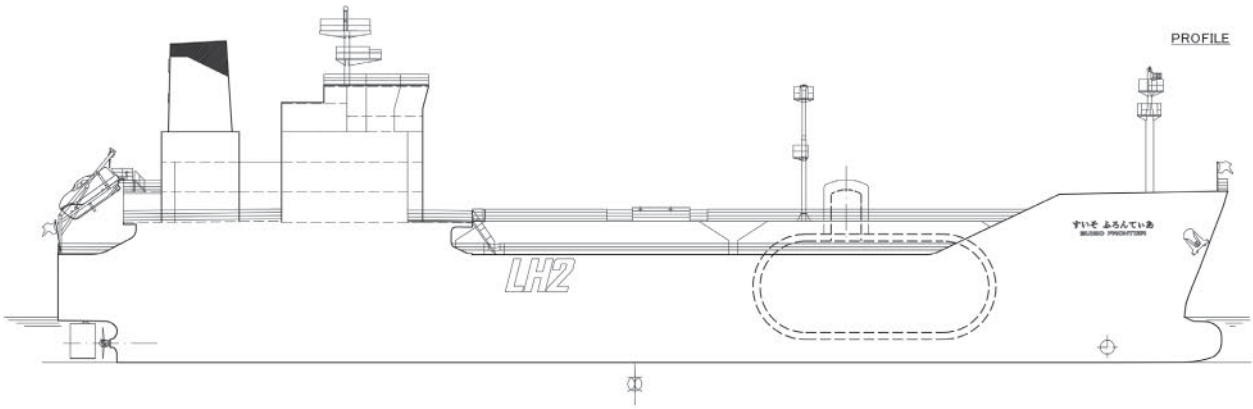
While the current solution is perhaps more brown than green – namely the brown coal from which liquified hydrogen is extracted from a purpose-built facility at the Latrobe Valley in southern Australia – the plan is to import nine million tons of hydrogen a year by 2050 using a fleet of hydrogen carriers built by Kawasaki Heavy Industries (KHI).

But before those ambitions can start to be realised a test project was required and in December 2021 KHI formally delivered *Suiso Frontier*, the world's first liquefied hydrogen carrier, which in late February completed its maiden laden journey from Hastings, Victoria, to Kobe, following more than two years of sea trials and other testing. The vessel has been built for the Hydrogen Energy Supply-chain Technology Research Association (HySTRA) partnership, which brings together Kawasaki, Iwatani Corporation, Shell Japan Limited and Electric Power Development Co. Ltd. (J-Power), with support from Japan's New Energy and Industrial Technology Development Organisation (NEDO).

KHI is, of course, no stranger to pioneering groundbreaking technology, having built the first Asian LNG carrier, *Golar Spirit*, more than 40 years ago, albeit in recent years Japanese yards have trailed behind their rivals in South Korea and latterly China. However, cryogenic storage and transportation of liquid hydrogen (LH_2) poses some distinct challenges from that of liquid methane, being eight times lighter and evaporating 10 times faster. KHI worked closely with Japanese classification society ClassNK, constructing the vessel's hull structure, machinery, onboard equipment and materials in accordance with ClassNK's 'Guidelines for Liquefied Hydrogen Carriers', published in 2017.

Prior to loading, hydrogen must be cooled to -253°C to be liquefied, reducing its volume to 1/800 of its original gas-state, enabling its safe and secure transport in large quantities over long distances by sea. The 1,250m³ capacity cargo containment system (CCS) has been built with a vacuum-insulated double-shell-structure liquified hydrogen tank which, although regarded as an IMO Type C tank, was newly developed by KHI with the support of NEDO and built at the nearby Harima Works facility. To achieve the requisite insulation new technologies were required, such as the glass-fibre reinforced polymers be used for the tank support structures.

PRINCIPAL PARTICULARS	
Name	*Suiso Frontier*
Length overall	116.0m
Length between perpendicular	109.0m
Moulded breadth	19.0m
Moulded depth	10.60m
Moulded draught	4.5m
Gross tonnage	7,849gt
Tank cargo capacity	1,253m³ (100% full at -253°C, excluding inner vessel dome)
Propulsion system	3 x Daihatsu DE-23 900rpm 1,320kW diesel engines; 2 x Nishishiba 1,360kW electric motors
Service speed	13.0knots
Capacity	25 persons
Registration	Japan
Classification society	Nippon Kaiji Kyokai (ClassNK)
Owner	HySTRA
Shipbuilder	Kawasaki Heavy Industries, Ltd. (Kobe Shipyard)
Designer	Kawasaki Heavy Industries



GENERAL ARRANGEMENT OF *SUISO FRONTIER*

All the cargo devices onboard have been tested using liquefied hydrogen at Kobe Hydrogen Demonstration Terminal for four months and their functions and performances were confirmed. *Suiso Frontier*'s propulsion system comprises three Daihatsu DE-23 900rpm 1,320kW diesel engines, fitted with selective catalytic reduction technology, and two Nishishiba 1,360kW electric motors.

While *Suiso Frontier*'s storage capacity is only modest it's important to remember that in many respects it is intended only as a proof of concept. In May of last year, ClassNK granted KHI Approval in Principle to a much larger 40,000m³ CCS, the largest of its kind anywhere in the world, for a 160,000m³ hydrogen carrier (consisting of four tanks) that's anticipated to enter service by the middle of this decade. ■

PROPULSION

DIRECT DRIVE ELECTRIC OFFERS SMOOTHER TRANSITION TO ELECTRIC PROPULSION

By **Jonas L Nyberg**, managing director – west hemisphere, Berg Propulsion

Driven by cost and sustainability imperatives, the maritime industry is increasingly attracted by electric propulsion technology, whose benefits include compatibility with a wider range of fuels, higher levels of integration and more flexible power management.

Yet while shipping's electrification is clearly under way, not everyone is onboard: many shipowners remain unconvinced that the advantages of conventional electric propulsion are straightforward enough to warrant a shift away from diesel mechanical set-ups.

In response, Berg Propulsion has collaborated with green technology expert The Switch to develop an alternative solution that offers superior electric propulsion efficiency compared with conventional systems – alongside a robust and simplified configuration to appeal to both new and existing user groups.

Efficiency gains through consolidation

In the conventional approach to electric propulsion, power is fed from the generators into the power distribution system before moving on to the frequency controller, passing through the electric motor and finally reaching the main propeller shaft via the reduction gear. While this process offers enhanced flexibility to adapt to changing loads, energy is lost at every step.

Named 'Direct Drive Electric', Berg's new solution minimises conversion losses by consolidating several of the systems that comprise a conventional electric propulsion power train.

Consolidation opportunity 1:
The revised configuration (see Figure 1) uses proven permanent magnet motor technology for higher efficiency, reduced electrical losses and optimised flexibility at varying rpm, torque and pitch.

In this set-up, the electric motor is part of the propeller shaft and drives the propeller directly, with no reduction gear installed, to achieve 2–3% greater fuel efficiency. The more robust arrangement also simplifies installation, addressing the issues of systems complexity and high component numbers, which have been acknowledged as a key factor in many shipowners' resistance to electric propulsion.

As well as improving efficiency and simplifying installation, removing the reduction gear decreases wear in ancillary components to cut maintenance requirements, while the addition of a separate bearing unit, located before the electric motor on the shaft, eliminates inherent alignment and integration issues.

Consolidation opportunity 2:
The power distribution and the frequency controller – respectively responsible for 1–2% and 3–5% conversion losses in the conventional electric propulsion set-up – offer a second opportunity for consolidation.

Direct Drive Electric features a DC hub, or 'superdrive', that draws on the main power generation source as well as any sources of stored energy such as batteries and fuel cells. The superdrive outputs interface separately with main propulsion and hotel/other

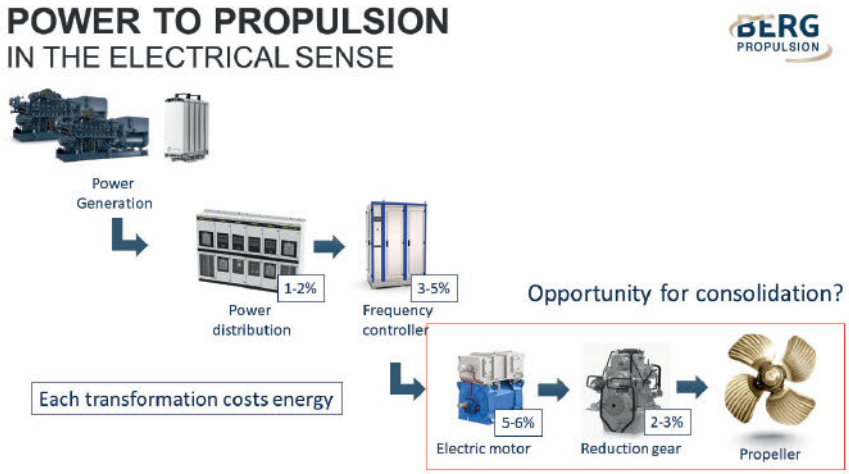


FIG 1: BERG DIRECT DRIVE SYSTEMS – CONSOLIDATION 1

electrical systems, establishing an integrated power source that can be distributed for optimised fuel efficiency at all times.

The capacity to draw on stored energy significantly improves vessel responsiveness and efficiency, with peak loading available as required and zero-emissions battery power possible for certain operations.

Design advantages of Direct Drive Electric

Direct Drive Electric also offers advantages in propulsion system design, with the removal of gears allowing a shorter shaft line, fewer bearings and a smaller engine room footprint. In addition, the solution's extremely high torque capability enables far larger propeller diameters than are usually possible in an electric propulsion installation, further increasing efficiency.

When combined, performance enhancements achieved through the absence of a gearbox, the superior performance of the electric motor and the larger propeller can yield efficiency gains of up to 30% as compared with conventional or podded propulsion systems.

Direct Drive Electric use cases

Already fully operational, Direct Drive Electric has been included in orders featuring Berg's patented Twin Fin system, where it is installed within compact, hydrodynamically shaped fins custom-designed to optimise flow through the propellers and thereby minimise fuel consumption and noise.

As an example, Berg Propulsion has supplied Direct Drive Electric to a 26,000dwt self-unloading bulk carrier designed by Deltamarin and built at CSSC Chengxi Shipyard, China. The vessel, named *Nukumi*, has now successfully passed sea trials and been officially delivered to Canadian shipowner CSL Group; she is currently enroute to Canada where she will commence operations.

A complete electrical integration package from Berg includes variable speed permanent magnet alternators through DC switchboards, the Direct Drive Electric motors and power management with AC distribution. Furthermore, the vessel's propulsion system has been fully adapted to optimise performance in relation to its hull form.

The CSL newbuild will be equipped with two fully feathering controllable-pitch propellers, each directly powered by a three-megawatt permanent magnet electric motor housed in the dual fins attached to the hull. Meanwhile, its four diesel-electric MaK gensets will deliver a combined total power of 9.5MW, helping the ship to reach a service speed of 12–14knots.

While this is a specialised application for Direct Drive Electric, the solution is also available and generating interest in applications for vessels where the motors

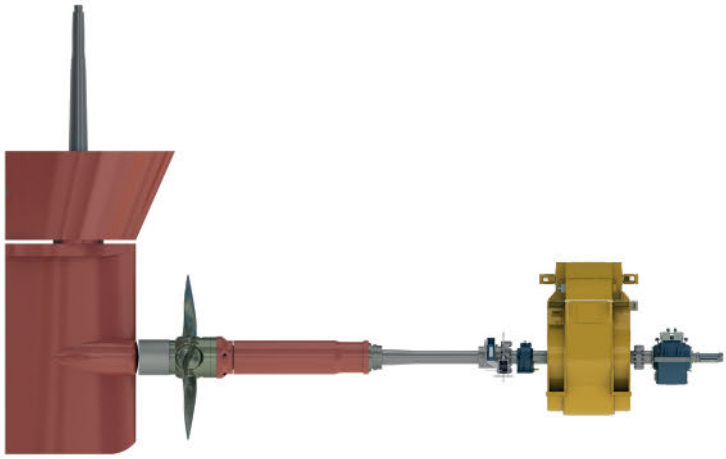


FIG. 2: BERG'S PATENTED TWIN FIN SYSTEM

are installed inside the hull. Examples include single-screw cargo vessels, RoPax ferries, patrol vessels and other ships whose energy transformation and operational profile are better served by an electrical set-up than by a mechanical concept.

Vessel electrification made easy

With the industry-wide transition towards vessel electrification now under way, Direct Drive Electric represents an ideal solution for integrating gas or dual-fuel engines, other fuel alternatives, fuel cells and batteries.

The solution's robust configuration makes it a particularly attractive proposition for owners of offshore vessels, who are, in general, already convinced of the advantages of electric propulsion. At the same time, Direct Drive Electric's ability to facilitate the integration of battery power could prove appealing to ferry operators. Owners of bunker vessels and single-screw cargo ships might be persuaded by its capacity to incorporate new low-carbon fuels and thereby support regulatory compliance.

Owners seeking to optimise efficiency, flexibility and sustainability – and whose ships require the high manoeuvrability or redundancy in which electric propulsion excels – should therefore see Direct Drive Electric as a direct response to a market need for a smoother transition to vessel electrification. ■

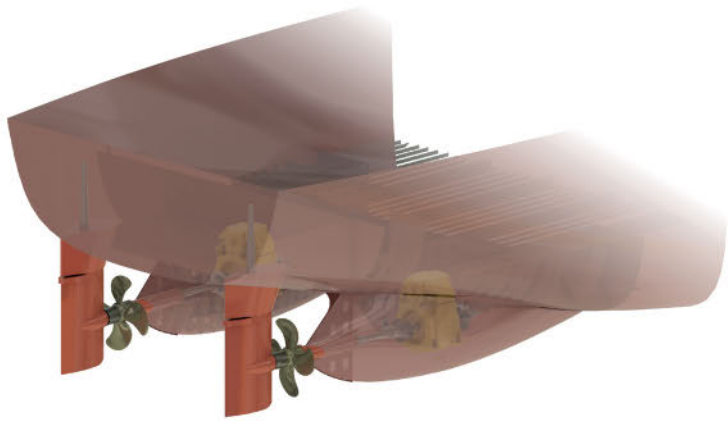


FIG 3: TWIN FIN HULL ASSEMBLY

CLARKSON RESEARCH SERVICES: HISTORIC AND SCHEDULED DELIVERY

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

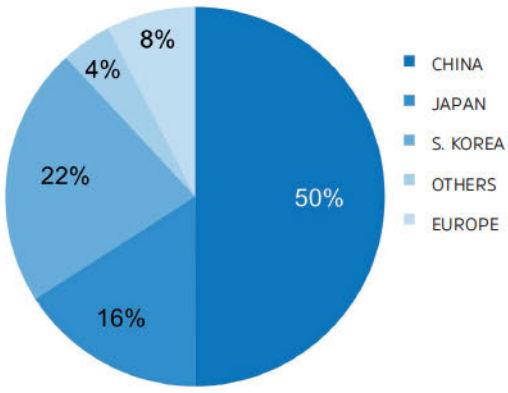
VESSEL TYPE	2010		2011		2012		2013		2014		2015	
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half
VLCC >= 200,000	30	24	35	27	27	22	21	9	14	10	9	11
Suezmax 120-200,000	26	11	26	18	30	15	23	4	4	4	7	3
Aframax 80-120,000	37	31	28	31	30	15	14	6	4	13	22	10
Panamax Tankers 60-80,000	15	16	19	10	9	6	7	5	3	1	2	1
Products 30-60,000	65	46	45	28	27	30	49	29	49	49	60	57
Products 10-30,000	5	7	8	6	13	6	10	4	1	8	4	0
Chem & Spec. 10-60,000	78	58	53	39	39	8	7	13	12	11	36	29
Tankers < 10,000	71	56	56	58	76	41	38	39	32	25	19	23
Capesize > 100,000	101	111	129	122	149	65	63	40	56	38	46	42
Panamax 80-100,000	60	61	81	97	140	94	101	68	62	35	57	41
Panamax 65-80,000	18	33	36	44	53	39	34	42	42	20	19	4
Handymax 40-65,000	168	166	199	198	228	146	147	119	95	97	136	118
Handysize 10-40,000	186	186	186	180	226	117	116	83	101	71	108	86
Combos > 10,000	3	2	3	0	0	0	0	0	0	0	0	0
LNG Carriers	15	12	5	10	1	2	4	13	14	19	16	16
LPG Carriers	18	18	16	14	13	8	22	16	14	14	25	40
Containers > 8,000 teu	29	33	48	30	51	28	51	33	59	42	58	62
Containers 3-8,000 teu	76	41	31	21	39	19	46	29	26	25	18	6
Containers < 3,000 teu	57	26	34	35	37	40	29	19	22	28	26	35
Offshore	20	23	25	20	27	10	11	19	31	30	25	13
Cruise Vessels	9	4	4	2	6	1	6	0	3	2	5	1
Passenger	10	13	11	10	11	8	6	6	12	8	13	8
Other	173	181	183	182	191	98	99	84	72	61	69	47
TOTAL	**1,270**	**1,159**	**1,261**	**1,182**	**1,423**	**818**	**904**	**680**	**728**	**611**	**780**	**653**

DATA INCLUDES ALL VESSELS WITH LOA ESTIMATED AT >100M

THE ORDERBOOK BY YEAR OF DELIVERY ON THIS PAGE IS BASED ON REPORTED ORDERS AND SCHEDULED DELIVERY DATES AND DO NOT NECESSARILY REPRESENT THE EXPECTED PATTERN OF FUTURE DELIVERIES

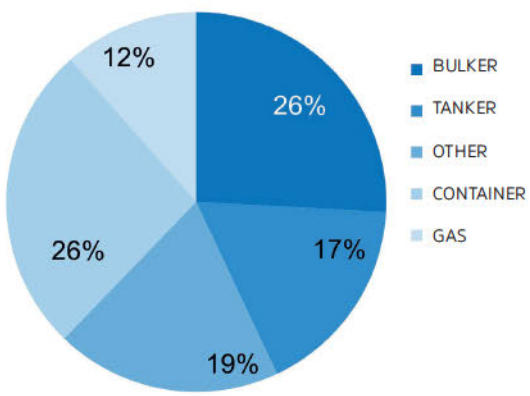
ALL DATA TAKEN AS OF **1ST FEBRUARY 2022**

ORDERBOOK BY BUILDER REGION (NUMBER OF VESSELS)

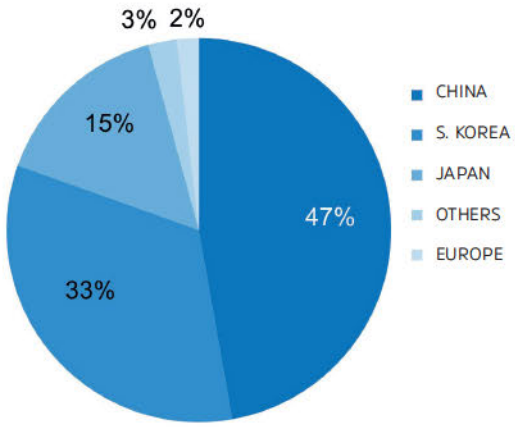


	2016		2017		2018		2019		2020		2021		Scheduled Orderbook		
	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half	2nd half	2022	2023	2024
	23	24	29	21	21	18	39	29	22	15	23	12	44	24	0
	8	19	35	22	25	7	23	3	11	19	20	3	39	10	1
	31	22	36	28	26	24	41	12	12	6	28	25	46	39	9
	7	11	10	11	7	6	6	7	6	5	1	1	2	0	0
	60	42	39	25	27	22	50	46	43	29	39	37	64	35	0
	3	2	6	6	10	8	5	10	4	6	7	11	6	4	0
	43	38	38	31	45	41	34	28	32	24	25	23	69	28	16
	23	16	25	37	45	43	26	29	27	27	23	34	58	25	2
	64	39	55	20	30	21	31	49	64	48	52	36	55	55	31
	71	40	75	27	39	25	69	64	96	47	65	37	93	107	25
	1	2	6	1	2	2	1	4	3	0	0	1	7	9	1
	123	90	121	51	57	33	55	77	91	56	60	56	123	70	43
	86	51	73	34	50	44	54	40	43	43	72	54	91	66	22
	0	0	0	0	0	0	1	2	0	2	3	0	0	0	0
	15	18	20	12	32	23	22	20	16	21	35	30	40	48	76
	49	33	45	17	26	9	16	13	19	15	19	14	55	79	20
	37	26	34	36	47	23	27	23	13	22	28	26	50	99	109
	2	0	2	5	7	3	6	1	1	5	5	1	6	69	96
	40	28	35	42	50	38	45	55	42	56	54	47	126	140	51
	24	19	18	24	24	14	8	9	5	5	10	12	41	27	12
	8	2	7	3	8	4	12	10	6	8	8	13	34	24	14
	6	16	20	11	11	18	16	16	11	11	15	15	45	14	10
	49	61	50	54	49	48	57	53	38	63	81	84	190	70	64
	773	**599**	**779**	**518**	**638**	**474**	**644**	**600**	**605**	**533**	**673**	**572**	**1,284**	**1,042**	**602**

ORDERBOOK BY SECTOR (NUMBER OF VESSELS)



ORDERBOOK (DWT) BY BUILDER REGION



WEATHER ROUTING

SHIP EVALUATION USING FLEET DATA AND OCEAN HINDCAST DATA

By **Yoshiko Sato**, **Masahiro Maeda**, and **Minayo Hata**, Japan Weather Association

FIG. 1 FLOWCHART OF THE ACTIVITIES OF INMARSAT'S FLEET DATA

The Japanese government aims to eliminate greenhouse gas (GHG) emissions generated by the country's international shipping activities to realise the goal of achieving carbon neutrality by 2050. This is in response to International Maritime Organization's target of achieving GHG emissions as early as possible in this century.

To achieve this goal, it is first necessary to analyse the current condition of ships in the actual seas, on the basis of which effective improvement measures for realising GHG zero emissions can be considered. Using dense ship sensor data and accurate ocean data, it is possible to evaluate the ship's propulsion performance at sea, understand the lifetime history of the external forces encountered by the ship, verify its fuel consumption during a voyage, and determine the Carbon Intensity Indicator (CII). This article presents useful data and case studies to implement this effort.

In recent years, owing to the advances in sensor and ship-to-shore communication technologies, considerable amounts of ship monitoring data have been collected. Innumerable organisations offer data collection services, e.g. Fleet Data (Fig. 1), a data collection service that uses satellite communication operated by Inmarsat Global, and the Internet of Ships Open Platform (IoS-OP; Fig. 2), an open data collection platform operated by the Ship Data Centre (ShipDC), a subsidiary of ClassNK.

These services are characterised by their ability to automatically collect data in real time. In addition, an environment is created wherein multiple service providers can provide solutions using the data collected and stored on the cloud. To date, the noon report, as reported by the ship crew, has been typically used as ship operational data. However, this mechanism of automatically collecting and storing data has made it possible to provide various solutions and contribute to carbon neutrality and energy saving in ships.

However, to analyse the ship sensor data, information of the external forces on the ship, such as meteorological and oceanographic data, are indispensable. In addition, it is also important to collect the most probable data, namely, the hindcast data,

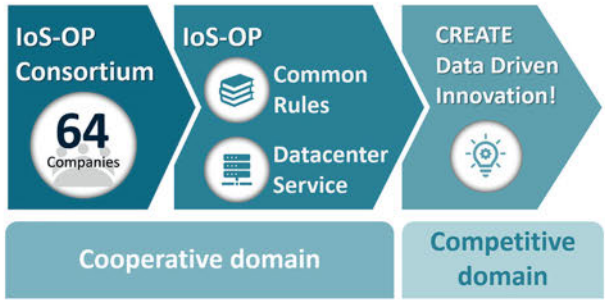


FIG. 2 FLOWCHART OF THE ACTIVITIES OF IOS-OP PROMOTED BY THE SHIP DATA CENTRE

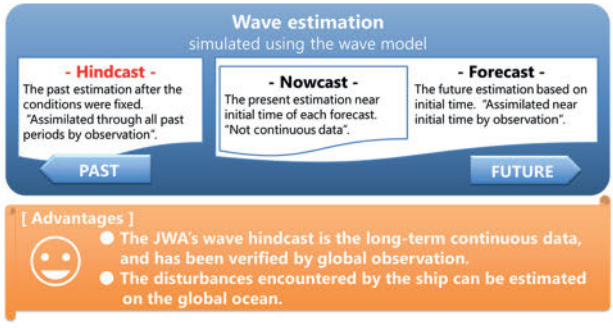


FIG. 3 ILLUSTRATION OF VARIOUS ESTIMATIONS TO PREDICT A WAVE

	Global	Japan Regional
Items	Ocean wind, Significant wave, Wind sea, Swell, Ocean current, Sea temperature	Ocean wind, Significant wave, Ocean current
Term	After 1987	After 2001
Providing method	• API / e-mail - download from the application - direct connection to the system	

- **The ocean data associated with the ship's track is provided via web API .**
- **The minimum time interval of this data is 10 minutes, and the shortest distance interval is approximately 20 m.**

FIG. 4 OVERVIEW OF POLARIS HINDCAST DATA

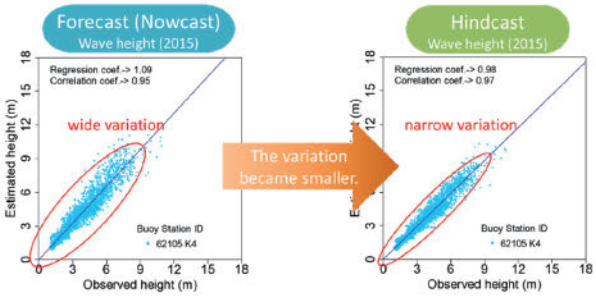


FIG. 5 ACCURACY COMPARISON OF THE WAVE HEIGHT IN A SCATTER PLOT

which are reanalysed past data, rather than only the nowcast or forecast data (Fig. 3 and Fig. 4).

As shown in Fig. 3, the nowcast and forecast data are the estimated future values produced using a numerical model; the nowcast is the initial value of the forecast, whereas the forecast is the estimated future value. In general, the time resolution of the nowcast and forecast data is six hours.

Yet, as mentioned earlier, the hindcast data is a re-estimation (reanalysis) of past meteorological and oceanographic conditions using observations. The Japan Weather Association (JWA) has constructed and provided a hindcast database for over 50 years; the time resolution is one hour, and accuracy verification is performed using the observation data.

Furthermore, in 2020, POLARIS Hindcast (Fig. 4), a hindcast data service, was initiated for the maritime industry. The hindcast data was evaluated by linking the data to the ship's track and improving them to provide a spatiotemporal interpolation of a minimum time and distance of up to 10 min and 20m, respectively. This high-quality database, POLARIS Hindcast, can accurately reproduce the actual phenomenon compared to the commonly available nowcast data.

For example, Fig. 5 shows a scatter plot comparing the buoy observation data at a certain point with nowcast and hindcast, using waves as an example. It can be said that the hindcast has less variability when compared to the observed values. Fig. 6 shows an example of a time series comparing the buoy data with nowcast and hindcast when the world's maximum wave height (19.0m) was recorded. It can be observed that POLARIS Hindcast can accurately reproduce the wave height peak, which enables an accurate reproduction of the time, location, and type of waves encountered on the route.

By using the high-precision and high-resolution hindcast data, accurate evaluation of various ship parameters (Fig. 7) is possible. The JWA links the POLARIS Hindcast data to the ship sensor data collected by Inmarsat's Fleet Data and performs ship evaluation analyses.

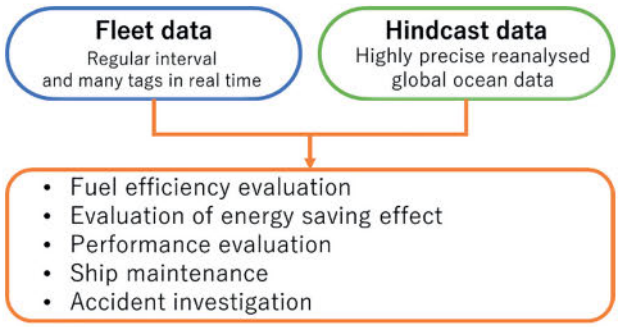


FIG. 7 EXAMPLE OF SHIP EVALUATION

For example, it is possible to evaluate ship propulsion performance on the sea, i.e., the moving ability of the ship on actual seas on a real-life basis. Typically, the propulsion performance of a ship in calm water can be evaluated using a sea trial conducted at the time of ship construction. However, there are no winds or waves, and the loading conditions may differ from the actual operational conditions; thus, it is difficult to determine the propulsion performance on actual seas.

Nonetheless, using ship sensor data with fine sampling intervals and the POLARIS Hindcast data, which is the accurate past reanalysis ocean data, it is possible to determine the ship propulsion performance in high-wave-height fields and the extent to which ship performance will deteriorate (Fig. 8). In other words, planning a voyage when severe weather is predicted can now be performed more accurately than before.

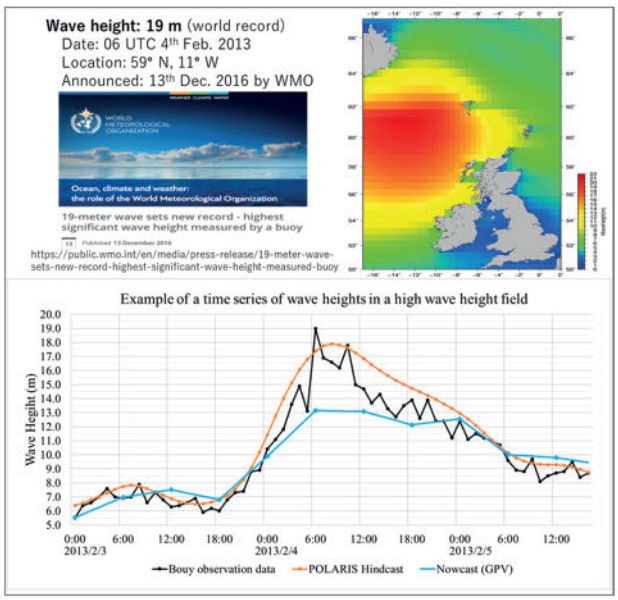
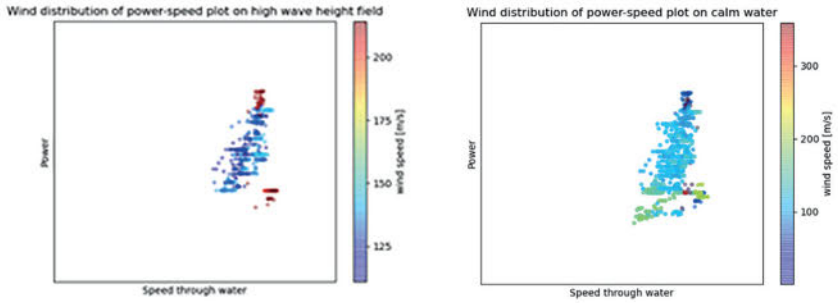


FIG. 6 ACCURACY COMPARISON OF WAVE HEIGHT IN A TIME SERIES

FIG. 8 POWER–SPEED CURVE (LEFT: ON HIGH-WAVE-HEIGHT FIELD CONDITIONS / RIGHT: ON CALM WATER)



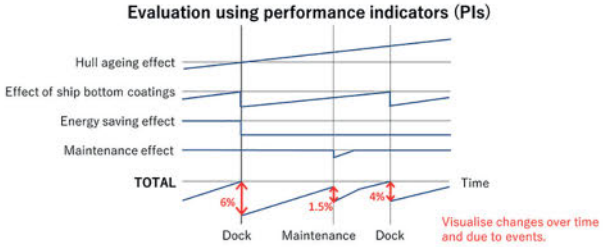


FIG. 9 EVALUATION USING PERFORMANCE INDICATORS (PIS)

In addition, because ship performance changes over time, by performing this evaluation on a regular basis, it is possible to determine parameters, such as age-related propulsion performance defined by ISO 19030, and examine the optimal maintenance time (Fig. 9).

Furthermore, evaluations based on ship data and ocean hindcast data are useful for determining the history of the various external forces a ship has encountered. Since the history of the external forces encountered by the subject ship can be confirmed, the degree of ship fatigue can be estimated. In addition, by understanding the trends by route and sea area, feedback can be received on ship allocation plans and the design of new ships (Fig. 9).

Fuel consumption can be verified with high accuracy if the fuel data is collected as ship data. The effect of energy-saving techniques as well as the optimal route and the deceleration voyage can be verified, which leads to improved navigation (Fig. 10).

Furthermore, it is possible to comply with the new GHG emission regulations for 'Carbon Intensity Indicator: CII' for all oceangoing vessels globally, which will be implemented in 2023. The 'POLARIS Report' service that provides these ship evaluation results using the Inmarsat's Fleet Data and the POLARIS Hindcast data is scheduled to start in 2022. ■

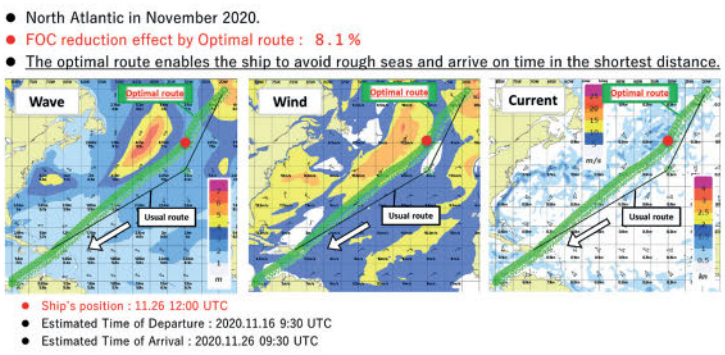


FIG. 10 EXAMPLE OF FUEL CONSUMPTION VERIFICATION

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