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Subscriptions & Publications Manager Jim-Ray Semanhyia
Publisher Mark J Staunton-Lambert

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The Royal Institution of Naval Architects
Editorial & Advertisement Office:
8-9 Northumberland Street
London, WC2N 5DA, UK
Telephone: +44 (0) 20 7235 4622
Telefax: +44 (0) 20 7245 6959
E-mail editorial editorial@rina.org.uk
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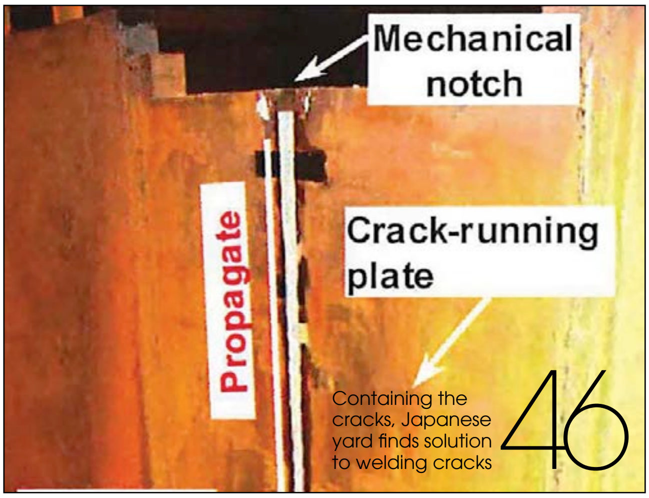

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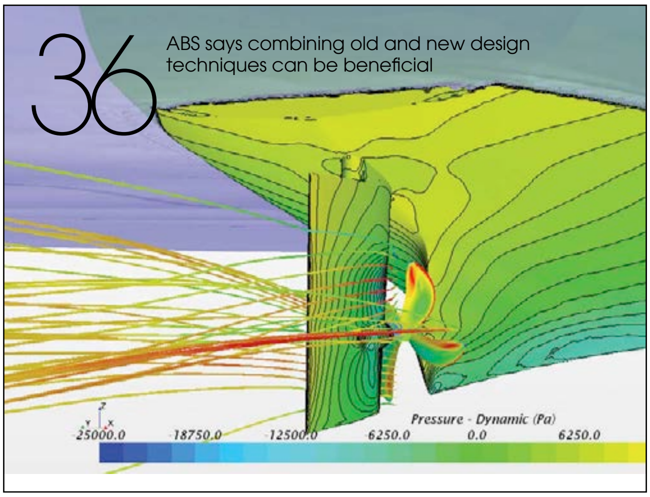

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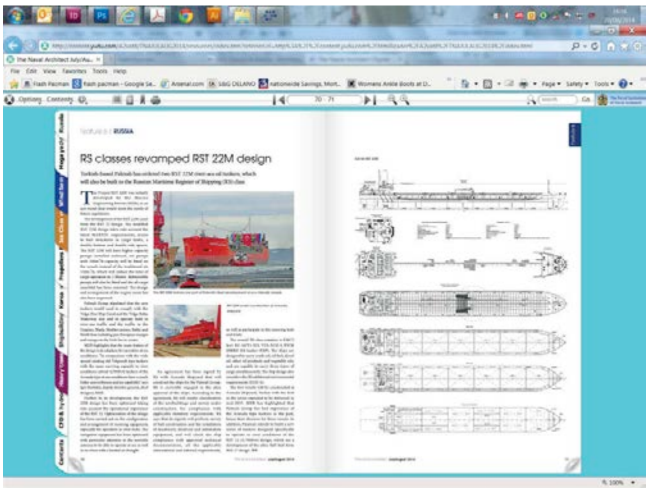
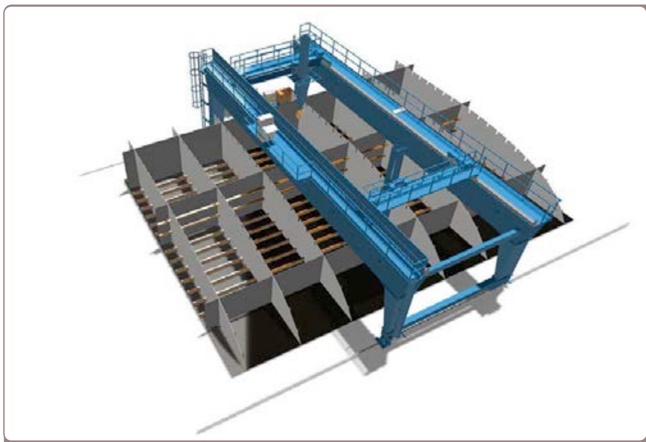




Rules move technology forward

The marine industry is investing in technology for a better tomorrow, aiming for greener times and an end to the downturn

A common feature of this month's issue is how some sectors of the industry are using the significant downturn to restructure production and modernise the techniques used in both design and shipbuilding. The shipbuilding industry is fast developing from a labour intensive sector to a highly technology intensive business.

Rules and regulations are also driving the development with environmental issues and safety at the forefront of new rules. For example, regulation of the Northern Sea Route (NSR) is recognised by all as playing a fundamental role in the preservation of a highly environmentally sensitive region. In order to ensure the preservation of this region, the Russian Register of Shipping (RS) has updated its rule book as seen in this month's In-depth story.

In China Ship News' story the theme followed is the restructuring of the Chinese shipbuilding industry, its modernisation and the use of technology to improve the productivity and quality of the output from the country's yards.

Shipyards in many regions are using the downturn in the shipbuilding market to modernise their businesses, entering a new digital era by re-tooling their yards with sophisticated equipment, such as Kranendonk's automated welding solutions. In the company's most developed offering, eight welders operating in pairs on four gantries controlled via a central controller using the company's own software improves productivity immensely. The system is currently in use in various forms in Japan, the US and Europe.

These newly automated yards may well be producing new container feeder ship designs, as the focus in this sector shifts from larger ships to smaller vessels. The container feeder ship sector has an ageing fleet with a number of owners already preparing orders for new vessels. With this in mind, Knud E. Hansen has developed a new 3,800TEU feeder vessel.

Knud E. Hansen's view is that any new vessel design must have operational flexibility and has designed its feeder ship with the option for the owner to switch to LNG or other fuels.

The company is also offering an innovative design of a trimaran, or what the company describes as a mono-hull with two out riggers, to help with the stability issues that often plague smaller containerships.

In other international rule developments, the latest regulation on enclosed spaces from the IMO, XI-1/7covering atmosphere testing has been enacted and will ensure the safety of people entering enclosed spaces on vessels from 1 July this year (See News Analysis page 12).

In February 2012, *The Naval Architect* highlighted the problem of crew and other staff entering enclosed spaces on ships and the design techniques, as well as operational fixes that could be employed to safeguard those entering confined areas that may have limited oxygen or poisonous gases lurking within them.

IMO must be applauded for its recognition of the safety issues regarding enclosed spaces and its comparatively swift move to apply regulations in an attempt to protect staff.

Regulation of the shipping industry has principally been in two areas, safety and the environment, and this issue's computational fluid dynamics (CFD) feature concentrates on ship efficiency and meeting the demands for cleaner vessels. ABS is calling for the combining of an established technology, the towing tank, with new technology, CFD, to help squeeze every ounce of efficiency from ship designs.

Wärtsilä's approach is similar to the ABS view, but the Finnish company believes that ship design techniques are in transition and that change will occur over a prolonged period.

CD-adapco, who in the past has argued that CFD could end the use of towing tanks in vessel design (*TNA* July/August 2015 pages 22-24), has used the technology to show how aerodynamic improvements can improve vessel performance.

Modernisation is undoubtedly driving the maritime industry and new technological innovations will continue to secure greater productivity in shipyards and a reduction in pollution from ships. *NA*

Rules

EEDI debate reaching critical point

Two meetings took place in Hamburg and Copenhagen in June where discussions of the role of Energy Efficiency Design Index (EEDI) in shaping the next generation of ro-ro vessels concluded that errors have been made in the formulation of EEDI.

The Naval Architect understands that the ferry operators association, Interferry and the German Shipbuilder's Association, suggested that EEDI for ro-ros should be "independent of speed". This prompted one observer, Hans Otto Kristensen of the Danish Technical University, to point out that such a move flies in the face of other versions of EEDI for ships such as tankers, bulk carriers and containerships.

Discussions at the closed meeting in Hamburg that included representatives from ro-ro operators as well as vessel designers and ro-ro associations concluded that it would be difficult to make EEDI work for ro-ro ships as the term covers a varied number of ship types that operate under very different conditions.

Anne Katrine Bjerregaard, head of the secretariat for the research organisation Green Ship of the Future, said she was disappointed and "more than a little sad that mistakes have been made".

To highlight those mistakes Alberto Portalano, from Grimaldi's ship efficiency division said that the latest con-ro ships that are being delivered, including *Atlantic Star,* delivered last year from a yard in Pudong, China, are "around 25% more efficient than the previous class of vessel".

According to Portalano: "you can build a ship with 2,000 lane metres extra cargo space, but the problem is that the increase in deadweight will mean it cannot fulfil the EEDI regulation".

As a result, the last in this current series of vessels had its keel laid before the January 2016 deadline, when the EEDI for ro-ro ships was enforceable, but this will be the last in the series as the design will not meet current EEDI rules.

More *Atlantic Star* vessel types will not be built as they do not meet EEDI regulations

Kristensen said that the vessels with the lowest and therefore the best EEDI number were emitting the highest levels of CO_2 per payload and "therefore EEDI is not a measure of environmental performance". He added: "If you had three ships and you want to rank them, if I reduce the deadweight I get credit EEDI-wise, but environmentally I get credit for carrying as much as possible, that is really a problem."

Software

First step to Smart Ship ecosystem

South Korean Shipbuilder Hyundai Heavy Industries (HHI) signed a Memorandum of Understanding with SK Shipping, Intel, Microsoft, the Ulsan Center for Creative Economy & Innovation (UCCEI) and the Daejeon Center for Creative Economy & Innovation (DCCEI) to create a Smart Ship ecosystem.

The intention is for the partners to enable small and medium-sized technology companies to develop "17 Ship Service Software that meets the needs of shipowners for safe ship operation and improved crew well-being".

Ship Service Software will be applied to Smart Ships by 2019 and will allow ballast tank inspection, remote medical treatment services for crews, virtual reality training, automatic voyage information reporting, and maintenance for key equipment.

HHI and SK Shipping will provide technological mentoring services and Smart Ship platforms for the software when it is developed and UCCEI and DCCEI will hold briefing sessions on the technology demands of shipbuilders and shipping liners to encourage the participation of the technology companies.

To aid the development of the software, HHI and Accenture jointly unveiled their Smart Ship OceanLinkTM in May. Through a network of sensors and analytics software, shipowners can monitor a ship's status and condition in real-time and have at their disposal a wide range of ship operation information including weather, location, onboard equipment data and cargo status data.

Research

Cavitation tunnel in transit

A £1.5 million (US$1.94 million) investment in Newcastle University's School of Marine Science and Technology will see the refurbishment and relocation of the University's Emerson Cavitation Tunnel.

The fund aims to create a Centre of Excellence for Marine Hydrodynamics, Coatings and Materials, and will

Newcastle University's Emerson Cavitation Tunnel is to be future-proofed for the next 50 years through its refurbishment

involve the moving of the tunnel to a new, purpose-built research centre in the port of Blyth, where it will join the University's research vessel, *Princess Royal*.

The University says that the purpose-built laboratory space planned for the site will be double the size of the existing provision, increasing research capacity and allowing for closer collaboration with industry leaders.

Any impact on research, for PhD students and industry partners alike, has been mitigated, according to Peter Bowes, facilities manager of the cavitation tunnel. Students have been given the opportunity to complete their research before or after the move of the tunnel, and industry partners are onboard with the move to new and improved facilities. Bowes adds that the refurbishment work will future proof the tunnel for the next 50 years.

Professor Andrew Willmott, head of the School of Marine Science and Technology, says: "Work on the cavitation tunnel was well overdue and this major investment and relocation means this unique facility will be a valuable research asset for many years to come."

The tunnel will be fully refurbished in Poland by Polish-based ship design and research centre Centrum Techniki Okrętowej (CTO) before travelling back to its final destination in Blyth in September. It will then be fully operational by early 2017 for the testing of propellers and turbine blades and subsequent research on propeller design and surfaces.

The School will also start the process of appointing a Reader/Professor in Experimental Marine Hydrodynamics this summer. The post holder will provide leadership in this field, with emphasis on leading research and consultancy that will utilise the Emerson Cavitation Tunnel in its new location.

Archive centre

New archive centre goes live

Japan's classification society ClassNK announced that its ClassNK Archive Center (NKAC) went live from 1 July.

The class society said that "the maritime industry's first onshore digital archive centre that fully complies with IMO Goal-based ship construction standards (GBS)" has become operational.

As from 1 July the new SOLAS regulation II-1/3-10 made GBS applicable to bulk carriers and oil tankers of more than 150m in length contracted on or after the applicable date.

The regulation means that a Ship Construction File (SCF) must be established on delivery of the vessel and kept onboard the ship and/or ashore. The SCF will provide information related to the design and construction of the vessel and will ensure the safety of the ship throughout its operational lifetime. The SCF will include documents that are recognised as highly sensitive intellectual property.

ClassNK said: "The Industry Standard (The SCF Industry Standard (IS) and SCF Supplementary Guidance (SG)) was developed by a cross-industry group including the Shipbuilders' Association of Japan (SAJ) and other organisations such as CANSI, CESA, KOSHIPA, SCA, ICS, INTERCARGO, INTERTANKO, BIMCO, OCIMF and IACS. It provides industry guidance relevant to new shipbuildings, substantial repairs, conversions and major modifications to the structure of bulk carriers and oil tankers and was noted at the 96th session of the IMO Maritime Safety Committee (MSC 96) held in May 2016."

Acquisitions

Eniram acquired by Wärtsilä

Finnish energy management and analysis company Eniram was snapped up by its Finnish counterpart, Wärtsilä for €43 million (US$47.68 million) with the deal taking effect from 1 July 2016.

With a turnover of more than €10 million (US$ million) and 89 employees in locations that include the UK, US, Germany and Singapore, Wärtsilä says that this technology will help its customers to maximise their assets.

"Digitalisation offers significant growth potential for our customers and for Wärtsilä," Jaakko Eskola, President and CEO, Wärtsilä Corporation, commented on the acquisition.

"Eniram has world-class analytics capabilities, and by joining forces we can provide our customers with an unbeatable offering on both the vessel and fleet level" says Pierpaolo Barbone, president, Wärtsilä Services. *NA*

New rules open door to man trap testing

New amendments to safety rules on atmosphere testing came into force on 1 July 2016 as the industry continues to grapple with the dangers posed to crew members by enclosed space entry, *writes Sandra Speares.*

Fatal accidents continue to occur as a result of a failure to test oxygen levels in enclosed spaces before crew members enter them. It is a problem first highlighted in *The Naval Architect* in 2012 (Man Traps pgs 25-28 Feb 2012) and has remained in spite of repeated warnings by industry experts about the need for strict enforcement of testing procedures.

The new regulation is aimed at protecting seafarers who need to enter enclosed spaces by requiring ships to carry portable atmosphere testing equipment.

According to the IMO, the new regulation XI-1/7 Atmosphere testing instrument for enclosed spaces in the International Convention for the Safety of Life at Sea (SOLAS) requires ships to carry an appropriate portable atmosphere testing instrument or instruments, capable, as a minimum, of measuring concentrations of oxygen, flammable gases or vapours, hydrogen sulphide and carbon monoxide prior to entry into enclosed spaces.

Enclosed spaces covered by the regulation include, but are not limited to, cargo spaces, double bottoms, fuel tanks, ballast tanks, cargo pump-rooms, cargo compressor rooms, cofferdams, chain lockers, void spaces, duct keels, inter-barrier spaces, boilers, engine crankcases, engine scavenge air receivers, sewage tanks, and adjacent connected spaces.

Similar requirements for offshore drilling units enter into force under amendments to the Code for the Construction and Equipment of Mobile Offshore Drilling Units (1979, 1989 and 2009 MODU Codes).

Associated guidelines to facilitate the selection of portable atmosphere testing instruments for enclosed spaces as required by SOLAS regulation XI-1/7 (MSC.1/Circ.1477) have been agreed to facilitate the selection of a portable atmosphere testing instrument for enclosed spaces.

The London P&I Club says it continues to see cases of injuries and fatalities associated with entry into enclosed onboard spaces, including cargo holds on bulk carriers where atmospheres have not been treated as potentially dangerous.

In a recent case, two shore staff were permitted by the ship's crew to enter the cargo hold of a bulk carrier via the usual means of access. Due to an atmosphere which did not have sufficient oxygen to support life, one member of the shore staff died, along with a crewman who made an attempt to rescue them without following proper emergency procedures.

London Club loss prevention manager Carl Durow says: "Despite the recent introduction of legislation relating to drill requirements for personnel engaged in entry into enclosed spaces, the club is still concerned about the number of spaces which should be considered potentially dangerous but may not be by crew who might focus on the traditional spaces such as ballast tanks and bunker tanks.

"The carriage of goods in bulk which may deplete oxygen content or produce toxic substances remains a threat, together with the dangers arising from the use of fumigants in ships' holds."

The International Chamber of Shipping (ICS) has issued guidelines on enclosed space entry and rescue based on its Tanker Safety Guide (Chemicals). As marine director John Murray explains, IMO has issued two specific sets of safety guidelines: Assembly Resolution A.1050(27) (Revised Recommendations for Entering Enclosed Spaces Aboard Ships); and MSC.1/Circ.1401 (Guidelines on Tank Entry for Tankers Using Nitrogen as an Inerting Medium).

The ICS guide emphasises the "safety precautions needed, particularly on chemical tankers, because with the new inert gas regulations there will be more opportunity for risk or hazard on chemical tankers than before. Therefore the need for correct procedures to be followed is ever more important on those ships".

Murray says he welcomes the IMO work which has been reflected in the ICS guide. He says the guide goes beyond that in terms of equipment. ICS is very stringent on the testing of the atmosphere before a crew member goes into the space and also says everyone who goes into a space on a chemical tanker should have personal equipment as well. "The ICS is fully behind the need to tackle the issue properly in order to reduce and minimise accidents."

Another point to mention, he says, is that while there will still be accidents on tankers, the risks are well known and appreciated and systems are in place to deal with the problem. However, accidents are still taking place on other classes of ship as well, and in places where people do not expect to have to deal with them. "Not realising there is a risk is perhaps an area that could benefit from more effort".

Nigel Cleave, CEO of Videotel, which produces guidance on the enclosed space issue, adds: "Videotel welcomes the SOLAS regulation due to come into force on Friday to require ships to carry appropriate atmosphere testing equipment to check air quality prior to entry into enclosed spaces. Any regulation which helps to safeguard crew is important." *NA*

Seals & bearings

Yamal ships toughen up

Equipment provider, SKF, is working with ABB to ensure Arctic reliability for ten Yamal LNG carriers set to operate around the Yamal Peninsula in the Arctic Circle.

The company was included in the development of ABB's Azipod propulsion units for the vessels because of its experience with demanding marine applications, according to a spokesperson from SKF. The collaboration's aim is to ensure reliability and reduce life cycle costs despite the harsh operational environment, which will present severe operational conditions throughout the year.

SKF will provide custom-made thrust bearing arrangements, which incorporate housing and seals, and high performance self-aligning CARB toroidal roller bearings for the propeller shafts.

Sami Kontturi, project manager at SKF, says: "We are privileged to be lending our expertise and state of the art technologies to one of the largest industrial undertakings in the Arctic…we can help ABB and its Azipod propulsion units to deliver enhanced performance and efficiency on the LNG carriers as the Yamal project takes a great step forward in the global search for natural resources."

www.skf.com

Facilities

Bridging the oil gap

Rolls-Royce is weathering the oil and gas crisis by investing £44 million (US$53 million) in a new marine thruster facility in Rauma, Finland.

The new facility will combine the offerings of two existing manufacturing sites, consolidating the production of Rolls-Royce's whole range of Azimuth thrusters in Rauma.

Olli Rantanen, managing director of Rolls-Royce Finland, says: "This investment will allow us to plan for the future, and enable us to efficiently produce our existing range and develop new and larger mechanical thrusters."

At present, only one of the existing buildings can hold the largest Azimuth thruster in the range, the ARC type, which provides 7.5MW of power for icebreakers and can weigh up to 190tonnes.

The new site will feature modernised operations, borrowing experience from other segments of the Rolls-Royce business to provide increased flexibility and more efficient flow lines in the assembly process. The investment will also see the installation of a 200tonne capacity crane and at least six factory acceptance test rigs. Work on the new site is due to be completed in 2020.

www.rolls-royce.com

Paints & coatings

New application process improves protection

Propulsion manufacturer Schottel has optimised its coating processes to offer more robust Rudderpropellers that have improved corrosion protection.

The company promises 2.3 times greater abrasion resistance and approximately 60% greater adhesion than with a conventional standard coating.

Schottel says this is achieved through the implementation of an optimised air-mix painting process and by having "ideal conditions for preparation of the substrate" at its recently completed plant in Spay/Rhine, Germany, which boasts new blasting booths for substrate preparation of the entire Rudderpropeller.

A new coating approach improves protection for Schottel's Rudderpropellers

The new processes are also more environmentally friendly, featuring lower quantities of volatile organic compounds and solvents.

Schottel's coatings meet the highest corrosion protection class C5-M requirements, according to the company, and are harmless to aquatic organisms.

www.schottel.de

Acquisitions

Palfinger poised for TTS takeover

PALFINGER AG intends to make a bid for Norwegian-based equipment company TTS Group ASA through its subsidiary Palfinger Marine GmbH in an effort to become one of the top three ship equipment suppliers.

Herbert Ortner, CEO of Palfinger AG, says: "Together with the acquisition of Harding, this acquisition would place Palfinger Marine among the global top three ship equipment suppliers. In the future, we want to be a one-stop shop, internationally offering all maritime customer industries competitive products and services."

The takeover bid has met with a positive response from TTS Group's CEO, Toril Eidesvik, who says: "TTS has clear ambition to grow through the development of a wider range of products and product packages within the deck- and cargo handling equipment to the various vessel segments. Joining Palfinger Marine, and potentially also Harding, will give large synergies and create a solid platform for the planned growth."

Palfinger believes that the overlap of products and services offered by Palfinger Marine and the TTS Group is minor, and emphasises TTS' strong foothold in China – represented in TTS' three 50% owned Chinese companies – as a strengthening factor in the proposed takeover.

The company expects to finalise the intended acquisition in the fourth quarter of this year, but foresees that it could occur as late as January 2017.

www.palfinger.com

Accommodation & interiors

Stairway to shipbuilders

Schwepper, a lock and hardware provider for shipbuilding and other industries, has expanded its product offering with new standardised components for building aluminium stairways and a new lock.

The new Solenoid locks can be integrated with a vessel's electronic operation system, allowing users to lock/unlock multiple locks with the push of one button. Each lock is made of stainless steel and can be installed in backsets of 55-100mm.

Schwepper has also launched off-the-shelf components for designing and building aluminium stairways. This development comes in response to demand for a standard portfolio of components; the company previously had to supply a draft of components from scratch for each customer.

Schwepper has made the CAD data for these components available for download in order to aid designers.

Stairway design made simpler

A spokesperson for the company says: "We collected from all preceding projects and built up a standard portfolio of components, which can still be extended or adjusted to the individual need. Our answer is the structuring of this portfolio in conjunction with the publication of CAD data files, so that the designers can draft by themselves much easier."

www.schwepper.com

Valves

Shared accommodation

A new pneumatic double valve is making its way to the maritime industry, boasting a lightweight, compact design that safely shuts off gas flow in a gas pipe and combines two valves in one housing.

Valve manufacturer, Uni-Geräte, launched its PX series double valve in February and is now beginning to process orders for turnkey gas installations in the marine market.

"The new PX valve is a safety shut-off valve compliant with the new European Standard EN 16678 for use before thermal processing plants (gas burners as well as gas engines). According to the standard, two separate, independent shut-off valves must be installed in tandem. The PX valve is a shell combining the properties of two suitable valves," says a spokesperson for Uni-Geräte.

The double valve unit holds two independently functioning valves in a single housing and reduces the required installation space to the standard installation length of a single housing, according to the company. In addition, installation heights are 50% smaller.

These reductions, as well as the compact nature of the design, lower the oscillation amplitudes and loads experienced in applications in the gas engine sector.


Uni-Geräte's PX valve combines two valves in one housing

The company adds that pressure loss is reduced by up to 40% when compared with installations that have two single valves.

Material for the valve housing may be aluminium, steel or stainless steel and the cast steel housings used offer the material attributes required by classification bodies in the shipbuilding sector.

www.uni-geraete.com

Facilities

Just-in-time factory upgrade

Rescue technology specialist, Survitec, has modernised its major factory in Chevanceaux, France, to drive productivity with just-in-time manufacturing techniques that create products to meet demand.

The company says that the move to just-in-time manufacturing techniques ushers in better productivity and quality for the factory, SurvitecZodiac, which manufactures large escape slides and life rafts.

Nadia Delaoutre-Pollato, general manager of SurvitecZodiac, says: "The new factory layout is more efficient…By using just-in-time production our output becomes better streamlined while also reducing our operating costs. This gives us closer control over our long-term pricing and our customers benefit from this along with the reassurance that comes from knowing that their purchases are of the highest quality."

SurvitecZodiac covers a working area of 6,500m^2 and features unique cutting and manufacturing tools to meet its own specialised requirements, height adjustable floor areas, and can lift and manoeuvre large inflated liferafts and escape slides over 20m long.

The factory can conduct high and low temperature tests of new products and is equipped for the handling and safe storage of high pressure gases.

In addition, temperature and humidity levels are controlled throughout all of the workshop area to maintain the correct curing temperature for the adhesives used in liferaft manufacture, and medical supplies that are installed aboard the company's liferafts have specialised storage and control facilities.

www.survitecgroup.com

Flooring

Anti-slip glass for maritime

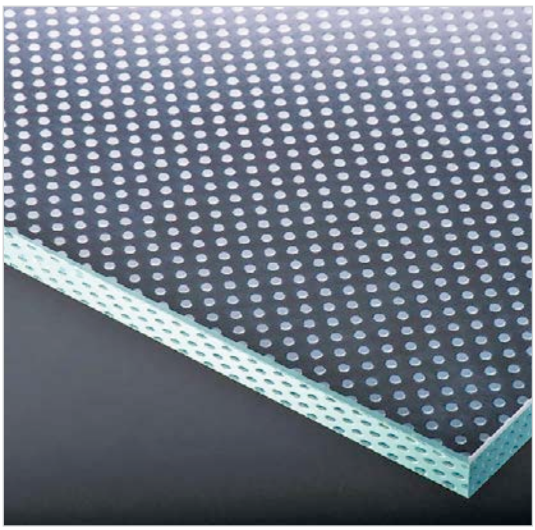
Windows, doors and hatches designer and manufacturer, Seaglaze, is collaborating with a float glass manufacturer to research anti-slip, 'walk on' glass for deck applications and marine closures, such as hatches.

The company says that a product of this kind would be attractive in situations where light might be required beneath, but a non-slip finish is required.

At present, three designs have been safety tested by The Institute for Occupational Health & Safety in Germany, but SeaGlaze believes other finishes can be achieved. The glass comes in thicknesses of 10, 12 and 15mm and has an anti-slip rating of R11.

www.seaglaze.co.uk

Seaglaze's anti-slip DREAM finish



FORAN rises to the challenge

Biennial FORUM meetings are held to discuss the FORAN CAD/CAM/CAE system developed by SENER. This year's event, held last month in Cadiz, Spain, allowed users and developers to meet and discuss the evolution of the system. Changing regulations and growing computer power means FORAN must constantly meet new challenges. Eric Tupper reports

The format adopted at this year's event was different from that of previous conferences. Roughly half the time was devoted to presentations by SENER staff on the features of FORAN – V80R2.0. The rest of the time was devoted to "Open Round Tables" after SENER staff had introduced various topics considered of interest to users.

The round tables were arranged in two simultaneous tracks, with delegates attending the track which most interested them.

After the welcoming address, Jesús Ángel Múñoz said that the release in June of V80R2.0 of FORAN would introduce important improvements increasing user productivity and efficiency. A new geometric core aims to provide better numerical results and faster calculations, as well as greater system robustness and better representation and modelling of the project. The applicability of the system to a series of ships provides a powerful tool for replicating similar, but not identical projects, which significantly increases productivity. Other improvements include a new geometrical kernel; improved definition of analytical surfaces; new corrugated bulkheads definition; and a new pipe line manager.

Antonio Valderrama discussed the new functionalities for welding management, explaining that control is needed in every aspect, from the concept design to the ship operation, and especially throughout all the manufacture steps. The right control, he continued, will make the difference between a regular and a successful ship, and distinguish a profitable shipyard among the rest. Control is particularly important in the military and offshore industries, with their higher standards and more stringent requirements. The welding process increases the ship weight by 1% to 3% of the steel weight. This has an impact on surface ships, but becomes critical for submarines.

SENER has incorporated a new functionality to cover the identification, codification, calculation and specification of each weld needed for the hull structure, piping, HVAC, cable trays, and outfitting structure. FORAN will contain the information to achieve full traceability of welds, calculate the weight increase and establish the time needed to perform the welding operations and define the welding material and procedure.

In a review of what he termed 'the new technologies' for engineering processes, Luis Sánchez outlined the use of virtual reality, tablets and PCs. The key factor for applying these technologies is the creation of a ship 3D model, integrating all design disciplines in a single environment. This development allows the 3D navigation and interaction with the model in an immersive experience, opening up a range of possibilities that benefit all stakeholders. 3D models represent the results of the design phase, while in production everything is real and analogue. Tablet PCs are consequently the bridge tool that connects the real and virtual worlds: design and production.

Virtual Reality (VR) is the most promising technology for engineering design and manufacturing, speeding up design, development, and planning processes in an interactive and collaborative environment that provides greatly improved product understanding for the shipbuilding industry. Sánchez said that by visualising 3D data in FORAN VR solutions, decision-makers are able to handle multi-discipline, multi-layer and multi-site capital-intensive processes in the best imaginable conditions.

These three presentations were followed by the first session of four open round tables. These covered:

1. FORAN for basic and class designs. The relative merits of basic design in 2D or 3D; the challenge of producing a single tool for the design and production of any kind of vessel from concept design to operation; integration of naval architectural calculations into one set of software; advanced surface modelling; 3D compartment layouts.
2. Openness of the systems in terms of how FORAN is able to communicate with other systems and capabilities that allow the users to introduce their own-functionalities at all stages of the process.
3. Long term product strategy and technological challenges. The discussion used the CAD Trends 2016 report including survey results for the last 3 years and predictions for up to 5 years into the future.
4. New collaborative engineering trends. This covers the experiences of BAE Naval Ships Glasgow (master site) and BAE Naval Ships Portsmouth which have approximately 120 users in Glasgow and 45 in Portsmouth. Their system runs on FORAN V70R3.0. At first the FORAN manager was sceptical, due to initial teething troubles, but today it is regarded as a stable and mature tool, far more efficient than initially expected. It is under consideration for the next project.

The following day opened with two more open round table discussions:

1. Optimisation of the production model outputs.
2. Integration with Product Lifecycle Management (PLM) tools. This discussed that PLM must be integrated with the relevant shipyard applications, allowing configuration management of a series of vessels but with user access and security implications. The FORAN 3D model has a PLM specific layer common to all PLM systems but interacting with users' individual systems.

The final session of the meeting opened with a presentation by Verónica Alonso on FORAN in naval shipbuilding. She said that naval programmes are becoming more constrained due to the demands of different stakeholders. Navies require powerful and multipurpose platforms capable of carrying out different tasks with minor modifications whilst complying with restrictive rules and regulations in a dramatically increasing security environment. Shipyards need to develop surface vessels and submarines over long design and production periods and be prepared to make changes during the programme within a limited budget.

These needs are affecting the traditional ways of designing, especially the way of managing the information, in design, production and operation. For many years SENER has been working closely with some of the most advanced naval shipyards and design offices in the world.

Next, Rodrigo Pérez discussed an economic study of the FORAN implementation in a shipbuilding environment. He described an analysis performed to provide a clear idea of the "return on investment" (ROI) of using CAD Systems - in particular FORAN - in a generic shipyard. The analysis considered the changes in productivity during the application period. Those changes can be represented by a transition curve during a learning period. After that period, the standard productivity gain is achieved. FORAN was shown to reduce design and production costs, making savings in materials due to a more accurate definition of components and material management, a significant reduction of design changes, a consequent reduction of rework in production, and savings of production man-hours due to the reduction of changes and rework.

A 1,200 passenger ferry, *Mapinduzi II*, designed with FORAN software

As a result, the ROI analysis and sensitivity analysis showed that the implementation of FORAN in a generic shipyard is justified. The expected benefits are considerably higher than the costs incurred, despite a high variability of productivity gain. In addition to the factors considered in this ROI analysis, there are others, such as the Internal Rate of Return (IRR). Assuming all CAD system investments require the same up-front investment, the CAD system investment with the highest IRR would be considered the best.

Another key aspect of the presentation was the analysis of the learning curve of FORAN implemented in a generic shipyard. This showed the rate at which the system was efficiently adopted. The data collected from hours expended designing blocks and units of different weights over a couple of years provided a very good tool for analysing the factors that affect the learning curve.

Rafael Martínez-Abarca followed with a review of FORAN development strategies. FORAN V70R3.0 was introduced in July 2014, V80R1.0 in June 2015, V80R2.0 in June 2016 and V80R3.0 is scheduled for the second half of 2017. This shows a high rate of system development. SENER continues to invest significant resources in enhancing the FORAN System capabilities in order to provide its users with the best tools to improve their efficiency in the design processes and to reduce total shipbuilding costs. To decide how FORAN should be in the midterm future, SENER establishes the FORAN users' requirements, and together with SENER's own vision, builds the strategic development plan.

The speaker went on to describe the main development themes, which included full integration with classification societies' design and scantling programmes; rule based design; and automatic pipes, ducts and cable tray routing. The aims are the paperless shipyard with the ability to design anywhere and build anywhere.

Over 60 delegates from 11 countries attended the conference and de Góngora described how SENER has maintained its clear vision of the way ahead for FORAN and continues to devote considerable resources to its development. There are many users of FORAN, producing significantly different ships/structures, and with interest in different stages of design, construction and maintenance. Each user has different methods of working. It follows that the core systems must be adaptable and capable of linking smoothly with shipyard systems. *NA*

Polar Code's ice design imperative

Increasing navigation of highly sensitive environmental areas, such as the Polar Regions, necessitate new rules and an accommodation of ship design to meet the challenges of operating in extreme weather conditions. The Russian Register is updating its 2012 'Methodology' for calculating pressure on vessels operating in these conditions

Russian nuclear icebreaker *Arktika* was launched in mid-June and is expected to escort vessels through severe ice. Source Nikita Greydin

Numerous research reports and presentations show that the freight volume on the Northern Sea Route (NSR) and the overall intensity of navigation on the NSR over the last two-three years has grown. For shipowners using the NSR for a voyage between European and Asian ports, the reduction of distance has been estimated to be almost 4,000miles compared with traditional routes.

At the same time, ensuring a high level of safety is still a serious challenge. The introduction of the mandatory International Code for Ships Operating in Polar Waters (the Polar Code) is a significant step forward, which is intended to enhance maritime safety and protect the fragile environment of Polar Regions.

According to the Polar Code, a mandatory Polar Water Operational Manual (PWOM) should be available onboard vessels operating in Polar regions. As the Polar Code indicates in Chapter 2: "the goal … is to provide the owner, operator, master and crew with sufficient information regarding the ship's operational capabilities and limitations in order to support their decision-making process". This requirement means that the methodology for calculating the operational limitations and permissible operational regimes in ice conditions should be available for the industry, and the subsequent calculations should be kept onboard the ship. Such methodology should incorporate the feedback from existing operational experience in icy conditions and address the structural integrity of the ship to avoid severe damage.

The engineering methodology addressing such aspects of ship operation in ice has been the focus of the Russian Register of Shipping's (RS) research for a number of years, supported by several joint research programmes with leading Russian institutes and universities possessing considerable experience in the design, construction and operation of ice class ships.

The introduction by RS of the Ice Navigation Ship Certificate (Ice Certificate) in 2012 moved this activity to a significantly more mature level, giving clients the opportunity to receive class approval that is supplemented with the calculation of a ship's permissible operational conditions. Such certificates have been offered as an optional and recommendatory class society solution aimed at assisting ship operators in the decision making process, with a view to reduce the risk of having massive damage to ship structures in ice conditions.

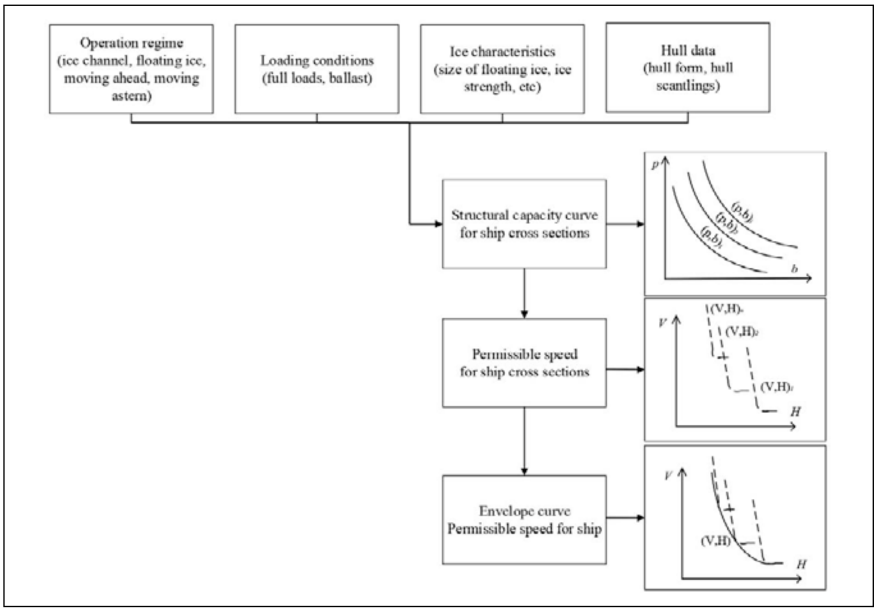
Together with the Ice Certificate, RS's "Methodological Recommendations for Calculation of Permissible Operational Regimes in Ice" (Methodology) was introduced in 2012. Methodology provides the calculation procedures to address the most critical aspects of ship interaction with ice from a structural strength point of view and to come up with ready-to-use recommendations to assist the decision-making process.

The aim of the calculation, which is a mandatory supplement to the Ice Certificate, is to determine the recommended permissible speed of the vessel (V) and the thickness of ice (H), presented as ready-to-use curves for different ice conditions. Such curves are based on the ship structural capacity, described by ice pressure (p) and ice load patch height (b) corresponding to the specified strength criteria.

Assuming the low probability of structural damage in normal operational conditions, a rather conservative approach is recommended with yielding criteria for framing and ultimate strength criteria for plating are accepted. This, however, does not restrict the shipowner from assessing the ultimate limitations of the ship by applying less demanding criteria and calculating the ultimate strength of the structures in the plastic domain using FEM.

A ship-specific approach was offered to evaluate the permissible operational conditions. It means that the calculation takes into account ship specific characteristics well known to significantly affect the structural strength in ice, such as the actual hull form of the ship and actual scantlings of the ship structures. This gives the possibility to take into account not only the class notation itself, but to get a better understanding of a ship's specific response in service and gives more flexibility during the ship design period when different hull forms and scantlings are compared from an in service perspective.

Input data related to the possible ice conditions in a vessel's operational sphere becomes highly important when assessing the permissible operational conditions. The impact with floating ice is taken as dominating a load case; therefore, all types of broken ice should be taken into account. Those differ not only geometrically (from "ice floes" to "ice cake"), but also from a strength point of view. Such ice properties like bending strength, compression strength and elastic modulus have a correlation with the period of navigation, ice formation history, salinity and other factors. In this context, the correct input data based on statistics is normally applied, with all mechanical ice properties calculated using semi-empirical formulae or by direct input from the database.

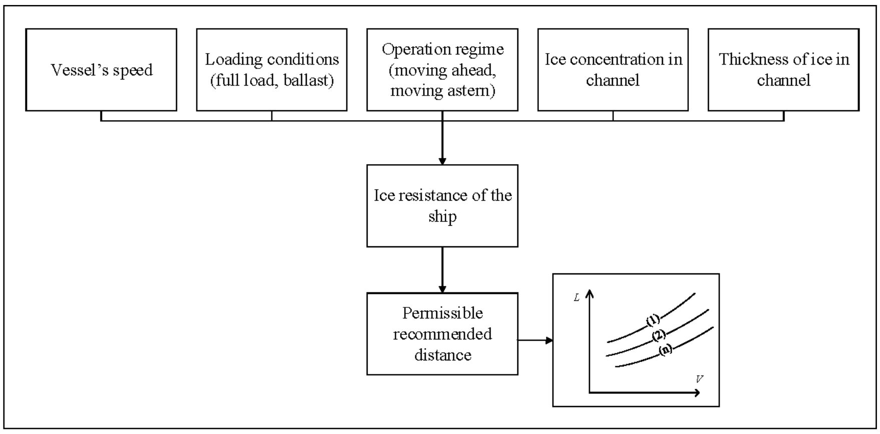


Simplified flowchart for permissible recommended speed calculation

Another important aspect of ship navigation in ice covered by the Ice Certificate is the permissible distance of an icebreaker escort. The exact value of such a distance is usually agreed before starting the escort and based on experience; however, an approximate calculation of recommended value made in advance could be useful in a decision-making process.

Permissible recommended escort distance is the distance between a vessel and icebreaker or another vessel in the convoy, and is equal to the stopway of the vessel during an emergency stop in channel. Ice resistance as a function of ship speed, can be calculated both by semi-empirical methods, one of which is presented in the Methodology, or by experimental methods using model basin and/or ice trials of the ship. Experimental data becomes increasingly important when assessing permissible escort distance; ship ice resistance is a complex function, which includes the factors closely correlated with ship hull form, ice properties, and even the characteristics of the escorting icebreaker itself, giving different values for different ice channel widths. Results of the calculation are presented as ready-to-use curves that show the relation between ship speed in an ice channel (V) and permissible recommended escort distance (L) for several sets of ice properties and ship loading conditions.

RS continues the further improvement of the Methodology. A first draft of the new edition was presented in 2015 at several Russian conferences (NEVA-2015 and others) and to a number of Russian shipowners continuously using ships in ice conditions. Positive feedback from leading Russian research institutions and universities has been received. The main goal is to implement the feedback into the new edition of the Methodology, which is expected to be finalised later this year. *NA*



Simplified flowchart for permissible recommended distance calculation

Jiangsu Shipbuilding: survival of the fittest

Last year witnessed the rapid rebalancing of the shipbuilding industry oversupply problem in China through the closure of yards with low productivity. Wu Xiuxia reports on the evolution of Jiangsu Shipbuilding

Focusing on the theme of "efficiency, quality improvement and delivery guarantee", Jiangsu Province shipping industry has given full play to the role of the key shipping enterprises, guiding these enterprises to develop risk-resistance competence and encouraging a larger percentage of high-end green vessels. The whole industry has been developing steadily.

Han Zheng, a member of Political Bureau of the Communist Party and Shanghai Municipal Party Sectary, and Zhang Yi, Party Secretary of State-owned Assets Supervision and Administration Commission of the State Council, are present at the ceremony and turn the wheel together, which initiates the founding ceremony of China COSCO Shipping Corporation

Prominence of the key shipping enterprises

Yards that failed to modernise were rapidly eliminated in 2015. However, some key shipping enterprises in Jiangsu Province have effectively countered different risks, thus laying the foundation for future development and elevating management competence.

Currently, shipping enterprises in Jiangsu Nantong, Yangzhou and Taizhou bases possess the production capacity to cover the series from shallow water to deep water, but they have also developed the capacity to design and manufacture all types of ships except luxury cruise liners. Some of the most competitive enterprises focus closely on the demand of the market and optimise the current product structures.

Some have gained a competitive edge in energy-saving vessels and environmentally -friendly offshore structures, while other yards with strong performances have introduced distinctive products into the international market. For example, NACKS has deployed its upgrading strategy for large-size containerships and clean-energy vessels.

The jointly operated COSCO and Kawasaki Heavy Industries (KHI) yard is also moving from traditional production to smart manufacturing. Seven types of vessel, including the 300,000dwt VLCC, 300,000dwt VLOC, 5,000-6,200 unit PCC and the 5,400, 10,000 and 13,000TEU container vessels, have bridged the gap between China-built and internationally constructed ships.

NACKS has established a high-end product image through its excellent performance and quality. Yangzijiang Shipbuilding (Holding) Ltd. has implemented a series of R&D plans and programmes, with 10,000TEU container vessels as the most significant designs in its portfolio; a vessel design that has proven popular in the market due to its volume, energy consumption and emission performance. Meanwhile, the Yangzijiang yard has a steady flow of orders and a steady cash flow.

Taizhou Kouan Shipbuilding CO., Ltd is persistent with balancing development and progress, and its orders in hand will keep the yard busy until 2018. The Nantong COSCO Shipyard has delivered its semi-submersible accommodation platforms Gaode No. 1 and Gaode No.2 to Mexico Cotemar. With the development of these key enterprises, Jiangsu shipbuilding industry's innovation plan has overcome technological barriers and promoted sustainable development.

The Jiangsu province industry head said that in the future, the shipbuilding industry in the region will be innovation-driven and will focus on the structural adjustment and strategy transformation, that it will integrate innovation factors and construct a technical innovation system, and that it will guide and support the enterprises to build R&D centres for offshore engineering and shipbuilding, leading to the development of independent patented vessel designs.

Consistent with this strategy of "high-end, brand promotion and diversified development", Jiangsu shipbuilding industry has formed an offshore business which has a large production capacity and is highly efficient. The province is working on promoting a series of model projects and will facilitate the most prestigious ones.

Faster pace in industry upgrading

In 2015, many shipbuilders in Jiangsu were dedicated to enhancing management capacity. Yangzijiang Shipbuilding (Holdings) Ltd., Kouan Shipbuilding, NACKS, etc., increased investment in R&D in new assembly, new craftsmanship and new methods for construction. Information on advanced manufacturing modes is also included in to the development criteria.

Increasing investment in R&D by Jiangsu shipbuilding companies provides an incentive for companies, ship operators, owners and designers, as well as the yards themselves, to develop new vessel designs.

During the process of upgrading China's shipbuilding industry, the percentage of bulk cargo has been decreasing and high-end green ship designs have come to the fore. With the establishment of the mode of assembly for shipbuilding, Jiangsu Province has dramatically improved itself in terms of technology, management, R&D and efficiency. The period of manufacture is now close to that of Japanese and South Korean shipyards.

In response to the national policies of "China Manufacture 2025" and "Internet Plus", some enterprises have initiated "Smart Manufacturing". In particular, NACKS has introduced an automatic production line for shaped steel, bar steel and robot welding, and many other enterprises are following the joint venture yard into these areas.

Jiangsu New Times Shipbuilding introduced pipe welding robots from the moment the shipyard was established. The replacement of manual labour not only reduces the burden on the remaining workers, but also guarantees quality and improves efficiency. A senior executive of the shipyard says that with the upgrading of the industry, it is unavoidable for shipbuilders to undergo a similar transformation if they want to survive and compete.

A visible hand and its power

In 2015 there was also conspicuous merging in the shipping industry and this has led to greater industry concentration with the influence of structural adjustment becoming more pronounced.

Since 2014, Jiangsu shipyards have merged and production has modernised, eliminating excessive capacity. By 2015, significant progress in restructuring the industry was made. In this way, Jiangsu shipyards have transformed their development from "quantity growth" to "quality growth". Yizheng City alone reduced excessive shipbuilding capacity by 1 million tonnes in 2015.

The market chooses the healthy yards and eliminates the unfit ones during these periods of industry recession. With multiple development strategies, product adjustment, effective management and a focus on high-tech & high value-added products, competent enterprises will improve their competitiveness and ensure survival. *NA*

CFD helps foster innovation

A novel way to harness wind energy on ships can be developed using CFD, explains Ciro Cannavacciuolo, senior engineer, CD-adapco

Ships operate in a wide range of environmental conditions and are constantly exposed to wind. If this source of energy can be tapped to provide a local source of electricity, it would reduce emissions and increase the efficiency of ship operations. In normal operations this interaction produces only additional resistance, but CFD could help explore ways in which wind energy is converted into useful energy by using novel devices.

The main challenges for such devices are the amount of energy produced with respect to the additional drag generated from the device and any negative impact on other aspects of ship design, such as structural strength or seakeeping characteristics. It is also important to ensure that the device can produce useful energy under the majority of different operational conditions.

So far in the industry, wind tunnel tests are mainly used to perform such analyses. However, these results have their own drawbacks due to scaling effects and the extrapolation techniques used. Hence, this article looks at the possibility of exploring an idea for such a novel device that could be operated on ships to generate auxiliary power. CD-adapco's main objective was to develop and showcase a methodology that can be implemented to optimise the device within STAR-CCM+ at full scale.

Starting with the basic idea of a ducted rotating device that produces a torque as a consequence of the interaction with the fluid, the aim was to provide a possible methodology to apply in CFD that results in valid configurations in all the scenarios of interest. The CFD analysis of such a device representing a novel concept was conducted using STAR-CCM+11.02 (for the fluid dynamic part of the activity) and HEEDS/Optimate+ (for the optimisation part of the activity).

The optimisation study was made on a simplified version of the geometry. In particular, the ship itself was replaced by a step with the aim of reproducing the typical shape of the super-structure of the ship.

All the studies were made at ship scale to eliminate any scaling errors. For the simplified geometry used for setting the methodology, a constant velocity profile for the wind along the vertical direction was used. Due to the wide range of conditions in which a ship can operate, the study took into account different wind speeds (u_{ref}), but limited the range to three values:

$\upsilon ref\_1=3$ [m/s];
$\upsilon ref\_2=4.5$ [m/s];
$\upsilon ref\_3=6$ [m/s].

These three wind speeds were described via a single Field Function in STAR-CCM+ using a double If Statement:

$$u_{ref} = (\$Time<=120)?(-3):(\$Time>120\ \&\&\ \$Time<=170)?(-4.5):(-6)\ [m/s]$$

A specific "weight", w, was assigned to each of the wind speeds that is equivalent to the percentage of time they are encountered:

$w_1=0.1$;
$w_2=0.7$;
$w_3=0.2$.

In particular, the torque generated by the rotating device and the drag of the entire system were defined as follow:

$$Total\ Weighted\ Torque = \sum_{i=1}^{n} \bar{Q}_i \cdot w_i$$

$$Total\ Weighted\ Drag = \sum_{i=1}^{n} \bar{D}_i \cdot w_i$$

n = number of wind speed

$\bar{Q}$ = mean value of the torque

$\bar{D}$ = mean value of the drag

Due to the number of variables involved in this kind of study, a fully automated optimisation analysis was performed in order to find the best combination of geometry configurations and the positions on the superstructure of a ship.

An overview of the computational domain is provided in Figures 1 and 2. The Overset Region in the shape of a cylinder included the rotating device and was completely built inside the 3D CAD. This made it possible to parametrise the geometry and to expose all of the parameters inside HEEDS/Optimate+ as variables of the optimisation study.

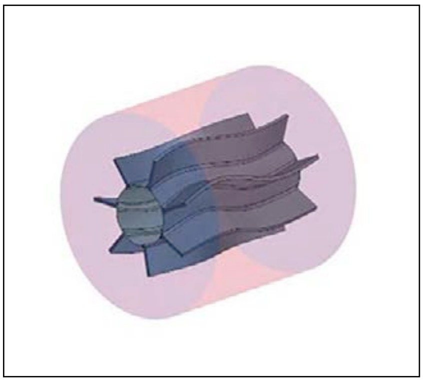


Figure 1: Overset Domain containing the turbine

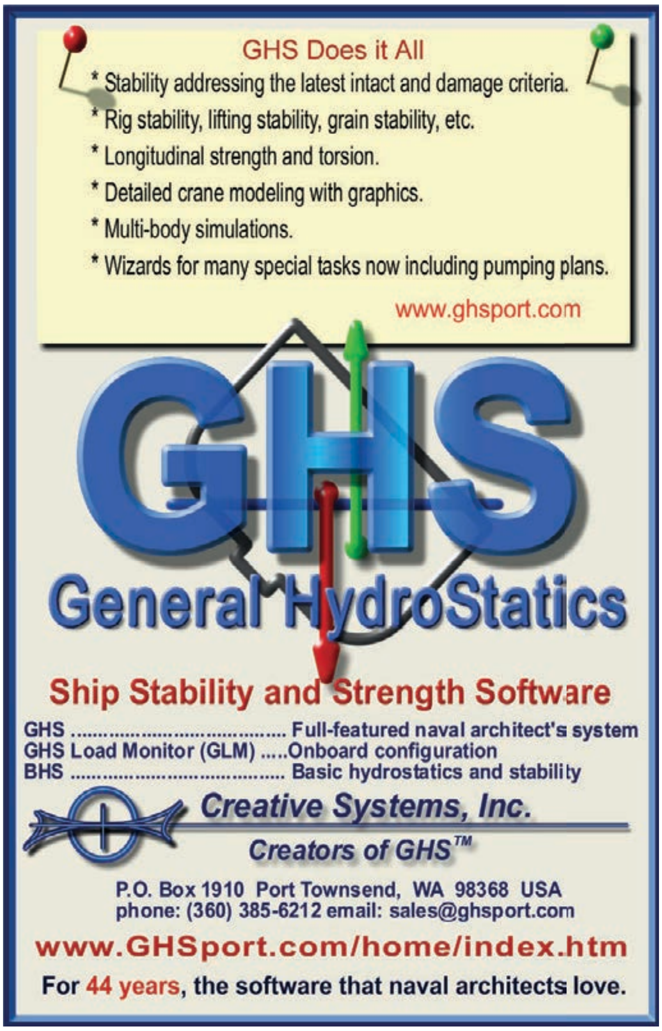
The rectangular domain (Background Region) containing the simplified geometry of a ship's superstructure and the duct of the rotating device is shown in Figure 2.

In order to expose the geometric parameters in HEEDS/Optimate+, it is necessary to draw the geometry in the 3D CAD tool. A sketch with some of the turbine parameters is shown in Figures 3 and 4.

An initial idea to independently expose all of the blades proved inefficient for an optimisation study. The lack of constraint preventing intersections between the duct itself and the rotating turbine were producing too large a number of invalid geometry configurations for HEEDS/Optimate+, affecting the quality of the optimisation process.

For this reason, a specific procedure was implemented where some of the parameters were defined as "dependent variables" of other quantities explicitly treated as variables of the optimisation study.

The same approach was used to parametrise the shape and the position of the duct. This was modelled via a spline with four control points (Pi, i=1, 2, 3, 4. P1 and P4 were the control points of the Leading Edge and the Trailing Edge, respectively).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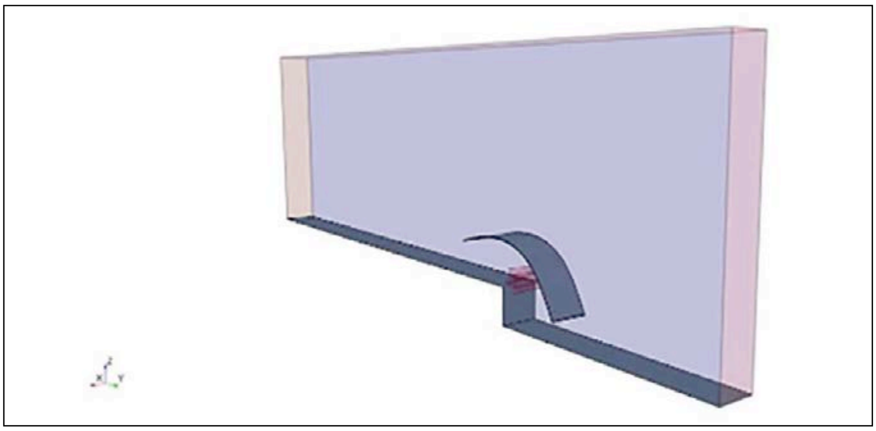


Figure 2: Background Domain containing the flap and the simplified ship geometry

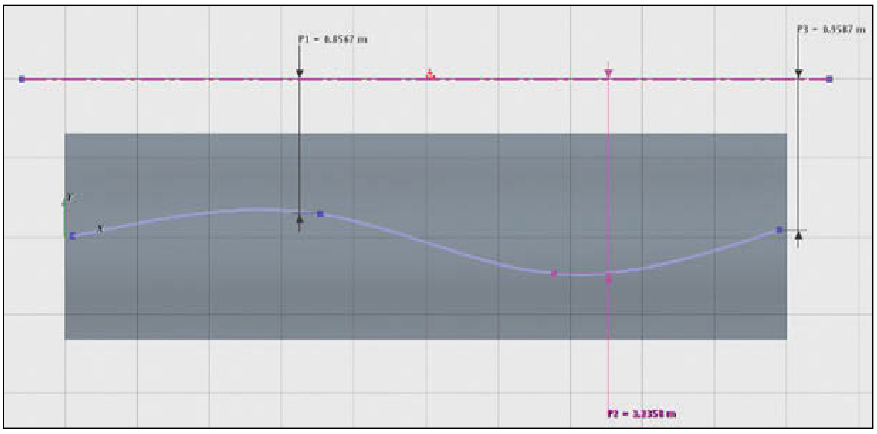


Figure 3: Parametrisation of the blade profile in 3D-CAD

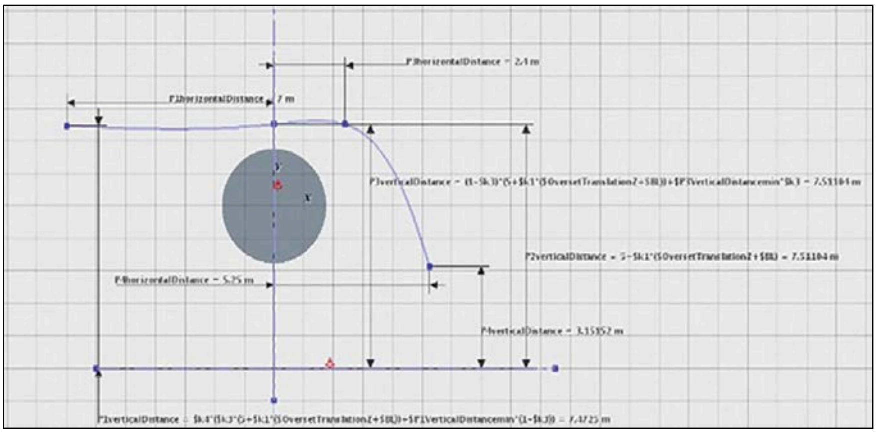


Figure 4: Parametrisation of the duct profile and position

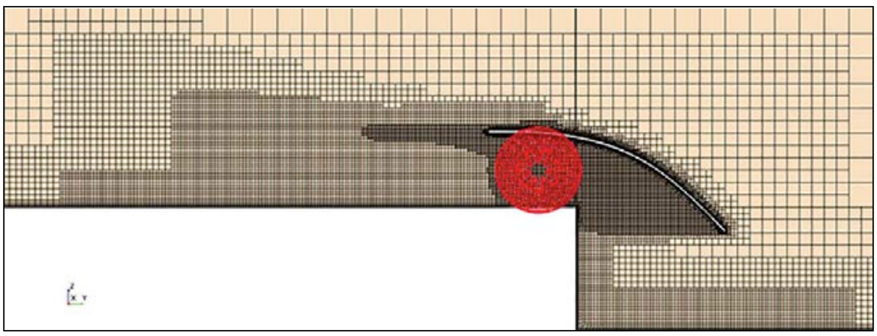


Figure 5: Mesh Refinement in the Overset (red) and Background (black) region

In addition, we defined four groups of variables based on the way their values were specified:

1. Independent Turbine Variables, controlling the number and the shape of the blade section, the position of the turbine and its distance from the duct
2. Independent Duct Variables, controlling the shape of the duct
3. Independent Shared Variables, controlling at the same time the distance between the Wind Turbine and the superstructure and the vertical position of one of the duct's control points
4. Dependent Variables that are still part of the optimisation process. However, in order to reduce the number of invalid geometry configurations, their values are not explicitly assigned by HEEDS/Optimate+/user. These values are calculated via a specific formula as a function of one or more independent variables.

Considering that the part of the domain below the water was not of interest in this study, only the part of the geometry exposed to the air was defined.

The Realisable K-Epsilon turbulence model was used and the flow was solved as Segregated. The Two-Layer All Y+ wall treatment was used to solve the boundary layer. Due to the transient nature of the flow, the Implicit Unsteady solver was used (1st Order Temporal Discretisation scheme). The flow was considered incompressible. In STAR-CCM+, Moments of Inertia and rotations are always calculated with respect to the position of the Centre of Mass (CoM) and this quantity depends on the position of the wind turbine.

The motion of the rotating device was totally un-prescribed and it was dependent on the geometry of the device itself and the duct. For this reason, the DFBI solver was enabled. This solver required the definition of the mass properties and in particular of the initial conditions. The wind turbine location was a variable of the optimisation study so a Java macro was used to update the initial position of the Centre of Mass accordingly with the overset translation chosen by the optimisation algorithm.

The Overset Methodology allows an arbitrary number of meshes to be

In brief: SHERPA

SHERPA is a proprietary hybrid and adaptive search strategy available within the HEEDS software code that forms part of CD-adapco's software suite. It uses the elements of multiple search methods simultaneously (not sequentially) in a unique, blended manner. This approach attempts to take advantage of the best attributes of each method. Attributes from a combination of global and local search methods are used, and each participating approach contains internal tuning parameters that are modified automatically during the search according to knowledge gained about the nature of the design space. In other words, SHERPA efficiently learns about the design space and adapts itself so as to effectively search all sorts of design spaces, even very complicated ones.

superimposed over each other. This methodology was used in order to model the rotating device and is particularly suitable for this kind of analysis, allowing easy movement of the rotating device around the ship without involving any extra operation to prepare the fluid domain.

The computational domains were discretised using a trimmed-cell mesh, comprising of hexahedron cells aligned with the direction of the nominal flow. This way, the mesh-induced numerical diffusion is kept to a minimum.

The mesh strategy has been partially affected by the overset methodology. It actually imposes that the "mesh sizes had to match as much as possible around the overset boundary". In general, it requires the definition of a volumetric control with the same mesh settings in both regions. Due to the fact that the overset region position is a variable of the optimisation study, it was necessary to constantly update the position of a volumetric control with the new position of the wind turbine accordingly. This has been reached using the same Java macro that was controlling the Centre of Mass location.

The duct geometry (profile's shape and length) was also part of the optimisation study and so was affected by modifications. A fixed volumetric control would only have worked if a similar strategy was used for the wind turbine. Instead of using another (and similar to the previous) Java macro, the STAR-CCM+ Wake Refinement feature was used.

By specifying the Distance, Direction, Spread Angle, the Target Size and the boundary (the duct), a "shape independent" fully automated wake refinement was defined (Figure 5).

Optimisation strategy

The aim of the study was to find the geometric configurations of the duct and the wind turbine (shape and position) that would generate the highest power at the minimum cost in terms of additionally produced drag at the three different wind speeds. This meant that the final result was the one that represented the best compromise between the variables involved rather than performing best at any particular wind speed.

The study used the following formula for the Weighted Torque:

$$\textit{Total Weighted Torque} = \sum_{i=1}^{n} T_i \cdot w_i$$

In HEEDS/Optimate+ the objective function for the power to be maximised was defined as:

$$\textit{Total Weighted Turbine Power} = \sum_{i=1}^{3} \overline{T\omega_i} \cdot w_i$$

The second objective was to minimise the Drag, defined as:

$$\textit{Total Weighted Drag} = \sum_{i=1}^{3} \bar{D}_i \cdot w_i$$

Due to the fact that two objectives were defined for this simulation, the MO-SHERPA algorithm for the definition of the Pareto Front was used in the optimisation study.

MO-SHERPA (Multi-Objective SHERPA) is a specific version of the algorithm SHERPA (see box) for multi-objective Pareto searches. It works fundamentally like SHERPA, but has the advantage of handling multiple objectives independently of each other to provide a set of solutions, each of which is optimal in some sense for one of the objectives.

Results

The first objective was to develop a sufficiently robust methodology for an optimisation study. The quite large number of totally independent geometric variables involved in the optimisation study was unavoidably generating too large a number of invalid configurations. In a preliminary CAD Robustness test performed in HEEDS/Optimate+, only 31.5% of designs resulted valid. By using the methodology described the CAD robustness test showed a score of 91.5%.

128 designs were run in the optimisation study, allowing us to build the Pareto Front for the Total Weighted Drag vs the Total Weighted Turbine Power (Figure 6).

By looking at all the Non-Error Designs the first important information obtained was that a non-negligible number of designs showed a very low Turbine Power with a quite high Drag (left hand side of the plot showed in Figure 6). By analysing the results, these designs were all characterised by an "oscillating" turbine. In other words, the interaction with the flow was not able to let the turbine start rotating, resulting in an oscillation of the rotational speed around 0 rad/s.

Figure 7 shows a comparison between the instantaneous drag of the baseline and some of the best designs identified by SHERPA. It appears evident that the mean value of all the best designs is lower than the baseline (from a minimum of ~9% to a maximum of ~22%, depending on the wind speed).

This result has been justified by the fact that the baseline case was characterised by a large flow recirculation downward of the step (Figure 8). This separated flow was mostly reduced (in some cases completely removed) by the action produced by the duct. The expected extra resistance produced by the turbine was, in the Pareto Front designs, lower than the reduction produced by the "duct effect". If confirmed on a ship, an important consequence of this is a reduction of power required to keep the ship's cruise speed under these wind conditions.

In terms of Total Weighted Power, it is important to highlight that "the time required for the wind turbine to produce power" was an important aspect in the study.

For this reason, a time of 220seconds was fixed and the performances of the different designs have only been evaluated within this interval of time. With this assumption, the designs on the Pareto Front are the ones that, limited to the first 220seconds, are producing the largest amount of ideal power at the minimum cost in terms of drag.

Figure 9 shows the instantaneous torque produced by some of the designs on the Pareto Front. In this plot, the curve named Torque001 refers to the baseline design run in HEEDS/Optimate+. All the designs on the Pareto Front are optimised compared with it.

Conclusions

This study was primarily focused on showcasing how current state-of-the-art CFD technology allows for the exploration and testing of ideas, such as a performance optimisation study on a novel green energy concept under several wind conditions.

The parametrisation of the geometry, achieved using 3D CAD in STAR-CCM+, created the possibility for exposing all the design parameters in HEEDS/Optimate+ and easily updating the configuration during the run.

In order to improve the quality of the optimisation study, it proved necessary to define some design parameters as functions of others. This allowed us to automatically control the shape of the geometries in order to reduce the number of invalid configurations (~8.6%) as much as possible.

The reduction of the number of parameters to optimise from 23 to 11 was an additional achievement obtained with this approach.

The mesh strategy applied (wake refinement feature and volumetric controls location defined as a function of the Centre of Mass of the turbine) guaranteed a consistent method and quality of the mesh, fundamental for a comparative study.

In terms of flow solution, the studies on the simplified version of the ship identified some geometric configurations that were not able to let the wind turbine "start" i.e. rotate, resulting in a very low level of power produced.

The optimisation has been performed based on "weighted" quantities, but looking at the instantaneous values and comparing

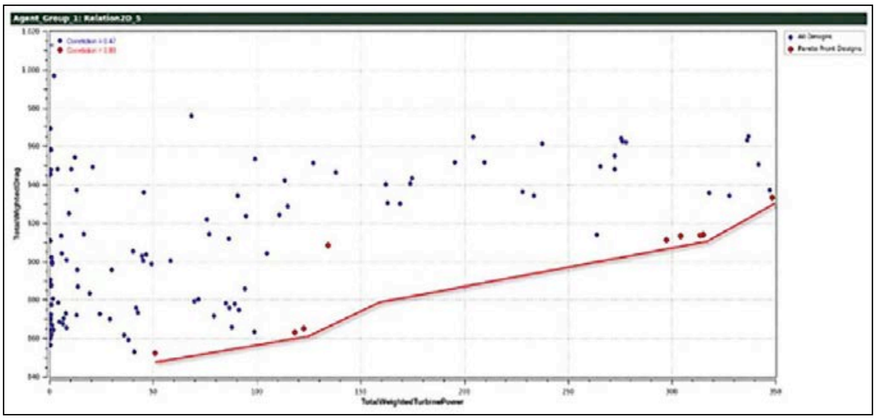


Figure 6: Pareto Front calculated by SHERPA

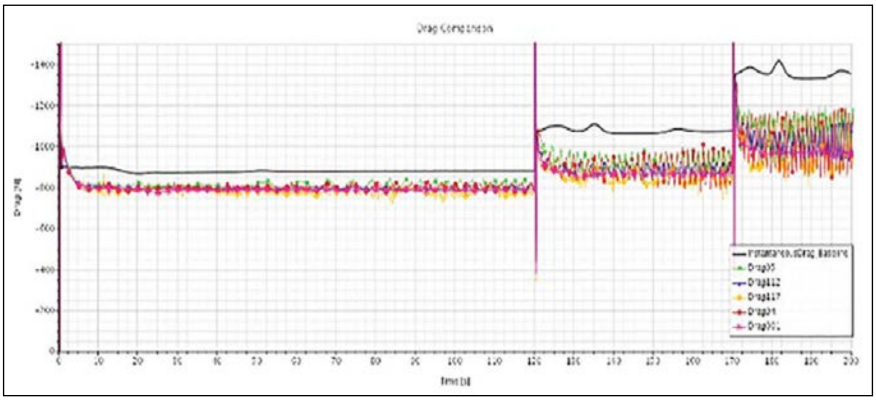
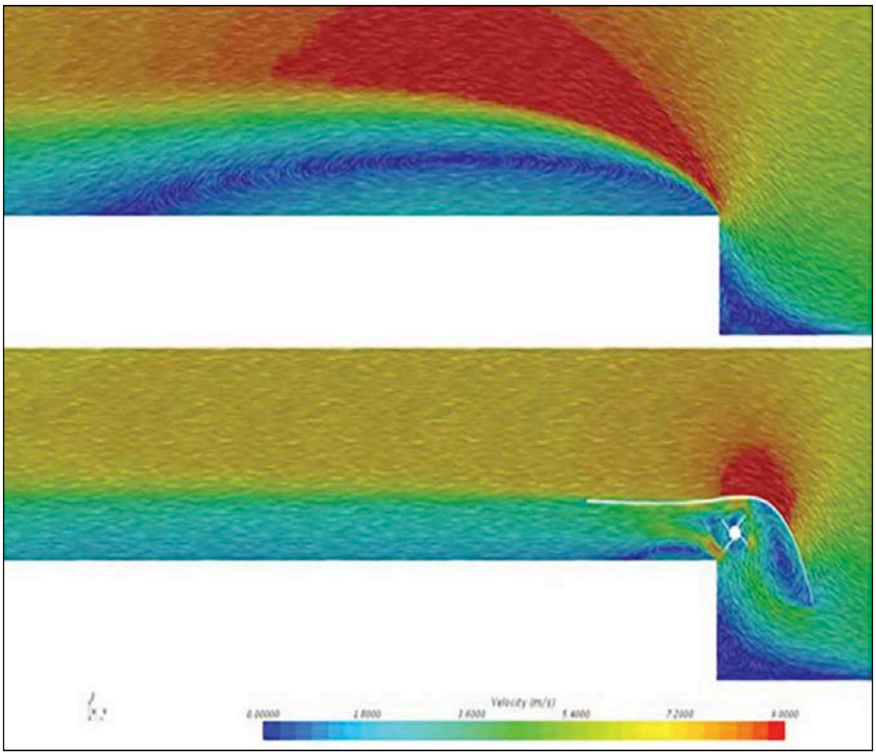


Figure 7: Comparison between the drag of the baseline (no turbine, no flap) with the drag generated by some of the Pareto Front designs

Figure 8: Effect of the duct on the recirculation of the flow



Pareto Front designs with the baseline showed a large improvement at each wind speed (Figure 10).

The effect of the duct reduced the total drag of the system and all the designs on the Pareto Front resulted in better performances than the baseline geometry (where there was no duct or turbine).

The next step is to apply the same methodology on the actual geometry of a ship superstructure. At the moment, two possible approaches are under investigation:

1. The device is optimised on a simplified geometry and then "installed" on a ship
2. The optimisation study is carried out directly on the ship geometry.

This second approach is more computationally expensive but creates the opportunity to let HEEDS/Optimate+ undertake a deeper investigation, exploring a wider range of possible locations for the device. There is also the possibility of defining structural constraints with this approach. *NA*

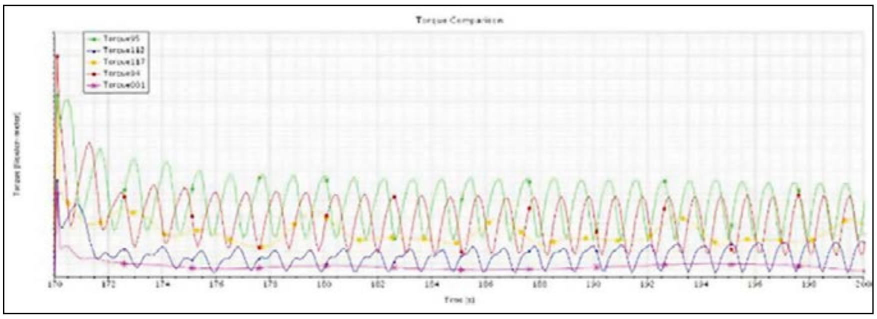


Figure 9: Instantaneous Torque produced by the Pareto Front Designs vs the Design 001

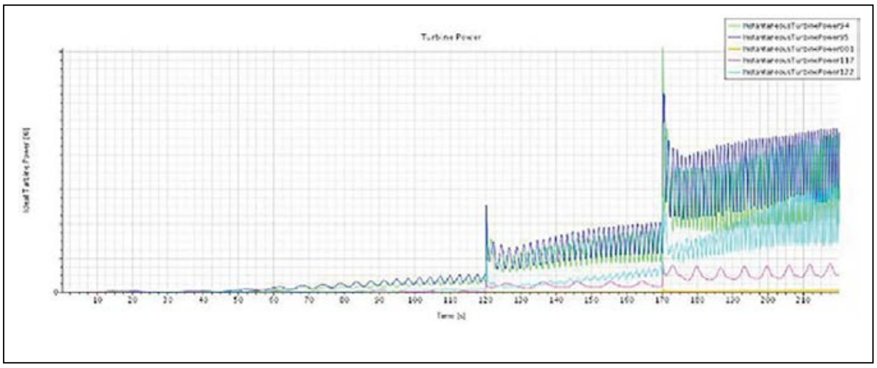


Figure 10: Instantaneous Power produced by the Pareto Front Designs vs the Design 001

Hybrid approach wins out

Norbert Bulten, general manager of hydrodynamics at Wärtsilä, extols the virtues of implementing CFD in the design process

The maritime industry is experiencing a transition from the use of conventional model experimental testing methods to the use of numerical flow simulations. As is often experienced in change, there is a degree of scepticism and opposition. So, in order to get the best of both worlds, Wärtsilä currently proposes a hybrid approach.

This article will detail the benefits of the use of numerical flow simulations based on a number of viewpoints. First, the motivation for a change of the established experimental methods will be given, followed by the evaluation of potential analysis methods. This evaluation will be based on some simple business criteria, including achievable accuracy and precision, cost and lead times.

The implementation of new ways of working might also bring additional new features and capabilities, as observed when smart phones were introduced to replace conventional mobile phones. In the case of research and development of products concerning fluid dynamic principles, methods which can visualise the flow phenomena and quality of the forces acting on the various subcomponents of the system can significantly enhance our overall understanding. Better performing designs can then be made with this greater understanding of the actual flow phenomena. In addition, given the fact that the driving forces of CFD simulations, namely software and hardware, are continuously under development, an outlook on future developments is also represented.

Motivation for change

The motivation to change the current model testing approach is supported by two forces:

- Market pull to get to the best possible overall efficiency
- Developing technologies that can push the capabilities of numerical flow simulations

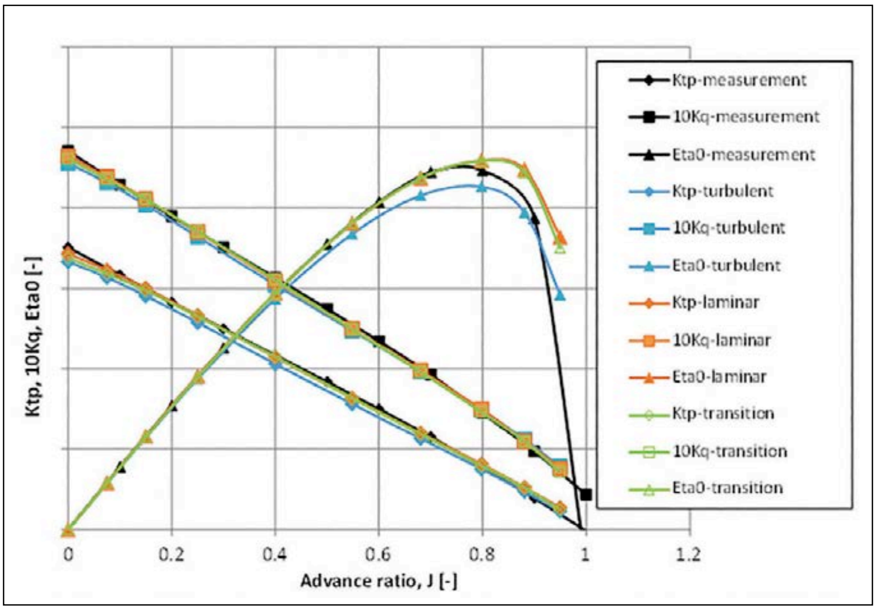
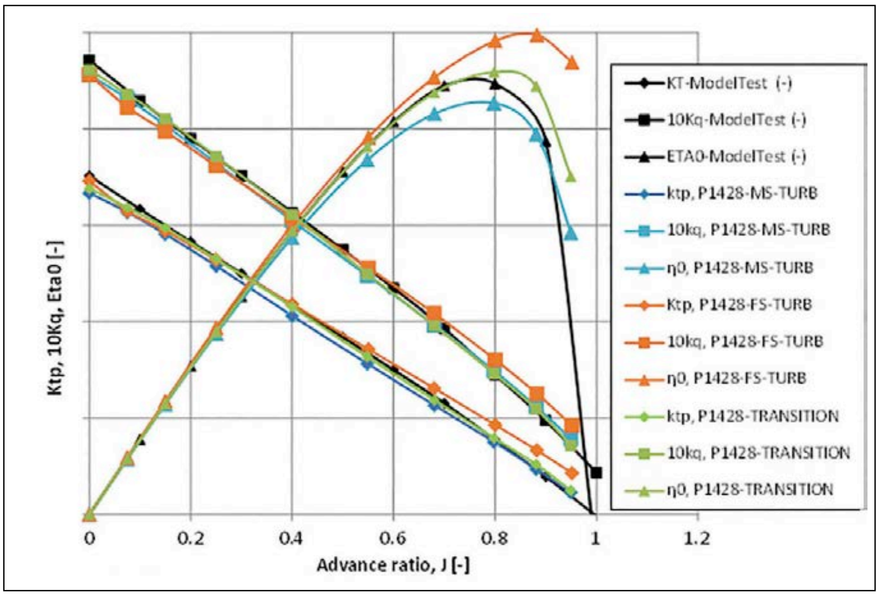


Figure 1: A comparison of measured propeller performance on model scale with CFD model scale results for various turbulence modelling approaches

The current situation in the maritime industry calls for the best possible overall efficiency of a vessel in operation. With new regulations such as the Energy Efficiency Design Index (EEDI) and the Energy Efficiency Operating Index (EEOI), a clear focus on the overall energy efficiency has been established. As a response to this search for highly efficient systems, hull and propeller

Figure 2: A comparison of model scale and full scale CFD results with experimental data



designs are undergoing reviews, but various energy saving devices (ESDs) are also on the market, for example, rudder-bulbs, propeller boss cap fins, pre-swirl stators and ducts. The efficiency gains of the various ESDs are often in the range of a few percent.

Nowadays, such gains can still be regarded as vital in the industry, but these fairly small differences draw more focus on the reliability of the applied evaluation method. In cases where model testing is used to determine the differences between two concepts, it has to be taken into account that the model test suffers from a certain amount of measurement spread (precision or repeatability). Because of this, differences within 1% cannot be attributed solely to the differences in tested geometry.

The technological push from developing numerical simulation tools can be seen in other industries like the automotive industry, which covers everything from Formula 1 cars to large trucks. The competiveness of Formula 1 is a key driver in the use of these tools, while large trucks must meet constraints that are similar to those within the maritime industry. Implementation of CFD in the automotive industry has been a process where part of the research carried out in wind tunnels has been gradually replaced by CFD. A similar transition needs to be made in the maritime industry.

Accuracy and precision

For a certain analysis method to be of value the accuracy and precision of the outcome must be ensured. The main focus of CFD is often on the accuracy of the results based on comparisons with model scale measurements. This approach is basically correct, though not complete. The fact that model test results are subjected to extrapolation methods to predict the actual full scale situation is often overlooked. Over the years, various extrapolation methods have been developed to overcome the fundamental difference in the Reynolds number of the typical flow phenomena when model tests are being used.

Fairly recent work on propeller CFD simulations has revealed some interesting phenomena regarding the so-called open water performance determination. In such a set-up the propeller is operating in a uniform inflow, so with the ship hull just upstream of the propeller. It is assumed that with a sufficient size propeller and RPM the flow would be fully turbulent in the model scale test. CFD calculations of various propellers have been carried out with a laminar-turbulent transition model. Agreement between CFD simulations and measurements of both thrust and torque has been found to be very good over the whole range of operating conditions, from zero advance speed (bollard pull) up to advance velocity, where propeller thrust becomes negligible. The open water efficiency, which is a function of thrust and torque, shows a good correlation between CFD simulations with the laminar-turbulent transition model and the measurements as well.

Once the quality of the methodology was established, two additional CFD simulation sets were carried out assuming either fully turbulent or fully laminar flow; these flow situations are regarded to be extreme cases which should be covered

Driver	Open water	Self-propulsion
Propeller RPM	Larger RPM⇒turbulent	Smaller RPM⇒laminar
Flow field distortions / velocity gradients	Uniform⇒laminar	Non-uniform⇒turbulent

Table 1: Evaluation of possible flow regimes in open water and self-propulsion tests

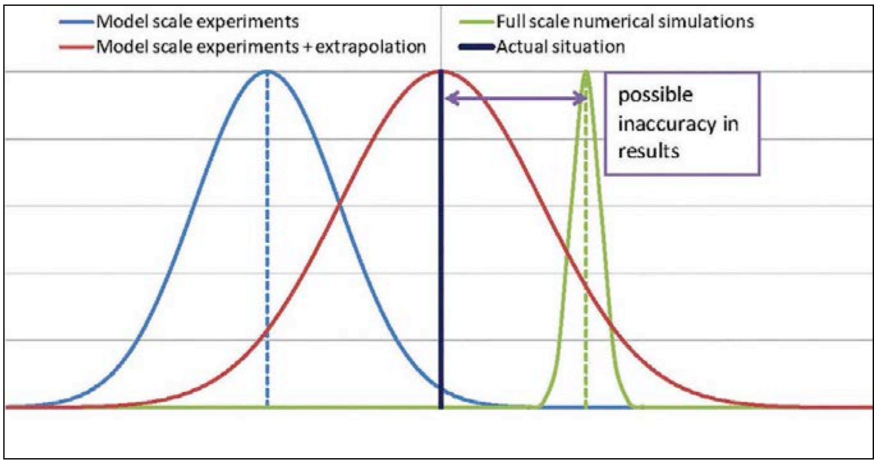


Figure 3: The concept of accuracy and precision applied to speed-power predictions

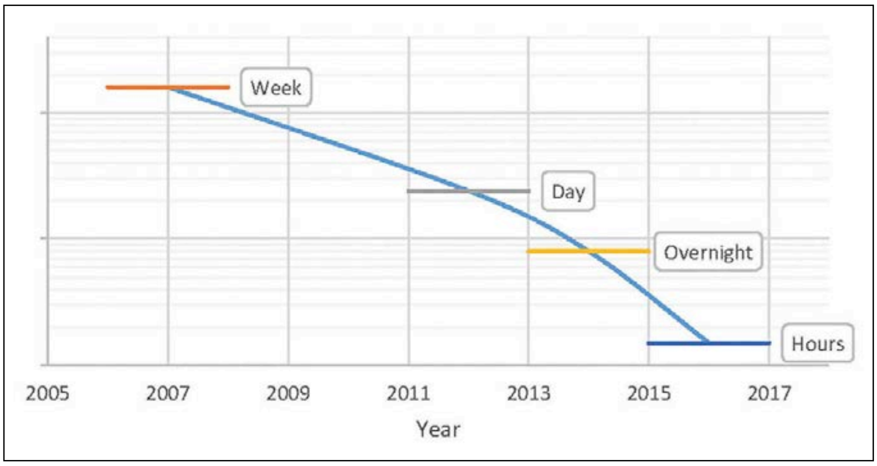


Figure 4: The changing lead times of a typical CFD calculation over time

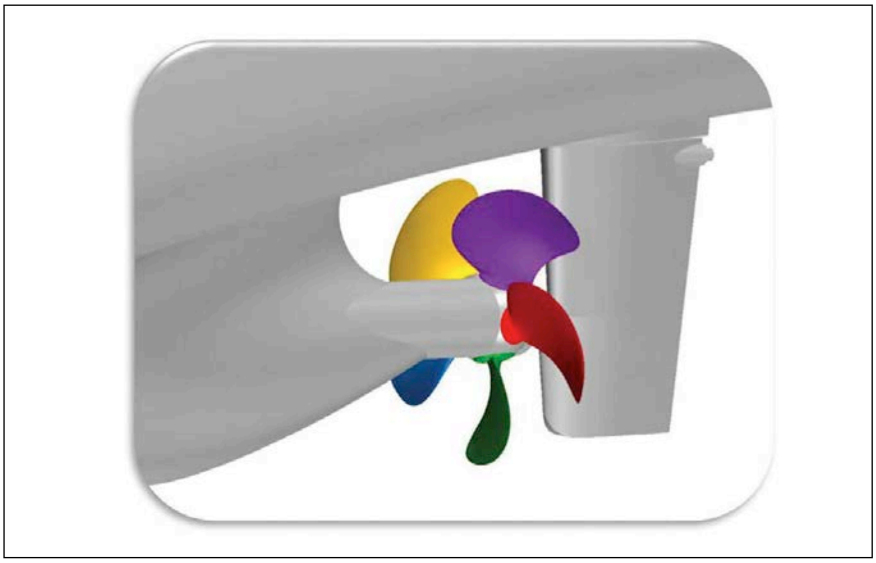


Figure 5: Concept of monitoring separate blade forces

by the laminar-turbulent transition model. Quite surprisingly, it turned out that the results of the fully laminar and the laminar-turbulent transition model both agreed well with experimental data. This seems to indicate that the actual model scale open water experiments might suffer more from laminar flow than initially anticipated. It also begs the question: what kind of flow regime is present in the self-propulsion measurements where the propeller RPM is often lower, but where the inflow velocity distribution is much more disturbed?

In cases where flow disturbance is the driving factor instead of the used propeller RPM, ideas about the presence of either turbulent or laminar flow might change dramatically. The two approaches, either RPM driven or based on the irregularities in the inflow, are reviewed both in open water condition and in self-propulsion condition (Table 1). Based on this approach, the statement that the flow could be turbulent in the self-propulsion model tests is defendable.

The precision of numerical flow simulations has the potential to be very good, but this requires full control of the applied process. Unfortunately, this scope of control is wider than simply the meshing of the geometry. Nevertheless, after sufficient time and gathered experience, it is very well possible that precision values below 0.1% could be achieved, qualifying the methodology for analyses to find the last percentage of efficiency gains.

Impact of Reynolds scaling effects

The validation process for CFD often uses model scale measurements as reference. This seems to be a logical step, since full scale measurements are so difficult to control, the accuracy of measurement data is limited, and the variation in operating conditions is often very limited for sensitivity analyses. However, it should be remembered that the truth is only in the actual sailing vessel, which should push for the application of full scale simulations.

An example of the impact of the Reynolds scaling effect is shown in the chart where the model scale results from CFD and measurements are compared to the full scale CFD simulations. In the end, the differences between the model scale measurements and the full scale CFD simulations might be regarded as limited, though it should be noted that the difference is partly covered by the laminar flow effects at model scale. In the case of other propulsion systems, like ducted propellers and steerable thrusters, the differences between model scale and full scale are much more pronounced.

The concepts of accuracy and precision are presented together in the chart, and it is assumed that the final full scale predictions, based on model scale measurements, are accurate, which is regarded to be the norm. The spread in the full scale prediction is a result of the measurement spread at model scale and the impact of the extrapolation methodology. At this moment, it is stated that the CFD simulations have a better precision, though due to lack of proper validation material it has not been

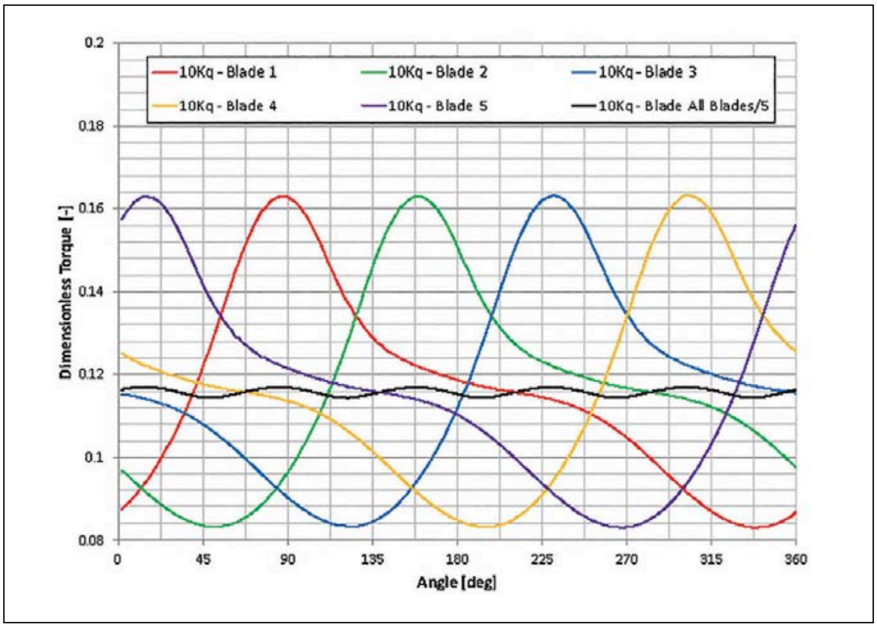


Figure 6: Fluctuating propeller blade torques during a revolution

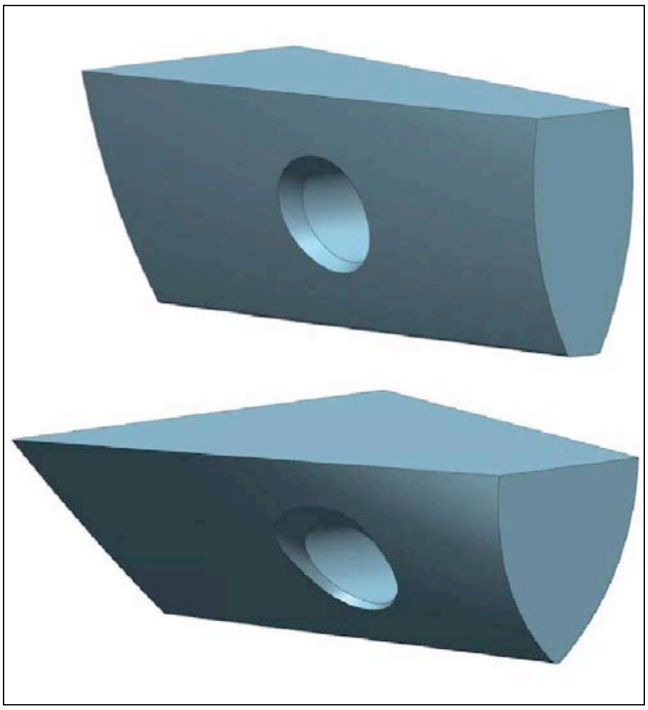


Figure 7: Example geometries of the parametric 3D-tunnel modeller

possible to give a proper indication of the achieved accuracy.

As a consequence, a hybrid approach has been proposed where the full scale prediction based on model scale should provide the accurate speed–power estimate of a ship design and the full scale CFD simulations can be used to compare various design variants where the performance differences are within a few percent. In this approach it is assumed that the possible inaccuracy of the CFD modelling is made in a similar way for the various designs so that the difference in performance outcome can then be related to the applied geometry changes.

Cost and lead times

Even if the model scale experiments have an alternative to come to similar results, there will always be an evaluation of the cost and lead times. Within the commercial sector there are limits on the allowed lead time of a new propeller and the costs of the required engineering and calculation time.

For CFD simulations, typical lead times can be distinguished where the initial developments often require days to weeks in calculation time. However, after some time it becomes possible to run a certain simulation overnight, by which it can be coupled to an engineering process. The following phase starts when it can be done within a few hours, because this enables full integration in the process. Figure 4 shows the development of typical lead times where the lead time is shown on the vertical axis in logarithmic scale. This trend gives a good indication of the expected future lead times for the current ongoing method developments, which may still require a significant number of days. However, it has to be recognised that with the time it takes to reach market acceptance, the actual lead times at full market introduction are not critical anymore.

Understanding flow phenomena

Once a high quality data set from a CFD simulation is available, detailed analysis of the occurring flow phenomena can be made. With such analysis the actual performance of the complete ship can be reviewed. The most obvious evaluations will focus on the pressure distributions on the hull and the propeller, and the velocity field around the vessel. In addition, the wave pattern of the vessel and the development of the limiting streamlines give insight into the potential improvements of the hull resistance. One level deeper, the forces of the various subcomponents can be quantified separately, which helps in understanding where the actual performance gains are to be sought.

The CFD simulations of the propeller-hull interaction also reveal the transient forces of the propeller blades during a revolution. Based on the evaluation of the forces and moments of each blade with respect to its position in the wakefield, the actual performance of the propeller blade can be determined in every circumferential position. This knowledge and understanding is a key feature in the development of the upstream energy saving devices. With the CFD simulations it is possible to couple the local blade load fluctuations to the inflow velocity field. Changes in axial or tangential velocity upstream of the blade are directly transferred into changes in the blade loading.

Once the changes in flow field are understood, the impact on the performance should become obvious. In this way, the fact that the CFD simulations might suffer from inaccuracies is circumvented.

A good performing propulsion product should not only have a high propulsive efficiency, but also low vibrations and noise. Typical applications where noise and vibrations play an important role are navy vessels and cruise vessels. The modern cruise vessel designs are equipped with a number of tunnel thrusters in the bow and the stern to have optimal manoeuvrability of the vessel. These tunnel thrusters need to be integrated in the ship hull, which is a challenging task for the naval architect. Space requirements are often tight and the V-shape of the bow can introduce a further complication.

With the aid of CFD analysis it has been shown that the local interface details between the hull and the tunnel shape play a very important role in the overall performance. In order to study this phenomenon in more detail, a parametric 3D-CAD model has been developed that can generate a large variation of hull shapes around the tunnel-thruster. Some examples of the 3D-geometries are shown in Figure 7. The parametric model can handle variations in tunnel length, the vertical shape of the hull, and location with respect to the baseline among other things. The detailed interface between the hull and the tunnel is another key-feature of the 3D-CAD model.

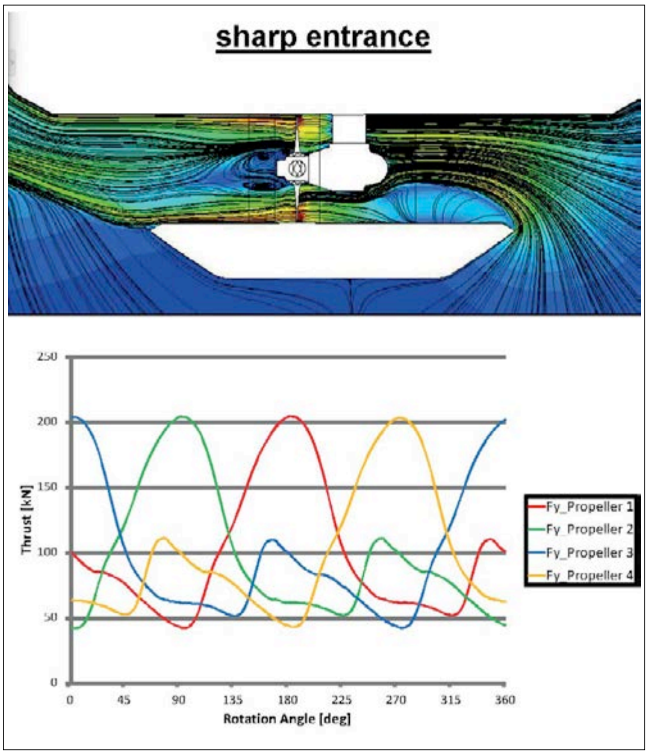


Figure 8: Fluctuating propeller blade force during revolution for a thruster with sharp edges

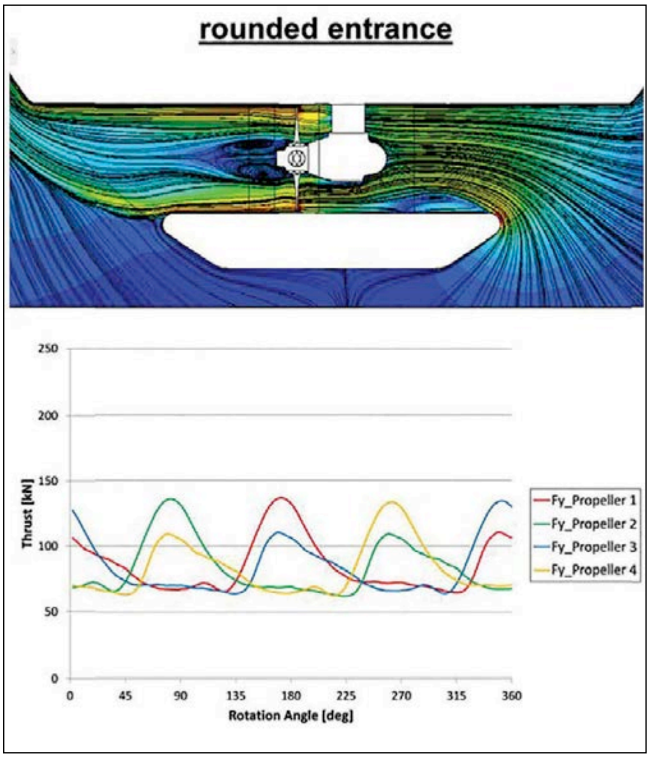


Figure 9: Fluctuating propeller blade force during revolution for a thruster with rounded edges

The impact of the local details of the hull-tunnel interfacing is shown in Figures 8 and 9, where a comparison is shown between a configuration with a sharp entrance and an improved variant with rounded edges. This analysis shows that once the flow separation has occurred at the entrance of the tunnel, large load fluctuations will occur on the propeller blades. As a consequence, the vibration levels will be impacted negatively. The load fluctuations will also lead to more dynamic cavitation behaviour, which will contribute to more noise and vibrations as well.

The fact that the relatively small detail near the tunnel entrance can play such a significant role has been often underestimated. And so based on the current presented research, it has helped naval architects at various ship yards to place more focus on the design of this detail of the vessel.

The situation shown for the rounded entrance shape is preferred, but it has been acknowledged that an interface consisting of various segments can do a similarly good job. It has, therefore, not only been an academic study to improve the flow situation, but also a very practical way to establish how a realistic shape could be made at the ship yard with sufficient margin against flow separation.

Future developments

Current state-of-the-art CFD simulations may offer a similar level of insight to the self-propulsion measurements in towing tanks. However, there are other types of tests, such as performance evaluation in waves and cavitation tests, where work still needs to be done. In order to be able to address these phenomena, the physical models in the software have been extended. Initial CFD simulations with an activated cavitation model give results that are well in line with experimental observations.

It was recognised many years ago that a ship's wakefield suffers from Reynolds scaling effect and that the full scale wakefield will thus differ from the model scale wakefield. However, it is possible to record the development of a cavity in a sophisticated model scale test in a vacuum tank with high speed cameras, and this cavity will develop itself based on the model scale wakefield. In order to get better correlations with full scale observations of the cavities and pressure fluctuation measurements, some correction procedures are now being investigated. The effort, therefore, to further develop the full scale CFD simulations with cavitation modelling included is well spent, since it will include the full scale wakefield as part of the solution. So, even though the computational time might still be challenging, there is a drive to further develop the experience on this application.

Extension of the numerical analyses to include environmental aspects like wind and waves in operation, and more detailed evaluation of the manoeuvring capabilities is possible; however the currently required effort for this kind of simulation needs to be compared with model scale experiments for seakeeping and manoeuvring.

Conclusions

Although the maritime industry seems to be a bit hesitant in adopting numerical flow simulations in the design process, it is a development which has been started and will continue. The accuracy levels of CFD are nowadays in line with model scale experiments, and for various types of measurements (propeller open water, hull resistance), the lead times and cost have been reduced significantly to offer a serious alternative to experiments.

> "Although the maritime industry seems to be a bit hesitant in adopting numerical flow simulations in the design process, it is a development which has been started and will continue"

This being said, a hybrid approach is proposed, for the moment at least, to combine the full scale speed-power predictions based on all of the experience from the model basins with the capabilities of CFD. This should facilitate analysis of the more subtle geometry changes, and, consequently, arrival at the final optimal energy efficiency at actual full scale.

This transition phase might initially lead to more discussions based on the interpretation of the new insights. It is possible that the actual full scale optimum design will not be the one found in model testing. However, as long as decisions are made based on model scale results, there will be an overestimation of the performance of some designs and an underestimation of others. Unfortunately, only the brave and stupid might select a design that does not show its full potential in model tests. *NA*

Schools of thought converge for better designs

The results of CFD analysis can be combined with traditional modelling techniques to provide benchmarks that shipyards can use to improve vessel design performance, writes ABS' energy efficiency, operational and environmental performance division

The desire of shipbuilders to develop vessel designs with improved operational efficiency has seen them embrace many new technologies in the cause of being able to market 'ecoship' tonnage to clients.

Among these techniques is Computational Fluid Dynamics (CFD), which has quickly taken hold as an effective way to generate detailed analysis of ship designs and the impact of making changes.

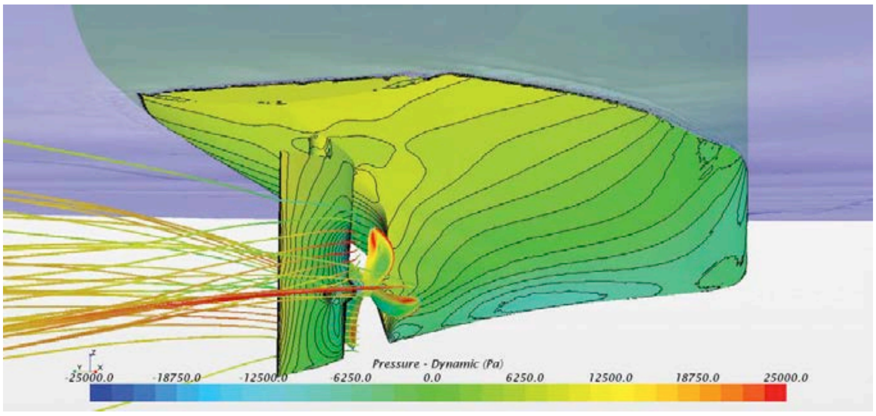
While towing tank model tests remain a proven means of assessing vessel behaviour, CFD provides an unmatched degree of detail and flexibility in terms of assessing the choices available to designers and shipyards.

While physical model tests provide some insight in terms of necessary vessel power, CFD analysis delivers detailed insight of the flow around the vessel and provides a better understanding of where improvements can be made to minimise the propulsive power needed for a given design condition.

In a recent project, ABS was approached by Bohai Shipbuilding Heavy Industry (BSHI) to evaluate the potential for improvements in hydrodynamic and propulsive efficiency of a 210,000dwt bulk carrier.

Featuring a draft of 16.1m and a design speed of 14.5knots, the design is a metre narrower than standard bulk carriers of this class due to size constraints at the shipyard. However, the design reflected a requirement to maximise the loading capacity from a length overall of 300m.

In seeking the input from ABS on potential improvement, the shipyard requested that any modifications to the original vessel design should have an effect on displacement of no more than 500tonnes, implying a design with maximum volume at the bow and stern.



The dynamic pressure distribution on the vessel aftbody, including the rudder and propeller, and the streamlines from the propeller disc

Evaluating design alternatives

BSHI sought ABS' assistance with CFD after two independent towing tank tests provided contradictory indications as to the ship's ability to achieve its design speed from the proposed level of installed power.

A first round of optimisation had succeeded in improving the performance of the original hull design to a small degree, but ABS was asked to make suggestions for possible further improvements.

The shipyard was primarily interested in knowing if the vessel's lines could be improved. The high block coefficient of above 0.85 meant such an optimisation would be hard to achieve given the strict constraints on the vessel's loading capacity.

Having analysed the initial optimisation and tank tests, ABS first focussed on improving the stern shape. A modified hull, featuring improved stern lines, but retaining the original propeller shaft height at 4.5m above baseline, succeeded in delivering a saving of approximately 1% in resistance.

Even though efficiency was improved, the desired design speed was not achieved. Since changes could not be made to the beam, length or draft, ABS examined the propeller diameter, which was quite small compared to similar ships in this class.

The design arrangement was such that the propeller was barely immersed, at the lightest load condition, leaving no room for a bigger unit. However, the yard agreed that if a larger propeller could provide significant savings, they would agree to revise lightest load conditions.

Through CFD analysis, ABS predicted the savings that could be expected from an increase in propeller diameter and a change to revolutions per minute. The larger unit was expected to operate at about 88% the RPM value of the original propeller.

The third design alternative, with the propeller shaft height raised to 4.9m above baseline, was able to accommodate the larger, 9.3m diameter propeller.

It was decided to keep the blade area the same and to examine different changes in diameter and pitch, as these both affect the RPM at which the propeller would provide the thrust necessary to equal drag at the design speed.

By altering the shaft height ABS was able to keep proposed modifications to a minimum, and, having tested the new configuration against the original one, results showed an additional 2.8% reduction in power requirement while achieving the design speed.

Based on the results achieved with hull and propeller, ABS also suggested to BSHI further possible modifications to improve efficiency, such as changing the rudder bulb and potentially using a twisted rudder to recover some of the rotational energy from the propeller.

Applying CFD techniques

ABS undertook CFD simulations of the original hull design and tested them in model scale against the revised aft body hull design. Engineers then tested the revised shape at full scale, confirming that it generated better efficiency with a slightly different percentage gain; this reflects the different balance between viscous drag and pressure drag at full scale and model scale.

The decision to undertake CFD in model scale was firstly done for validation, since the report data from the towing tank tests was available for comparison, and CFD could be used to ascertain whether the results could be replicated.

Making the CFD simulation at full scale also provided a way to accurately predict the drag at full scale. Even with the computational issues this presented, ABS decided that the efficiency of the revised hull design should be confirmed. Tests were also performed on the propeller originally proposed by the shipyard and a different unit used by the towing tank that carried out the initial optimisation, validating the results for comparison.

The next stage was to carry out detailed self-propulsion simulations, testing the full geometry of the propeller by combining all the physical effects with the conditions that would exist when it was rotating behind the ship.

Simplified processes exist for making predictions on power requirement, but ABS decided to use physical principles and make a full-blown simulation to resolve the flow around the hull and the propeller.

This presented some timescale challenges because the flow of water around the hull and the flow on the propeller are very different. ABS developed a procedure to overcome these challenges by first resolving the flow around the hull and then slowing the simulation to resolve the flow around the propeller. Next, engineers tested the initial and revised hull and propeller configurations, which enabled them to judge the balance between the thrust from the propeller and drag from the ship by running the ship at the required speed and averaging the computed forces over one revolution.

Both simulations were run at two RPMs to compute enough data points from which to make a non-linear interpolation to find the self-propulsion point and compute the required power.

The power reduction was found to be slightly less than the required level calculated at the yard. Some further minor modifications were suggested that could increase drag reduction, which would, in turn, require less thrust from the propeller and therefore less power to push the ship.

Achieving energy efficiency

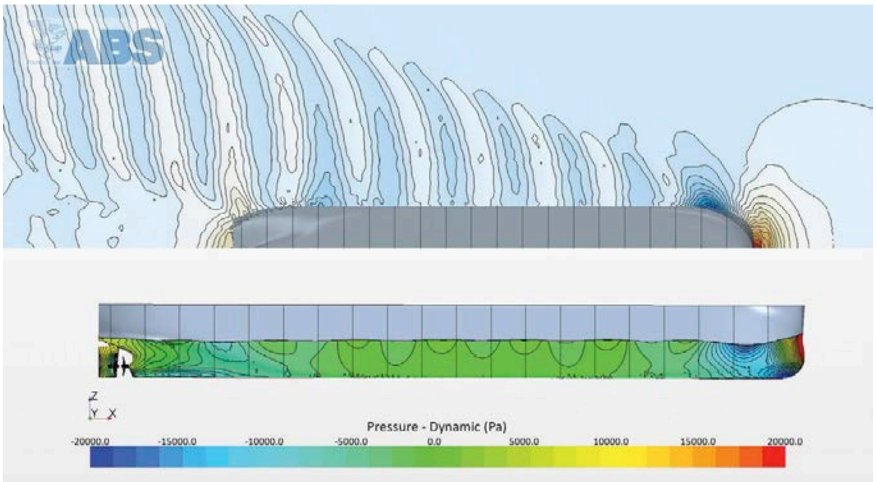
The CFD simulation process indicated a reduction in power requirement of slightly less than 4% could be achieved with an adapted hull and propeller configuration. However, this improvement did not account for the impact of additional energy saving devices, which the yard has successfully applied to other designs. As a result, it suggests that further savings are potentially possible provided they can be adapted to specific vessel designs.

The obvious advantage of using CFD for a design assessment in addition to a towing tank is that it is not necessary to build a physical model for every different hull shape to be tested. The only model required is digital.

By enabling the examination of different options side by side, at model and full scale, and for the hull and propeller, the project clearly demonstrates that CFD can provide an accurate representation of physical tank tests and provide results that can be used to suggest refinements. In this case, the value of the required power as computed by CFD for the original hull and propeller was within 1.1% of the extrapolated full-scale value from the towing tank experiments.

This application of CFD also shows that when seeking a defined objective – in this case a given power reduction which achieves a desired design speed – improvements can be made by combining a number of modifications, such as to hull lines, the stern, and bow shape, with an alternative propeller design. This delivers an overall improvement.

Authors: Christian Schack is assistant director of energy efficiency, operational and environmental performance, and Claudio Cairoli is CFD lead of operational and environmental performance, at ABS. *NA*



Wave and pressure acting on the test vessel. The top image shows the wave elevation, while the corresponding dynamic pressure distribution on the hull surface is shown below

Pushing the boat out

Shipyards are adapting to market shortfalls with extensive investment in shipbuilding technology. This, it is hoped, will position them for future shipbuilding and the changing demands of owners

The newbuilding slump seen across most maritime industry segments is driving fierce competition for new business while overcapacity reigns.

Yards must be more productive than ever and only those that can offer the very best value, in terms of speed of delivery and therefore cost, will be selected by cautious owners for the few major newbuilding orders still to be won. Shipbuilding technology is consequently more important than ever, and yards are investing in systems that utilise automation to an even greater extent.

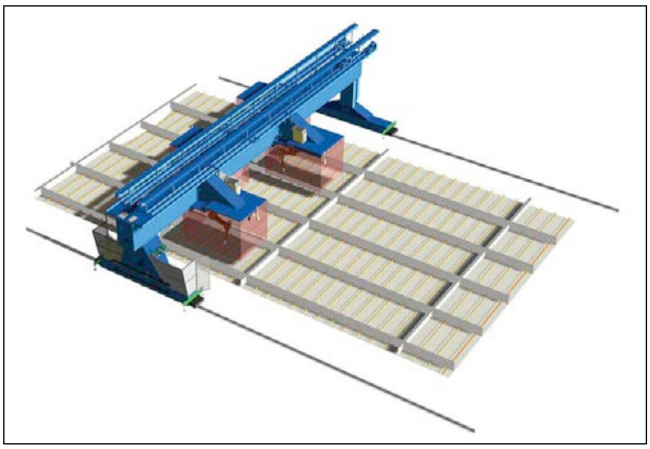
Up to eight robots can be simultaneously operated using Kranendonk's software

Kranendonk, an engineering company from Holland, integrates robotics in automation solutions for shipyards and has been developing innovative new solutions for robotic welding. Its most developed solution combines eight welding robots that work simultaneously according to a 'map'-based software programme, RinasWeld, and can be operated by only one supervisor.

Two eight-robot, double hull welding solutions were installed for an unnamed large shipbuilding group in Japan between 2014 and 2016. While the organisation and its yards cannot be named due to a non-disclosure agreement with Kranendonk, it was indicated that the group mostly builds bulkers and (mega) containerships.

The solutions were purchased for two of the shipbuilding group's yards and are arranged so that the robots are paired across four double beamed gantries. A further double hull welding solution deploying four robots over two double beamed gantries was ordered for another of the shipbuilding group's yards.

These technological improvements deliver a substantially longer ARC welding time, increasing it to reach up to 80% compared with the 15-20% of manual welding, according to the company. This means that the robots are able to weld longer than humans in relation to their total air time (the time a robot moves, but does not weld), improving production efficiency. Other time benefits are gained in work preparation, where the automated programming quickens the pace of production.



A panel welding gantry produced by Kranendonk

During the same two year period, the yards also took delivery of three panel welding gantries varying in span from 13 to 15.5m. The gantries provide an integrated solution, housing cabling, fume extraction capabilities, measurement systems, wire feeders, and wire cutters, among other components.

The RinasWeld software used to run Kranendonk's solutions has been around since 2003, but its sophistication has developed to exploit new ways of making the production process more efficient. Software teams in Denmark and The Netherlands have most recently incorporated bevel recognition, the welding of collar plates and coamings, temperature scanning before welding, and a facility for multi panel import. The company has also launched RinasAssembly to allow for the automated assembly of stiffeners and attachments to steel beams.

Sander Voerman of Kranendonk says: "Every company has its own challenges to overcome, but with experience in engineering custom solutions, RinasWeld is the tool empowering the customer to overcome these challenges.

RINA - Lloyd's Register
Maritime Safety Award

The safety of the seafarer and protection of the maritime environment begins with good design, followed by sound construction and efficient operation. Naval architects and engineers involved in the design, construction and operation of maritime vessels and structures can make a significant contribution to safety and the Royal Institution of Naval Architects, with the support of Lloyd's Register, wishes to recognise the achievement of engineers in improving safety at sea and the protection of the maritime environment. Such recognition serves to raise awareness and promote further improvements.

The Maritime Safety Award is presented annually to an individual, company or organisation that in the opinion of the Institution and Lloyd's Register, is judged to have made an outstanding contribution to the improvement of maritime safety or the protection of the maritime environment. Such contribution may have been made by a specific activity or over a period of time. Individuals may not nominate themselves. Nominations are now invited for the 2016 Maritime Safety Award.

Nominations of up to **750 words** should describe the nominee's contribution to:

- safety of life or protection of the marine environment, through novel or improved design, construction or operational procedures of ships or maritime structures
- the advancement of maritime safety through management, regulation, legislation or development of standards, codes of practice or guidance
- research, learned papers or publications in the field of maritime safety
- education, teaching or training in maritime safety issues

Lloyd's Register

The closing date for nominations is **31st December 2016.**

The Award will be announced at the Institution's 2017 Annual Dinner.

Nominations may be made by any member of the global maritime community and should be forwarded online at: **www.rina.org.uk/maritimesafetyaward**

or by email to: **maritimesafetyaward@rina.org.uk**

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

The view from a supervisor's screen at Kleven Verft

A welding gantry at Kleven Verft

"The rule-based software enables the user to use their own welding knowledge, and welding data, gained in their own history and environment of building ships. RinasWeld translates this unique wisdom, combined with the 3D CAD design, to collision free robot paths on the shopfloor."

The software has grown to include digital visual simulation of the robot paths, error reporting from the shopfloor, programme generation overnight, workload distribution over up to eight robots working on the same piece, tablet control functionality, and improved integration with available design software. These additions allow production managers and operators to plot the length of time a portion of the production process will take before the task of production is begun, using the system's facility for calculating total ARC time, total air time, and for finding welds the robots cannot reach.

Voerman believes that intelligent automated machines are necessary to drive productivity in an increasingly competitive market as well as to keep pace with the complexity of ship designs:

"The diversity and complexity of vessel design is reflected in the production processes and equipment needed to realise them. Next to knowledge and craftsmanship these processes require flexible machines that deliver the quality proscribed in the design, driving technological developments and better flexibility of the production environment."

With this aim in mind, Kranendonk is set to move to a new research facility in Tiel, The Netherlands, in September that should help "speed up the innovation process and make way for more developments", says Voerman. The facility will feature a new testing site as well as four large overhead cranes in contrast to the single crane the company uses at present.

Along the chain: adapting for future shipbuilding

Yards with advanced robotic automation systems have accepted the new technological regime.

On a recent visit to Norway, *The Naval Architect* was told how Kleven Verft of Ulsteinvik, Norway, is diversifying to mitigate the woes of the oil and gas/ offshore market, and has invested in new production technologies and facilities to take on vessel types that the offshore shipbuilding specialist has not previously constructed.

Of particular note is a recently confirmed order for a series of new Hurtigruten cruise vessels that Kleven will build to a Rolls-Royce design.

The order consists of two new vessels, each with a capacity of 362 cabins, and comes with an option for two more of the Polar ready cruiseships.

Kleven will be responsible for building the superstructure and around 50% of the steel volume work, utilising its modular building methodology and new technology, while the bow section will be built in Poland. The unannounced Polish yard will be a key part of the build strategy for these ships, according to Ellen Kvalsund, communications manager at Kleven, who says there is neither the capacity nor space to build everything on site at the Norwegian yard.

Investment in robotics and automation has consequently been key in Kleven's successful bid for the project. "New robots make it possible for us to build larger sections on site, and the robots provide us with the capacity needed to build the amount of steel needed for this," explains Kvalsund.

The new robotisation allows for offline programming of robots for assembly and welding, and welding rates of 80m per hour. Kvalsund says: "a welding robot can weld up to 40 times faster than manual welding – depending of course on [the] type of welding technology used and what type of module is being produced." This speed has the added benefit of removing misshapes from the production line, reducing heat exposure to the steel plates.

Cameras above the production line establish vision controlled welding by the Yaskawa Motoman robots from Japan. This intelligent sightline 'maps' the weld area, which can in turn be overseen by a supervisor, before the robot begins to weld. In addition, the robots use laser welding, which removes the need and cost of additives by melting steel into steel.

Robots sound exotic and therefore costly, but creating the software system and physical environment for the robots to function within was the most costly part of the development, according to Kvalsund, as the robots themselves are off-the-shelf and so relatively inexpensive by comparison.

A Yaskawa Motoman welding robot

The Norwegian University of Science and Technology (NTNU), SINTEF (an independent research organisation) and other Norwegian research bodies have contributed to the system's development over the last five years, and further study and innovation is set to continue.

Some larger yards, such as Meyer Turku or Meyer Werft, may feature similar systems, says Kvalsund, but this level of robotisation and automation is new for offshore yards. The introduction of this technology allows smaller yards to compete on the construction of larger vessels and also keeps them competitively priced in their main segments with shorter delivery times and reduced costs.

As a result, Kvalsund believes the yard is positioned for future shipbuilding, offering cost effective construction that is well-suited for modern production.

The yard deploys one 3D model that is shared by owners, class, production and robot programming, in the spirit of this type of production, integrating the design and production processes to improve efficiency. It is also continuing to innovate with work on an automated drawing production tool, which extracts drawings from 3D models.

Progress made in other areas of the yard's production chain, such as the way modules are produced, the level of outfitting of the modules prior to assembly, and the addition of technologies that allow modules to be moved faster and more easily, have drastically cut the time needed to assemble a vessel on slipway, slicing the time from 4-6 months to 5-10 weeks.

Kleven delivers "high flexibility regarding production volume based on module production with a mix of outsourcing and high end production at [the] home location", says Kvalsund. This, it seems, would not be possible without ongoing technological advancements. *NA*

The drawing board: revolution in a barrel

Mark Campbell-Roddis, a freelance marine, offshore & defence consultant, proposes that a new fundamental type of propeller may be beneficial for the marine industry

The Barrel Propeller is a potential fourth fundamental type of marine propeller, adding a longitudinal cylinder type to the triumvirate of lateral cylinder (paddle wheel), vertical cylinder (cycloidal propeller) and helicoidal (marine screw) propeller types.

The barrel consists of a series of blades, disposed circumferentially around a surface-of-revolution, that are set at an angle of attack in the transverse plane (Figure 1). This angle of attack causes the barrel to harvest fluid during rotation and move it through the hollow body of the barrel via the circumferential gaps between successive blades. Mounted on bearings, it is allowed to rotate about its central axis, and is connected to a shaft that drives the barrel around. Its shape may be cylindrical, convergent, divergent, or possess a more complex body of revolution.

In its simplest form, the blades could be aligned in parallel to the barrel's axis of rotation. However, the blades might be wrapped around the barrel in a helical or pseudo-helical fashion, where the helical pitch described by the blade span-line is not constant, but rather increases or decreases along the span of the blade. In addition, the pitch of the blades can be varied along the span of the blades (Figure 2) to match local inflow conditions and thereby optimise performance. The blades would typically be of aerofoil section, although other blade sections are possible.

The blanking structure is fundamental to the operation of the propeller and is fixed to or held against the barrel's forward end. Its purpose is to blank off the forward end of the barrel and guide the transition from radial flow to longitudinal flow. The aft end, by contrast, is unobstructed to allow a jet of fluid to be expelled, producing forward thrust. Examples of these structures can be seen in Figure 3.

Applications

The concept has theoretical applications in the propulsion of ships, boats and

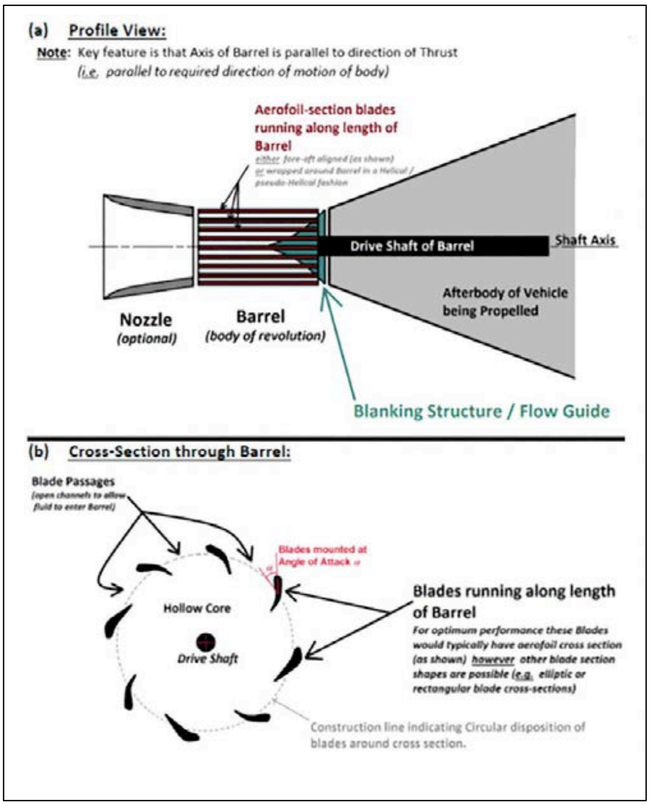


Figure 1: Components and key features of the Barrel Propeller concept

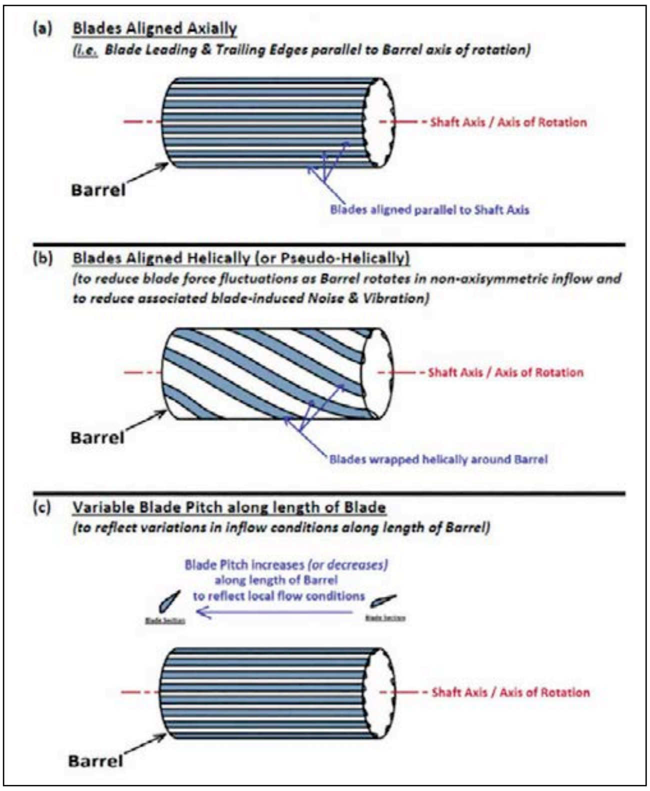


Figure 2: Alternative blade configurations on barrel

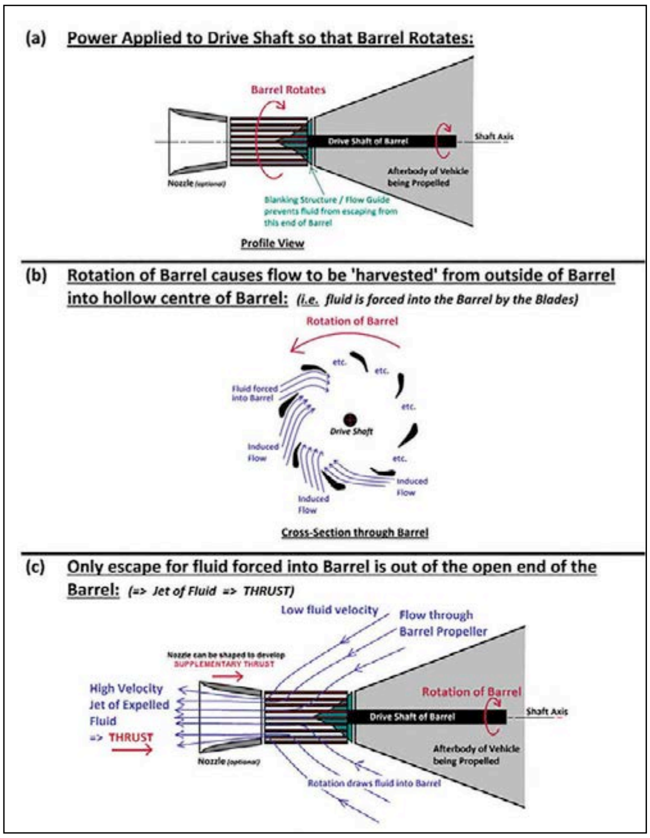


Figure 3: Principles of operation

underwater vehicles, and has potential applications for the propulsion of aircraft too.

The idea could be particularly advantageous for the marine industry in cases where the allowable propeller diameter is limited; a Barrel Propeller can achieve high mass flow at a comparatively low radius simply by increasing the length of the barrel. This is in contrast to a conventional screw propeller, which relies on a high radius to achieve high mass flow.

Because the blades of a Barrel Propeller extend over a limited range of radii, the flow regime they operate in at high speed (and such phenomenon as cavitation) is more predictable than for a conventional screw propeller, where the blades extend from a low hub radius to a high tip radius.

This means that the Barrel Propeller is suited to low diameter/high shaft speed applications. This in turn opens up the possibility for directly driving the Barrel Propeller from an engine without the need for an intervening gearbox or generator-motor combination to 'step down' the shaft speed. As a result, significant cost savings could be made in capital outlay.

The limited range of radii also means that the Barrel Propeller blades encounter less significant inflow variations along their span in comparison with conventional screw propellers, because inflow flow variations in the longitudinal direction behind ships are generally less marked than in the radial direction.

A Barrel Propeller is also potentially easier to manufacture, as the individual blade geometry is simpler and the blades have better structural support. The ability to support the blades at both ends of the barrel (Figure 4) means that their geometry is less complex and less challenging structurally; intermediate (ring-type) supports can also be stationed along the length of the barrel (Figure 4 and Figure 5). Blades can therefore be made thinner, reducing propeller weight.

This additional structural support of the blades also has advantages when trying to reduce noise and vibration, as the blades can be much more tightly constrained against vibration than the radially-cantilevered blades of a conventional screw propeller.

Whereas high levels of radial skew are required on a conventional screw propeller to counter the vibration risk associated with circumferential variations in inflow, comparatively gentle longitudinal (helical-type) skew is required to achieve a similar vibration-reduction benefit with the blades of a Barrel Propeller.

Furthermore, the propeller could also be applied to marine waterjets in place of a conventional (axial) impeller (Figure 6).

Suitability

The concept is potentially suitable for all manner of vessels, including the propulsion of commercial vessels over 100m long. A key thing in this respect is that the necessary high power rating can be accommodated through increasing the barrel length (rather than increased diameter, as is the case with a conventional screw). This means it is potentially suited to ships where a high power rating is required but allowable diameter is limited (e.g. by hull & keel-line clearances or immersion considerations). In addition, the use of helically-wound blades and the fact that the blades can be supported at each end (and at intermediate points on the blade span) means that it offers potentially low noise and vibration, which can be key on certain commercial vessel types, such as cruiseships.

A key factor will be how efficient the concept is for typical ship propulsion scenarios. Being fundamentally 'different' makes it easy for people to dismiss as a concept (just as the unfamiliar might in the past have dismissed the concept of Voith-Schneider cycloidal propellers on first sight). However, the reality is that no one can say how good (efficient) or bad (inefficient) it will be without a proper model scale prototype design study and model scale experiments.

It is clear that at zero speed (bollard pull conditions) the inflow into the

Barrel Propeller would be almost totally radial and the inflow/throughflow patterns would not be particularly elegant, making it unsuitable to fit on a Tug boat where prolonged operation at near-bollard pull conditions is required. However, the elegance of the flow through the propeller would improve with increasing forward speed, and would be particularly elegant for cases where it is mounted on a conical afterbody at higher speed. In this regard, and given its low noise features, the concept might be attractive for application to submarines (Figure 7).

An initial response to the wider concept suggested that turbulence losses may occur when the flow transitions from the radially inwards direction after the blades to the axial direction within the barrel. However, shape-optimisation of the flow guide within the barrel will minimise this turbulence, and because such turbulence would occur after the flow has passed through the blades and has entered the barrel, it is of less concern; energisation of the fluid is complete at this location and the flow is on its way out of the device. It should also be remembered that flow into marine propellers is (by its very nature) turbulent due to a thick hull boundary layer. The flow drawn into the barrel by the rearmost part of the barrel should also help to suppress the turbulence of the flow in the forward part of the barrel.

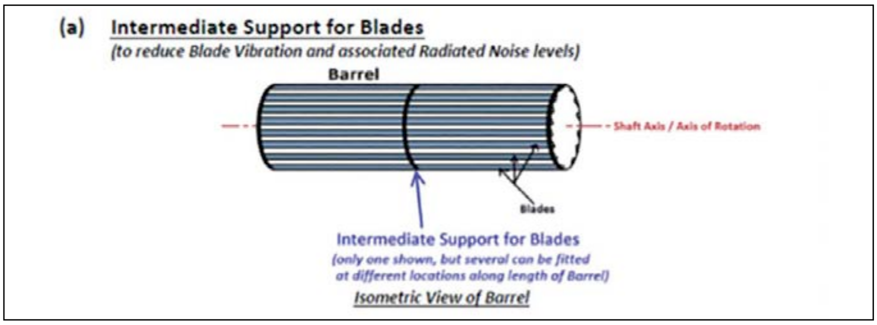


Figure 4: Blade support may reduce noise and vibration

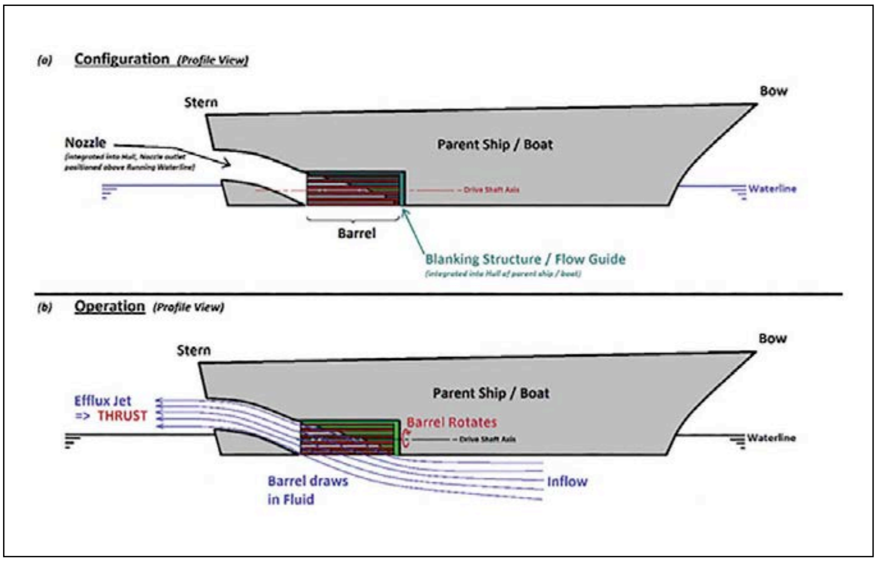


Figure 5: Concept applied to a surface ship

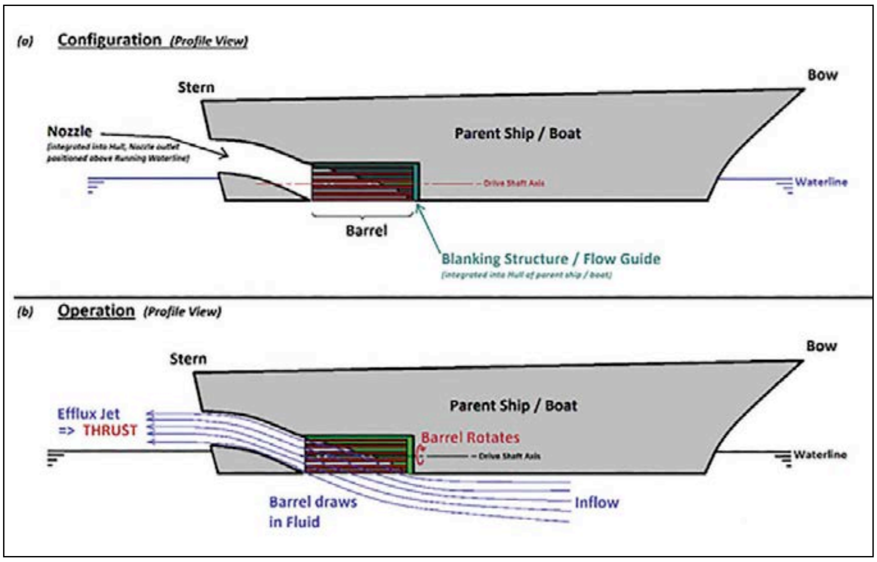


Figure 6: Concept applied to a marine waterjet

Conclusion

The focus of research on marine propellers and aircraft propulsion is very much on incremental improvements to established marine screw propeller and axial jet engine design methodology. However, it is now very much a case of diminishing returns in terms of the further performance improvements that can be squeezed from the lineal development of these fully-mature device types. It certainly seems a shame that propulsion research & development is so tightly constrained to refining the jet engine concept that Whittle developed way back in the 1930s/1940s and the marine screw propeller that Brunel pioneered back in 1840s, without devoting a little more effort to exploring more fundamental alternatives.

The Barrel Propeller concept presented here (and the associated Barrel Jet Engine concept) represents a fundamental break from such lineal development, potentially opening up a new avenue of propulsion devices. It would be a pity if the blinkers of near term research and the presumption that nothing will ever surpass current propulsor technology prevail, precluding proper evaluation of this concept. *NA*

Addendum

The Barrel Propeller concept proposal presented in this article is covered under UK Patent refs: GB1416639.1 and GB2530324. The full Patent Application is available to view free of charge via the UK Intellectual Property Office website (www.ipo.gov.uk).

Notes on the author

Mark Campbell-Roddis is a freelance Marine, Offshore & Defence Consultant. He holds a 1st Class Degree in Naval Architecture & Shipbuilding (Newcastle University, 1990) and a PhD on Pumpjet & Ducted Propulsor Design (University College London, 1994).

His experience includes 17 years of working in the UK Defence industry (1986-2004), including on submarine design & construction, aircraft carrier design and general naval consultancy.

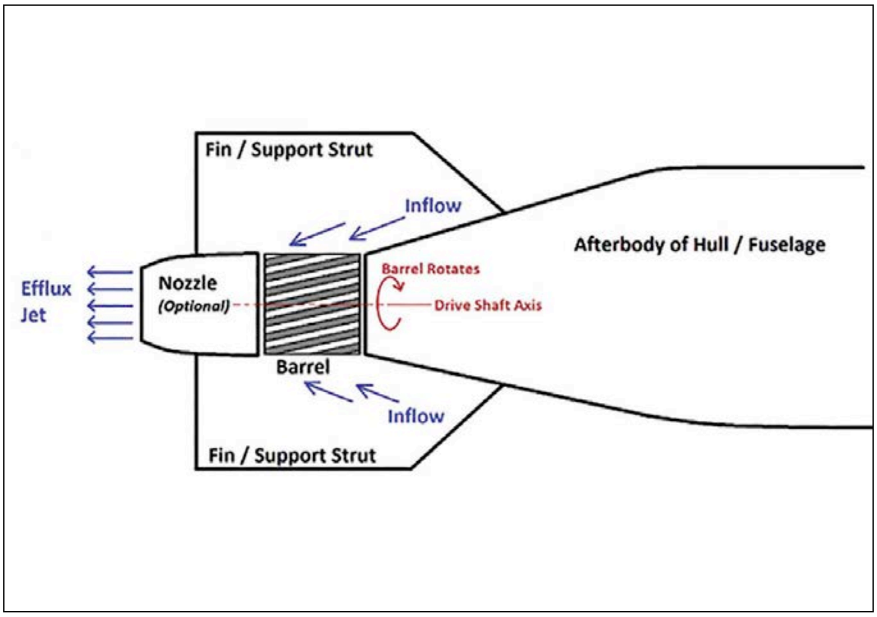


Figure 7: Concept applied to a submarine

More recently he spent eight years working in the offshore industry (2006-2014) on subsea cable installation projects and the build & upgrade of offshore construction ships.

Fillet Tee joint solution for containership cracks

A paper written by researchers* from JFE Steel Corporation, Japan Marine United Corporation, and IHI examines the application of a Fillet Tee joint to the strength deck structure of containerships to improve crack arrestability

Ultra-large scale crack propagation tests were conducted to investigate long brittle crack propagation/arrest behaviour in Fillet Tee joint structures. Their test results showed that the long brittle cracks which rush into the strength deck and hatch side coaming could be arrested in the weld metal of a Fillet Tee joint structure under the specific conditions controlling the leg length and toughness of the fillet weld metal.

This phenomenon shows the advantage of using a Fillet Tee joint for long brittle crack arrests in the strength deck structures of large containerships.

Containerships and bulk carriers are constructed with large deck openings to increase carrying capacity and improve cargo handling efficiency. Therefore, it is necessary to use heavy gauge plates in these ships, particularly in the hatch side coaming and strength deck.

in the welding of these steels, the high heat input welding process is often applied from the point of view of construction efficiency (Kiji, et al., 2005). Therefore, the advanced steels have been developed to improve the toughness of the high heat input weld joint (Shiomi, 2005).

If by chance a brittle crack occurs in the high heat input weld joint of the heavy gauge steel plate used for large containerships, it could propagate straight along a weld joint without deviating to the base metal (Inoue, et al., 2005). This phenomenon is being discussed in the context of applying the high heat input welding of heavy gauge plate to ship structures. To prevent the long brittle crack propagation, high arrest steels have been developed and applied to containerships (Nishimura, et al, 2007). High arrest steels were effective in preventing long brittle crack propagation in steel plate (Yamaguchi, et al., 2010).

The structural discontinuity is also effective in preventing the long brittle crack propagation. In previous studies, the ultra-large scale crack propagation test showed that the long brittle crack could arrest in the Fillet Tee joint structure embedded in an un-welded face without high arrest steel when a brittle crack initiated in the hatch side coaming propagated to the strength deck (Handa, et al., 2007).

However, when the brittle crack initiating in the strength deck propagates to the hatch side coaming, the effect of the Fillet Tee joint structure has not been investigated enough, except in the case of applying the high arrest steel to the hatch side coaming (Kubo, et al. , 2012). In this study, long brittle crack propagation/ arrest behaviour was investigated by the ultra-large scale crack propagation test which simulated that the brittle crack initiating in the strength deck propagates to the hatch side coaming without applying the high arrest steel. For comparison, a test that simulates a brittle crack initiating in the hatch side coaming and propagates to the strength deck was also conducted.

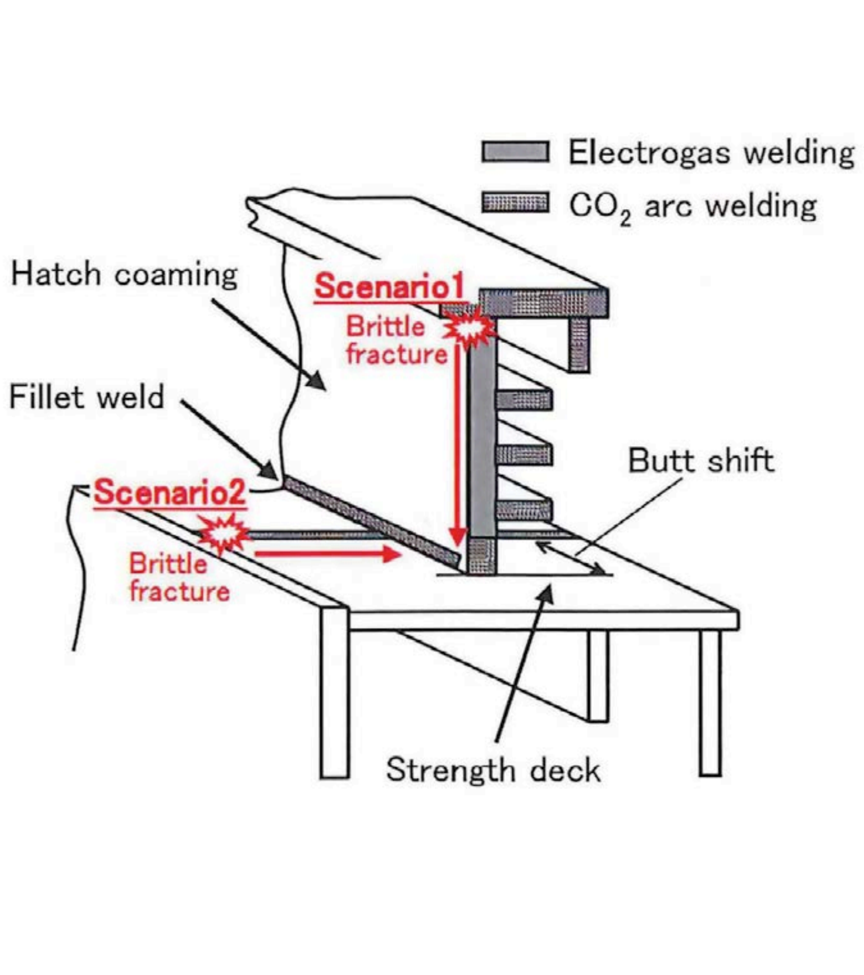


Figure 1: Brittle crack propagation assumed in this research

Experimental method

Brittle crack propagation assumed in this research covers two scenarios which are

considered for the brittle crack arrest design (Nippon Kaiji Kyokai, 2009). The first was 'to arrest a brittle crack initiated in the hatch side coaming at the strength deck', while the second was 'to prevent propagation of a brittle crack initiated in the strength deck into the hatch side coaming' (Scenario 2). This latest study also considers these scenarios. Figure 1 shows the brittle crack propagation assumed in this research.

Steel plate used in tests

The steel plate used for 'scenario 1', which simulates the strength deck, was a YP390N/mm^2 class heavy-thickness (60mm) steel plate for ship structural use. The steel plate used for 'scenario 2', which simulates the hatch side coaming, was a YP460N/mm^2 class heavy-thickness (55mm) steel. Their mechanical properties are shown in Table 1.

Preparation of Fillet Tee joint

Crack-running plate joints where a brittle crack is initiated and propagated were made with electrogas welding to prevent the brittle crack from branching during its propagation. In order to simulate scenario 1, in which a brittle crack initiates/propagates from a butt-welded joint in the hatch side coaming and extends into a Tee joint, the Tee joint was prepared by fillet welding a crack-running plate with 65mm thickness to the test plate with 60mm thickness (the test plate was the flange of the Tee joint).

In order to simulate scenario 2, in which a brittle crack that initiates/propagates from a butt-welded joint in the strength deck extends into a Tee joint, the Tee joint was prepared by fillet welding a crack-running plate with 60mm thickness to the test steel plate with 55mm thickness (the test plate was the web of the Tee joint).

Table 2 shows the welding conditions and a cross section of the Tee joint. It is known that the brittle crack arrest condition of scenario 2 was more severe than that of scenario 1 in fillet welded structures (SR169 committee, 1979). Thus, in this study, in order to arrest a long brittle crack in the Tee joint structure, the Fillet Tee joint of scenario 2 was fabricated by high toughness welding wire applied for low temperature steel, although that of scenario 1 was fabricated by normal welding wire applied for EH steel.

Crack propagation test method

Using the Tee joints fabricated as described above, test specimens with the shape shown in Figure 2 were prepared. So as not to cause bending stress when applying tensile loading to the Tee joint, a cruciform test piece was prepared by tack welding an auxiliary plate to the test steel plate or crack-running plate. In the tests, the test specimens were cooled to -10°C and held for 60mins. A load corresponding to 110% of maximum design stress for EH40 (257 X 1.1 =283N/mm^2) was then applied, and a brittle crack was initiated/propagated by striking the mechanical notch. Figure 3 shows the method of setting the test specimen on the testing machine tab plate. The distance between the pins (between load points) was 10m.

Steel	Thickness (mm)	YS (N/mm^2)	YTS (N/mm^2)	vTrs (°C)
EH40	60	476	569	-64
EH47	55	557	665	-69

Table 1: Mechanical properties of steel plate used for the test

Figure 2: Dimension of ultra-large scale crack propagation specimen (mm)

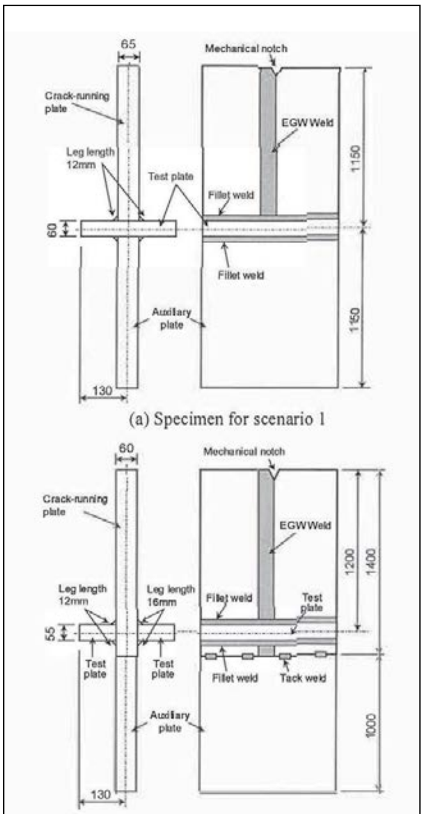
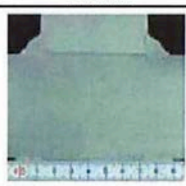
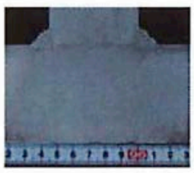


Table 2: Cross section and welding condition of Fillet Tee joint

Specimen	Scenario 1	Scenario 2	
Width of root face	60mm	55mm	
Leg length	12mm	12mm	16mm
Cross section of T joint			
Welding method	CO_2 arc welding		
Welding position	Horizontal fillet welding		
Wire for welding	DW-55E [ϕ 1.2mm]	DW-55L [ϕ 1.2mm]	
Welding condition	270A, 28V, 29cpm	310A, 34V, 28cpm	
Weld layer and pass for each side	2 layers, 3 pass	2 layers, 3 pass	3 layers, 6 pass

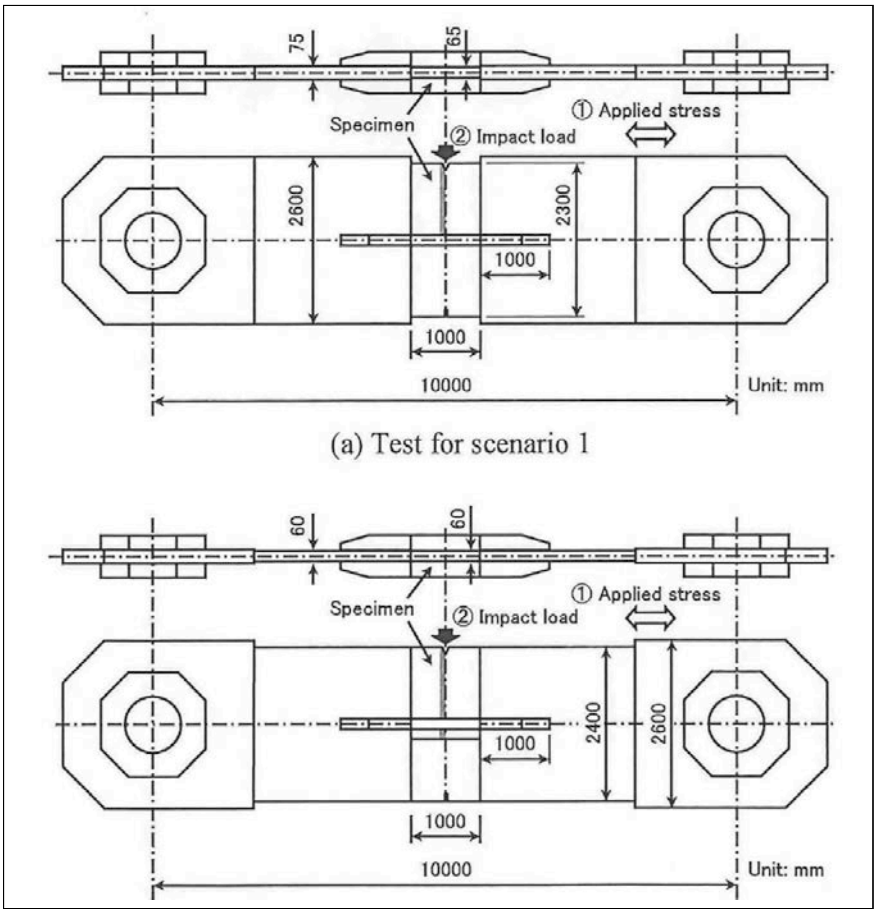


Figure 3: Test procedure of ultra-large scale crack propagation tests

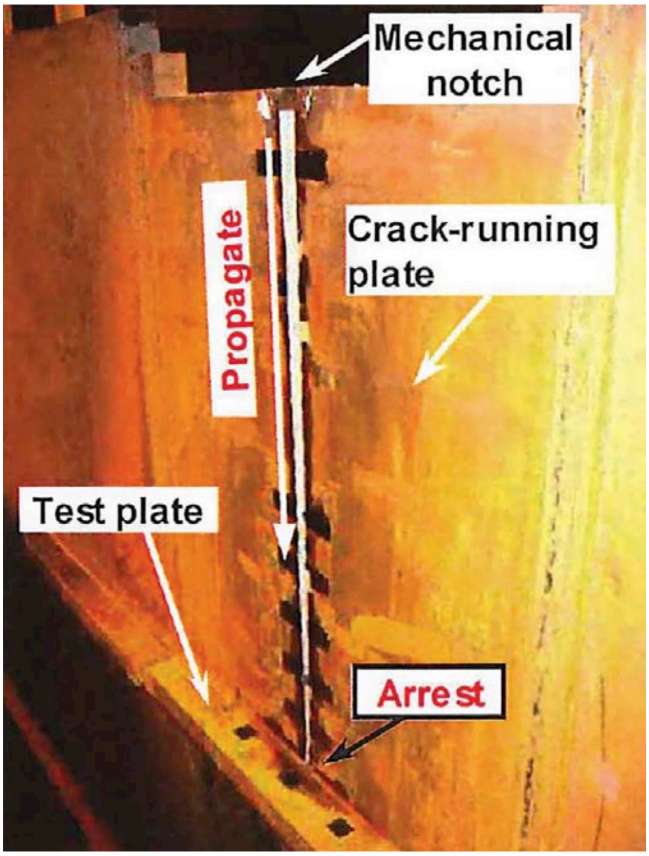


Figure 4: Fracture path in the scenario 1 specimen

Test results

Table 3 shows test conditions and results in the ultra-large scale crack propagation test in scenario 1. Figures 4 and 5 show the fracture appearance of the scenario 1 specimen. The long brittle crack propagated along the large heat input weld joint which is straight and was arrested at the Fillet Tee joint. Figure 6 shows the fracture surface of the scenario 1 specimen. The fracture surface was made to appear by the forced fracture after the test. The long brittle crack which extended from the crack-running plate into the Fillet Tee joint was arrested in the Fillet weld metal without penetrating into the test plate simulating the strength deck.

The results and test conditions of the ultra-large scale crack propagation test used in scenario 1 are shown in Table 3. Figures 4 and 5 show the fracture appearance of the scenario 1 specimen. The long brittle crack propagated straight along the large heat input weld joint and arrested at the Fillet Tee joint. Figure 6 shows the fracture surface of the specimen in scenario 1. The fracture surface was made to appear by the forced fracture after the test. The long brittle crack which extended from the crack-running plate into the Fillet Tee joint was arrested in the Fillet weld metal without penetrating into the test plate simulating the strength deck. The results of scenario 2 are yet to be published.

Conclusions

In this study, long brittle crack propagation/arrest behaviour was investigated by the ultra-large scale crack propagation test. This simulated brittle cracks initiating in the strength deck which then propagated to the hatch side coaming without applying the high arrest steel. For comparison, the test which simulated brittle cracks initiating in the hatch side coaming and which then propagated to the strength deck was also conducted.

Tests showed that the long brittle crack which extended from the hatch side coaming

Table 3: Test conditions and results

Specimen	Scenario 1	Scenario 2	
Width of root face	60mm	55mm	
Leg length	12mm	12mm	16mm
Wire for welding	DW-55E	DW-55L	
Test temperature	-10 °C		
Applied stress	283 N/mm^2		
Result	Arrest	Arrest	Arrest

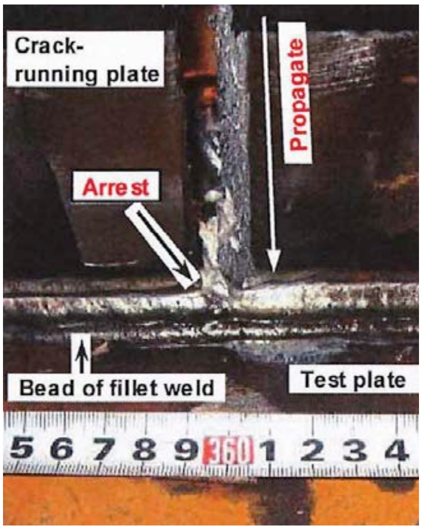


Figure 5: Appearance of brittle crack arrest point in the scenario 1 specimen

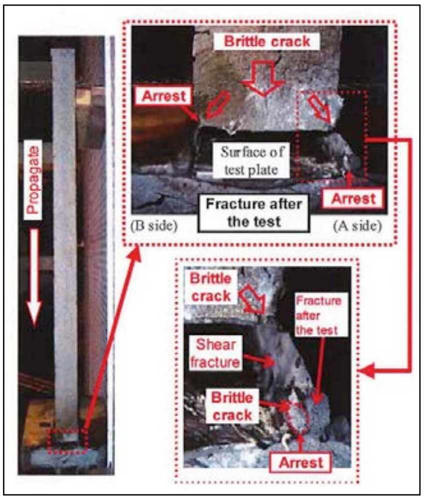


Figure 6: Fracture surface of the scenario 1 specimen

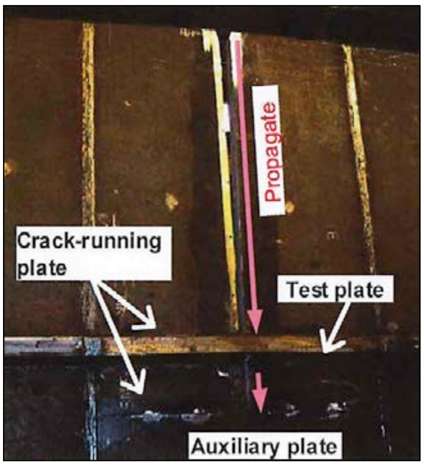


Figure 7: Fracture path in the scenario 2 specimen

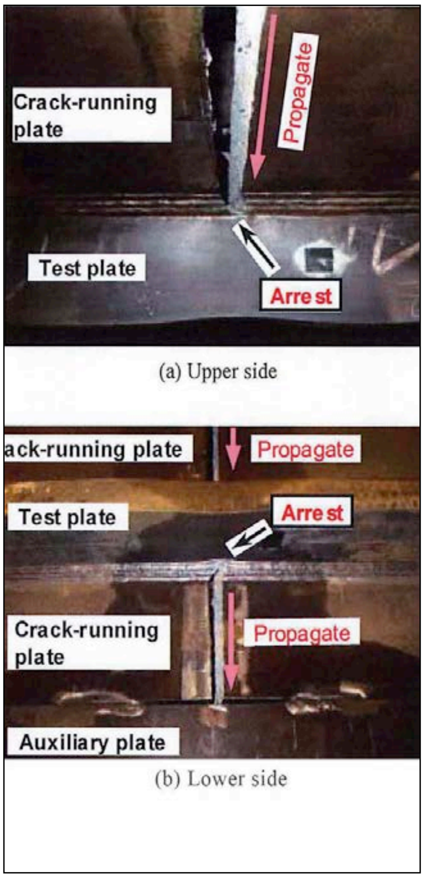


Figure 8: Appearance of brittle crack arrest point in the scenario 2 specimen (Leg length=16mm)

into the strength deck was arrested in the fillet Tee joint (welding wire: *DW-55E*, leg length: 12mm) even under the high stress condition: 110% of maximum design stress for EH40.

In addition, the long brittle crack which extended from the strength deck into the hatch side coaming was arrested in the Fillet Tee joint (welding *wire: DW-55E*, leg length:12-16mm), even under the high stress condition.

These test results showed that the long brittle cracks which rush into the strength deck and hatch side coaming could arrest in the weld metal of the Fillet Tee joint structure under the specific conditions controlling the leg length and toughness of the fillet weld metal. *NA*

Authors of the original paper:

Tsunehisa Handa1, Takahiro Sakimoto[1], Satoshi Igi[1], Kenji Ooi1, Masanobu Toyoda[2], Takashi Takeda[2], Noboru Kiji[3] and Koutarou lnose[4]

1 Steel Research Laboratory, JFE Steel Corporation, Chiba-city, Chiba, Japan

2 Initial Design Department, Ship & Offshore Division, Japan Marine United Corporation, Minato-ku, Tokyo, Japan

3 Kure Shipyard, Japan Marine United Corporation, Kure-city, Hiroshima, Japan

4 Production Engineering Center, IHI Corporation, Yokohama-city, Kanagawa, Japan

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Feeding the beast

Container feeder vessels are expected to be the subject of the next major ordering bout as ageing feeder vessels in the fleet will need replacing. Knud E. Hansen is gearing up for the expected orders with a couple of new designs, including an innovative concept vessel

As back of the envelope designs go, Knud E. Hansen's 3,000TEU trimaran, or more accurately 'stabilised mono-hull', offers a solution to the perennial problem for feeder vessels, that of stability with loaded vessels requiring the stability of a wider hull and lightly loaded ships requiring only the slender hull shape.

Knud E. Hansen's solution to the question of stability is to design an open top carrier with triangular outriggers, as seen in cross-section, that can stabilise the vessel when loaded.

Jesper Kanstrup, senior naval architect at Knud E. Hansen says: "The vessel essentially has three hulls so it will be more expensive to build, but it is an example of what you can do." He added: "Many have proposed an open top container vessel, but to prevent water from being shipped over the sides of the vessel and into the open holds when the vessel is rolling in bad weather, the hull depth must be very high. And with a deep hull, the handling time for the containers will be increased because of the increased vertical travelling distance."

This problem is solved by the narrow main hull which allows the sides of the open-top holds to be lower, and increases the speed of container handling as a result.

Kanstrup concedes that the possibility of this vessel being built remains slim, as "it might be too expensive and too novel," he says.

A more significant design is the naval architect's 3,800TEU geared container feeder ship, which is fitted with a larger diameter, slower-turning propeller that offers "propulsion efficiency which is not that far from the efficiency of a counter-rotating solution, but for a much lower cost," says Kanstrup.

Stability with this vessel type can be an issue, explains Kanstrup, with a greater proportion of cargo on deck; however, unlike the Bangkok-Max vessel, which was largely designed four years ago as a showcase for ABB electric power technology, draught can also be greater at 11.5m, and, with the new locks in the Panama Canal now open, the vessel can add stability through greater width.

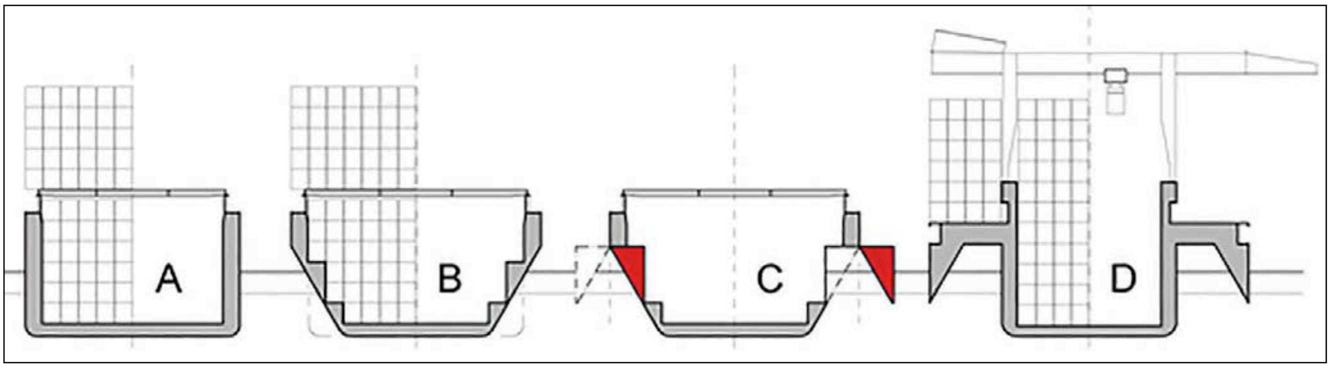
"Small [containerships] have a problem with stability", said Kanstrup, "but with the deck house further forward more cargo can be stacked on deck and stability becomes a problem; however, with the 3,800TEU ship, we have designed it with a wider beam at 35.2m, which is wider than the old Panamax limit, but we're considering making the design another 2.5m wider, further adding to its stability."

Kanstrup adds: "it also has to do with roll accelerations. In lightly loaded conditions, the container stacks will not be very high. Therefore, the so-called mass moment of inertia around the longitudinal axis through the ship will also be low. If the stability in this condition is too high, while the mass moment of inertia is low, that would lead to unwanted high roll accelerations. So in the lightly loaded conditions you do not want more stability than absolutely necessary.

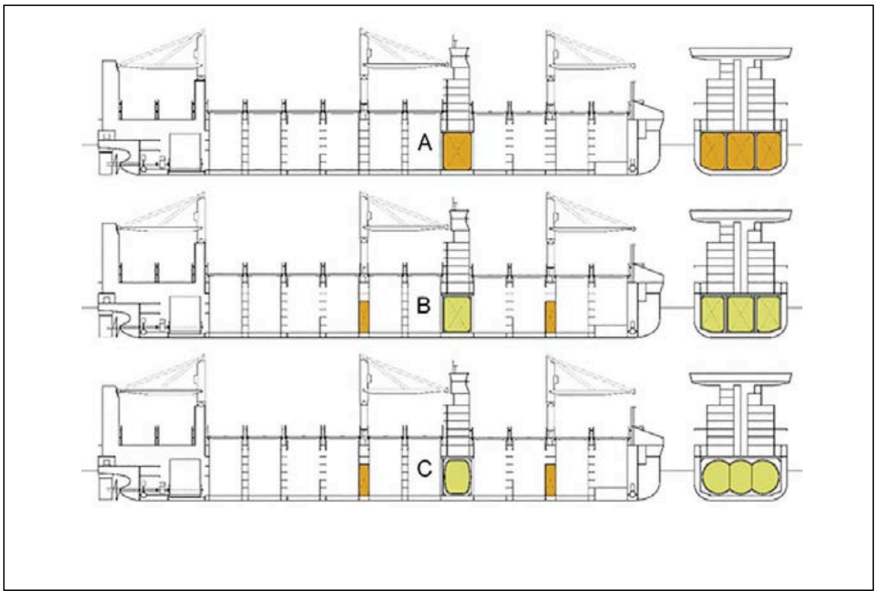
"In the fully loaded conditions, you need all the stability that you can get, but the mass moment of inertia is also higher, so the roll accelerations are still kept below acceptable limits. Everything is a fine balance between displacement, draught, stability and roll accelerations. In the trimaran, you can optimise this by optimising the shape of the inner surface of the outrigger hulls, which does not have to be straight, but could also be convex, concave or S-shaped."

The forward position of the deckhouse also allows the vessel to

Cross section of the 3,000TEU open top Trimaran showing the triangular outriggers with the vertical sides facing the quay



The Trimaran offers greater stability but extra capital costs mean it is unlikely to be built



The 3,800TEU containership - Sketch above shows options for conversion

A: Fuel tanks arranged below the deck house

B: Converted for dual-fuel – Membrane LNG tanks installed in former HFO tanks

C: Prefabricated tri-lobe C-type LNG tank installed in former HFO tanks

The 3,800TEU wide beam feeder vessel adds stability and flexibility with its LNG power capability

meet IMO requirements for the line of vision from the bridge, along with the extra stability, which means that the added number of slots can be utilised in real-life loading conditions.

According to Knud E. Hansen, this arrangement has additional benefits: "This prepares the vessel for LNG and dual-fuel propulsion – attributes that are becoming increasingly sought after. Here, we have a square block below the deckhouse, in which we can either have [large] HFO tanks or LNG tanks. What's more, the vessel can be built with HFO tanks and easily retrofitted for LNG the day the infrastructure for LNG is sufficiently developed if a dual-fuel engine is installed in the first place." Kanstrup believes that LNG conversion would be fairly straight forward with work taking around two to three weeks to complete. Conversion would need to take place if the ship was operating within emission control areas for significant periods of time.

Terminal cranes could also be an issue, according to Kanstrup, as many of the smaller terminals may not have cranes with sufficient reach to handle the wider feeder vessel. With this in mind prospective owners of the 3,800TEU New Panamax vessels will need to consider the operational profile of the vessels carefully.

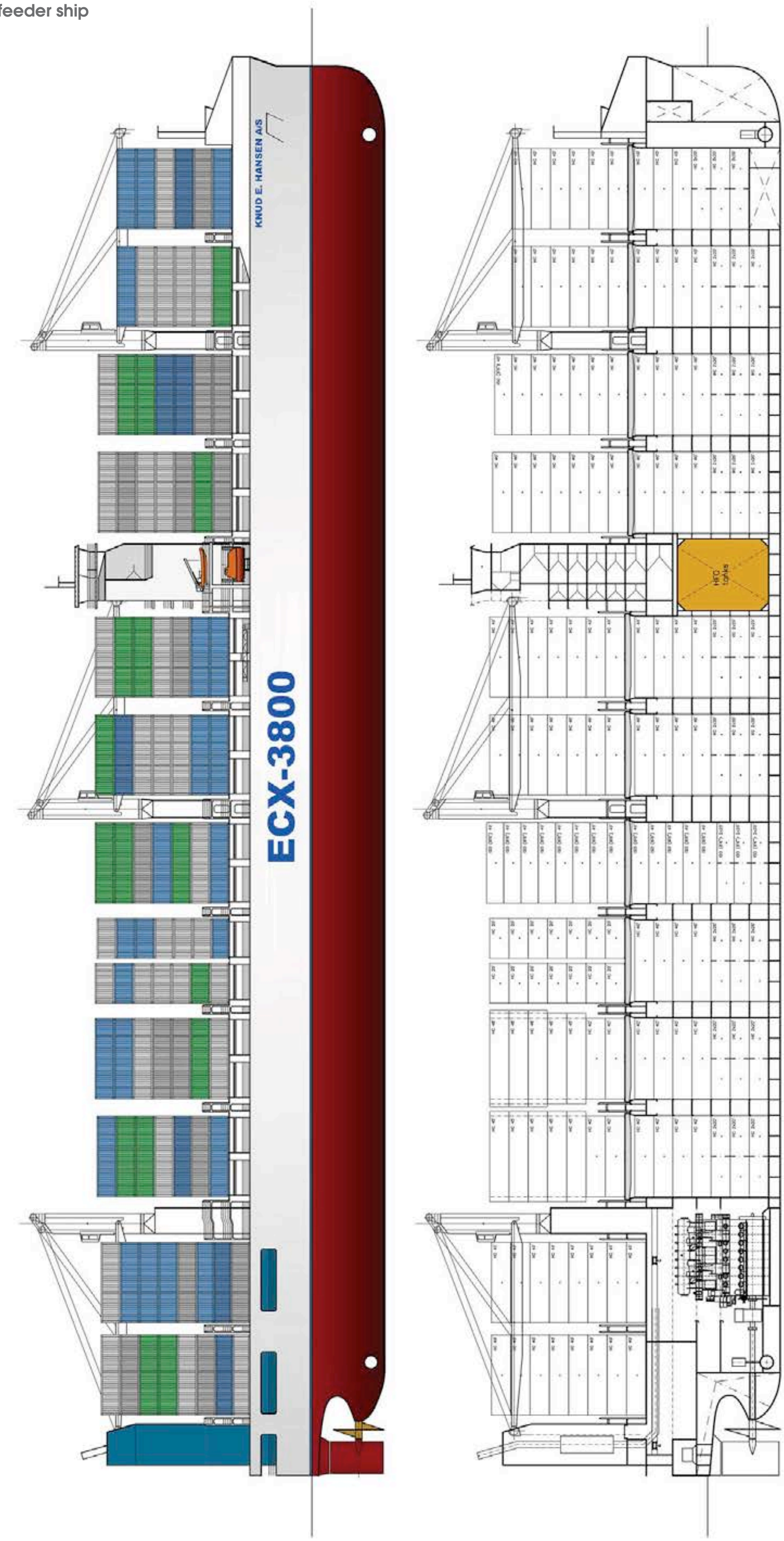
"Before the Panama Canal was widened, only very few container ships were wider than 32.3m. Therefore, the terminal cranes were generally designed for this breadth. This vessel is 35.2m wide, which corresponds to one row of containers more. However, on deck you have one row of containers more on each side than in the holds. Therefore, terminal cranes, which are designed for the old Panamax breadth, will still be able to reach all containers below deck," explains Kanstrup.

The width of the vessel is added to as the 3,800TEU ship is designed to carry four rows of wide bodied containers in the centre line, which adds a further 300mm to the width of the ship.

For a geared vessel like this, this is not an issue, but for a gearless version, a ship owner will have to consider if the terminal cranes in the ports that are relevant for him have outreach enough to reach all containers on deck.

In addition to the dual fuel main engine the vessel would need to be 'LNG ready', which for DNV GL, who is in consultation with Knud E. Hansen on its design and is expected to give the design an Approval In Principle, would mean that all auxiliary engines will need to be dual fuel, there will need to be double walled piping and space for LNG bunkering and tanks. A sketch (middle left) shows how the vessel can be converted. *NA*

GA of 3,800TEU wide beam feeder ship



Doughnut debate

Type	Membrane	CDTS	CDTS block coeff corrected
Capacity	170,000	210,000	188,764
Gross tonnage	124,237	138,458	138,458
Capacity/GT	1,368	1,109	1,000
Comprison	1,000	1,109	1,000

Dear Sir,
I note with interest the authors' reply which really doesn't deal directly with the points I made in my last letter.

1) It does not matter how long the CDTS system has been patented, other than perhaps emphasising the industry has not adopted the idea for over 40 years.
2) Table 2 of the response, although it has I think some simple mathematical errors in it, confirms the CDTS '*increases*' not '*significantly*' decreases gross tonnage.
3) The increases claimed in the original article did largely rely on a bulkier hull form than its competitors, but it now seems they are only claiming a 1% increase in capacity in Table 2 for the ship in the original article. Ironically, this is probably correct for the wrong mathematical reasons.

I try to be positive in criticism of innovative ideas, hence the attempt to eliminate the block coefficient difference in my earlier comments. I was in error estimating gross tonnage having forgotten that liquid LNG has just under half the density of water. The heading to Table 1 of the authors' response has suffered the same fate. I apologise, it's sloppy. However, if the error is the same throughout the competitors' and CDTS' data I offered, it does not alter I think the conclusion I made. Namely that the likely potential gain is about 10% with which the authors seem to now agree in both Tables 1 & 2 (corrected below).

I cannot comment further on the response to Table 1 as, to achieve parity of capacity, two of the other competitors would need to change their hull parameters.

Table 2, I assume, has to use the information in the original article (i.e. 300m overall is almost certainly 285m LBP), which is confirmed I think by the figures in the CDTS column. This being the case, the data for the membrane and CDTS versions become corrected as seen in the table above.

Thus when the basic calculations are corrected, the expected potential gain is around 10%. This of course makes the sweeping assumption that somehow you can still keep the same capacity with the reduced block coefficient calculated from the figures given originally. In the latter case, there is no gain in capacity/GT if you make the block coefficient correction. I think the authors have spotted this themselves because the new capacity gain claimed of 234,000m^3 reduces to 210,000m^3 when corrected for block coefficient.

I have one final question. The authors stated in the original article that there was better protection from side and bottom damage for their proposal. Is this done with increased clearance from a single hull all round or do they have double skin for bottom and hull? Neither of the latter are clearly shown or referred to in the original article or the response.

Yours faithfully

Cliff Thew
Eur Ing, Member

Second wind

Dear Sir,
I'm very grateful that Edmund Hughes from the IMO took the trouble to respond to my article: "Air Power; more than just a wind up" (May edition of *The Naval Architect*). It is vitally important that we all engage in open debate about issues critical to the very survival of our (and other) species. That climate change is an urgent existential threat is agreed upon by 97% of the world's climate scientists and is no longer considered to be 'treehugger' sentiment. One hundred and eighty eight countries, 500 cities, global corporations such as Unilever, Nike and WalMart have all publicly committed to reducing emissions in line with the 1.5-2.0° target agreed in Paris last December.

If shipping fails to adopt meaningful GHG emission targets it risks derailing this international agreement. The rest of the world is not just standing-by allowing shipping 'special' status; in these straitened times everyone has to pull their weight. Pressure is increasing on the international maritime sector to take action, and it is commercially prudent to do so. We are already experiencing the costly geo-political and commercial impacts of our collective failure to address climate change. The later we leave action the more expensive it will be. The IMO predicts that under current policy, shipping's CO_2 emissions will rise by between 50 and 250% by 2050, this would account for ~17% of the global total. Current emissions see us on target for a 3.3-3.9° temperature rise. This is a huge global challenge.

Global challenges demand ambitious global solutions.

The IMO is to be applauded for its focus on energy efficiency; it is a crucial element in reducing emissions as part of a wide ranging strategy that, crucially, also includes radical step change technologies. It is not smart to generate energy from alternative sources and then lose it through inefficient systems, but, on its own, efficiency is not enough. Energy efficiency complements new technologies and new business models. Fortunately, we can learn from systems approaches developed in other sectors.

As Mr Hughes notes, current alternative technologies that offer the power density required for more arduous trades currently do not exist and he has used the analogy of “mobile power stations”. My observation about the power station example was used to illustrate the evolution of energy generation onshore as a model from which we might learn useful lessons. Twenty years ago electricity generation without coal was unthinkable. Today, China’s switch to renewables, the US closure of more than 200 plants and Europe regularly meeting its total electricity demand from 100% renewable sources underline how rapidly complex systems can and will change.

The 21st century ‘power station’ exists on the roof of my super-insulated house, it is also an array of 8MW turbines situated offshore. Re-evaluating complex energy systems has revitalised the sector. Eight million people worldwide are employed in renewable energy, rising by 5% last year. Investment in 2015 was US$286 billion, a 17% increase on the previous year.

This global energy revolution was triggered by visionary leadership and, in many cases, governments’ commitment to accelerate innovation. The return on that investment is greater wealth, better jobs and a more resilient, future proof energy system that also happens to reduce emissions.

Shipping recognises a lucrative future in providing support for offshore windfarms. The paradox is that this very same energy source could provide suitable ships - to a greater or lesser degree - autonomy that at the very least enables volatile fuel costs to be hedged - be they fossil fuels or alternative drop-in biofuels.

Change is hard, but the later it gets left the more difficult and expensive it is. There is a myriad of technology available for the maritime sector to explore to build a more robust shipping system. This will offer wide ranging benefits that would be welcome in these very difficult days for the sector.

Yours faithfully

Diane Gilpin,
Smart Green Shipping Alliance

Technical Advisor

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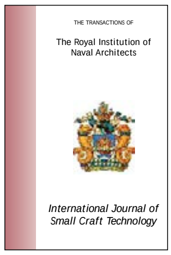

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www.seatrademaritimeevents.com/smme/

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Contract Management for Ship Construction, Repair & Design Course, London, UK
www.rina.org.uk/Contract_Management_Course_Nov_2016

November 9, 2016
President's Invitation Lecture, London, UK
www.rina.org.uk/PIL_2016

November 15-17, 2016
METSTRADE, international exhibition, Amsterdam, The Netherlands
www.metstrade.com

November 23-24, 2016
Energy Efficient Ships, international conference, London, UK
www.rina.org.uk/EES_2016

November 25, 2016
Workshop on ship scale hydrodynamic computer simulation (Lloyd's Register), Global Technology Centre, Southampton
www.lr.org/en/events/ship-scale-hydrodynamics-numerical-methods-workshop

November 29 – December 1, 2016
Seawork Asia, international exhibition, Shanghai, China
www.seaworkasia.com/

December 7-8, 2016
Historic Ships, international conference, London, UK
www.rina.org.uk/Historic_Ships_2016

December 7-9, 2016
INMEX, international exhibition, Poly World Trade Center, Guangzhou, China
http://www.maritimeshows.com/china/

December 9-10, 2016
10th International Conference on Marine Technology (MARTEC 2016), BUET, Dhaka, Bangladesh
www.icmartec.com

December 24-25, 2016
Computational & Experimental Marine Hydrodynamics, international conference, Chennai, India
www.rina.org.uk/Computational_Experimental_Marine_Hydrodynamics2016

January 24-25, 2017
Smart Ship Technology, international conference, London, UK
www.rina.org.uk/Smart_Ships2017

January 24-25, 2017
International Conference on Maritime Energy Management (MARENER 2017), World Maritime University, Malmö, Sweden
www.conferences.wmu.se/marener2017

February 22-23, 2017
Influence of EEDI on Ship Design & Operation, international conference, London, UK
www.rina.org.uk/ShipDesign_EEDI

March 29-30, 2017
Design & Construction of Wind Farm Support Vessels, international conference, London, UK
www.rina.org.uk/WFSV_2017

April 27, 2017
RINA Annual Dinner, London, UK
www.rina.org.uk/Annual_Dinner_2017

May 10-11, 2017
Design & Construction of Super & Mega Yachts, international conference, Genoa, Italy
www.rina.org.uk/superyachts2017

May 17-19, 2017
Torsional Vibration Symposium, Salzburg Congress, Salzburg, Austria
www.torsional-vibration-symposium.com

September 26-28, 2017
International Conference on Computer Applications in Shipbuilding (ICCAS 2017), Singapore
www.rina.org.uk/ICCAS_2017

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