The Royal Institution of Naval Architects

Power & Propulsion Alternatives for Ships

International Conference

Power & Propulsion Alternatives for Ships

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9:00h - 9:30h **Coffee and Registration.**

9:30h - 9:50h **Current and future scale limitations for alternative marine power and propulsion solutions**
Jan-Erik Räsänen, Head of New Technology, Foreship Ltd
Alternative energy sources for marine power and propulsion are in a phase of development which may be decisive. For several years, the potential benefits to shipping offered by battery energy storage have faced accusations of hype, focusing on whether the footprint of plant required can truly justify the energy generated. While battery storage has been deployed on smaller vessels, some see lack of progress on space efficiency as potentially fatal for the technology in larger projects. However, recent installations have seen fast-paced development in energy density, with new ways of packaging the technology emerging rapidly. Within the last six months, shipboard batteries generating 9.3kWh have become available that occupy the same space as that previously required for 6.5kWh. If the power/space balance can change by 30% in half a year, what is the true potential for this technology as a source of marine power and propulsion over the next five years? Is the sky the limit, or do significant gains today promise only diminishing returns tomorrow? Drawing on Foreship's unrivalled experience in cruise ship newbuilding and retrofit design work, Foreship Head of New Technology Jan-Erik Räsänen will consider the real advances made by battery energy storage, and assess whether it can make the leap from small to larger vessels. The acknowledged ship energy expert will offer a perspective on the obstacles faced for wider adoption, but also the true potential of battery energy storage, also exploring the pathways for shipping to exploit fuel cell technology in an economically viable way.

9:50h - 10:10h **Commercial Wind Propulsion Solutions: Putting the 'Sail' back into Sailing**
Gavin Allwright, Secretary, International Windship Association (IWSA), UK
We have seen a wind change in the industry over the last 4-5 years where it comes to shipping efficiency and this has gone hand in hand with a steady growth in commercial wind propulsion projects, matched by a very cautious and gradual change in the perceptions over wind propulsion in the industry. Nonetheless momentum has been building and this presentation will place that change into perspective, focusing on the change drivers, the barriers & solutions to that and examples of new build and retrofit projects to watch. Firstly, outlining the current state of commercial wind propulsion and how we have reached this point from a technical point of view (sail design, rotors, kites and new hull designs), detailing the financial and policy drivers and the market barriers and how those will likely affect uptake of wind propulsion. The International Windship Association (IWSA) establishment is a key development, the first organisation dedicated to the promotion and facilitation of commercial wind propulsion solutions in cooperation with the shipping industry and other major stakeholders. A key focus is on work streams tackling barriers and generating solutions in the policy, technical standards, finance, communication and cargo/market transformation fields. Examples of 2-3 wind propulsion projects at an advanced stage of development will provide the audience a clearer understanding of the potential for change, rating performance and outlining the expected costs, returns and other commercial considerations.

10:10h - 10:30h **Norsepower Rotor Sails - efficient and reliable auxiliary wind propulsion for ships**
Jukka Kuuskoski, Norsepower Oy Ltd, Finland
The Norsepower Rotor Sail Solution is a modernized version of the Flettner rotor - a spinning cylinder that uses the Magnus effect to harness the power of wind to propel a ship. When the wind conditions are favourable, Norsepower Rotor Sails allow the main engines to be throttled back, saving fuel and reducing emissions while providing the power needed to maintain speed and voyage time. Rotor sails can be used with new vessels or they can be retrofitted to existing ships. Norsepower's first two Rotor Sail units have been in operation since 2014 and 2015 onboard Bore's 9,700 DWT Ro-Ro carrier MS Estraden. Based on the successful sea trials and extensive testing during operation on the North Sea route, the two 18 m high and 3 m diameter Rotor Sails are confirmed to save an average of 6% of Estraden's annual fuel consumption on the North Sea route. A fuel saving potential of up to 20% can be estimated for vessels with multiple, large Rotor Sails sailing in favourable wind conditions. The paper describes the modern design of the Flettner rotor which Norsepower has developed and the operating experiences from the first two years onboard the Estraden. Various aspects related to ship design and operation with Rotor Sails are discussed and recently announced delivery projects for the Viking Line cruise ferry Grace and Maersk Tankers LR2 tanker are presented.

10:30h - 10:50h **Influence analysis of the wingsail system configuration on the technical performances and financial return of the technology on sail-assisted vessels**
David Ferrer Desclaux1, Mario Mantilla Sánchez, Albert García Plaza, Fran Saenz Saenz, José Miguel Bermúdez Miquel, Cristina Aleixendri Muñoz, Nuria Ferrés Rubau; 1 2 3 4 5 6 7 Research and Development Department, Bound 4 Blue S.L., Spain
Shipping industry's economic viability is highly influenced by fuel-related OPEX, being at the mercy of fuel volatile cost, with an increased pressure from IMO regulations. Various fuel efficiency technologies exist to face this challenge, being wind-based technologies the ones having the potential for double-digit fuel savings. bound4blue is a wind-based fuel efficiency technology supplier, having developed a light weight rigid wingsail technology. The goal of this research paper is to analyze, for a certain vessel, route and rigid wingsail technology, how the rigid wingsail configuration (wingsail size and number, airfoil used...) modifies the expected sail-assisted vessel performances and economic parameters, and how this impacts (meeting or not) the maritime transport financial, operational and technical requirements. For such investigation, bound4blue has developed a software tool that determines the performance and financial parameters of a certain sail-assisted vessel in a route. The tool is a combination of 3 modules: a Velocity Prediction Program (VPP), a route and historical weather software, and an economic analysis module. Moreover, a wingsail sizing parametric tool has been developed to calculate the expected weight and cost of the wingsail according to its dimensions, airfoil used, and structural parameters, between others. The investigation has been performed for two example case study vessels: a handysize chemical tanker and a car carrier vessel. The research shows that, for the same wind-based technology, the selection of the appropriate configuration is a key factor to meet industry requirements as some scenarios show large variations (+25%) on the performances and economic parameters.

10:50h - 11:20h **Coffee**

11:20h - 11:40h **Wind Powered Vessels with Hybrid and Autonomous Technologies**
Ken Goh, Knud E. Hansen, Australia
Reducing CO2 for shipping is a high priority but making small efficiency gains in current internal combustion technology is unlikely to make the significant changes to greenhouse gases that are being sought. Back in 1989 KNUD E HANSEN developed an impressive concept design for a fully wind powered vessel sponsored by the Danish Environment Agency - The WindShip. Comprehensive research into the economics and sail technology showed that a wind powered vessel for bulk and liquid cargo was entirely feasible. Recent developments in materials and power systems now make the concept even more attractive. The WindShip sail system is more powerful and efficient than other proposed sail systems, and its operation can also be fully mechanised. However the technology that will ultimately make the WindShip the ship of the future is autonomous and unmanned operation. Not only will this reduce operating costs, but it will increase the cargo capacity significantly and simplify the ship design and systems required. This paper presents a study of the new WindShip concept that combines hybrid and autonomous technologies that enable the WindShip to sail to tighter schedules. The feasibility study addresses a wide range of both design and operational issues and demonstrates that very large savings in emissions and the cost of operation are possible within technology that is available today.

11:40h - 12:00h **Using hybrid electric propulsion on a warship to increase flexibility and efficiency of operations**
Robert Taylor, Babcock International Group, UK
Warships have historically utilised a range of differing propulsion technologies from traditional diesel drive to electrical motor propulsion powered by large diesel and gas turbine engines. This variation in propulsion options has given Naval customers the ability to tailor the system to meet the operational profile and requirements of their vessel. A recent focus, in particular for Offshore Patrol Vessel (OPV) type platforms, has been to utilise diesel engine propulsion supported by smaller Power Take In (PTI) motors providing efficiency gains at lower speeds whilst loitering. With the recent development and increase in capability of battery systems there is now an opportunity to further increase the flexibility of propulsion systems to meet Naval requirements. This approach provides further advantages by increasing the efficiency of diesel generators but also helps meet the fluctuations in power demand that these types of vessels often have. Furthermore this technology can offer additional benefits for this application such as reduced airborne and waterborne noise levels. This paper looks at what a hybrid electric system could look like on an OPV type of vessel and how it can be utilised to support its range of operating modes. It will also discuss a number of the additional advantages that can be realised by adopting this technological approach for this application. A view will also be taken on the technical challenges and difficulties that must be overcome when designing and installing a propulsion system of this type.

12:00h - 12:20h **Reduce European Port and Shipping Emissions - 3 Step Process**
TBC, PBES, Canada
1. Zero Emissions in Port - Tugboats, Cargo & Cruise Ships; 2. Coastal Shipping Hybridization - Battery hybrid types and examples; 3. Shore Power - how batteries reduce burden on local grid and expand availability to Today, more than 100,000 vessels travel through 4,500 ports worldwide, producing emissions equivalent to 220 coal-fired power plants. With seaborne trade expected to double to as many as 24 billion tons annually come 2030, the shipping industry must reduce its carbon footprint and adopt technologies that maintain ability to economically conduct trade. Zero Emissions in Port: Zero or low emission harbour activities are now available to all vessels and machines in ports. Each type utilizes battery power. The presentation will explore how cranes, ORV, tugboats, cruise ships and container vessels can implement the technology today with economic benefit. Coastal Shipping Short trip ferries and costal shipping is prime for hybrid propulsion. Battery technology has increased and cost has decreased. Coastal shippers and ferries can utilize plug-in hybrid propulsion as prime movers to reduce costs and emissions. Shore Power: Traditional shore power connects directly to the grid; the addition of rechargeable battery banks (containers full of batteries) expands availability. Ports are no longer limited by power availability or infrastructure capacity. Battery packs are charged by grid or other renewable sources, and some cases be used to optimize and reduce on-shore power generation or provide emergency spinning reserve for the port.

12:20h - 13:20h **Lunch**

13:20h - 13:40h **Replacement of a diesel generator with a containerised battery system on-board a containership**
Petros Menegakis, Ioannis Dimakopoulos, Georgios Panagoulias, Spyridon Gkinis and Nikolaos Lampris, Newcastle University
This design proposes an energy efficient solution aiming at the reduction of emissions generated by the fleet of one of the largest sections of international shipping, containerships. By designing a containerised battery system capable of providing 10.3MWh of useful energy, the ultimate aim is to replace an existing diesel generator and to operate the battery system on manoeuvring. Using a load planner software, it was ensured that such a system can be loaded on-board a specific containership, without negatively affecting the stability and the structural integrity of the vessel. The battery system can be charged both by a shore supply as well as during the seagoing part of the voyage, by using excess power produced by operating the running generators at their optimum point. The energy feasibility of such a system and the emissions reduction were verified by developing several software models, allowing various case study trips to be investigated. Results suggested that with such a system on-board, emissions can be reduced by 18.55% when the ship carries only normal containers and by 43% when the ship carries normal and refrigerated containers, showing that battery systems on-board can be proven beneficial on reducing emissions. However, the financial analysis performed indicated that such an investment would result to a loss, primarily due to the current price of battery systems. In the future though, the price of battery systems is expected to decrease, making such a system economically viable.

13:40h - 14:00h **Wind assisted ships design exploration and operational constraints**
R Eggers, Maritime Research Institute Netherlands, The Netherlands; G Gaillarde, Maritime Research Institute Netherlands, The Netherlands
The Maritime Research Institute Netherlands (MARIN) is progressively working in several projects to better understand and to increase the performance of wind propelled/ assisted vessels. The present paper will highlight two developments: The influence of (hull form) design variations on overall performance; Testing of manoeuvring and seakeeping operational constraints. As part of a collaboration with Delft University of Technology, Dykstra Naval Architects and Damen Shipyards, MARIN analysed the hydrodynamic forces for a systematic series of hull forms that were analysed for performance as wind assisted ships. This systematic series was taken and enhanced with a description of aerodynamic, rudder and propeller performance data leading to an overall Power Performance Prediction. The hull form variations in the systematic series were matched with appropriate variations in aerodynamic, rudder and propeller characteristics. The overall performance is studied. Amongst others emphasis is given to the trade off between maximum righting moment too be able and carry a lot of wind power at low heel angles on hand and the poor lift/drag performance of wide shallow hulls that realise such high righting moment on the other hand. Secondly, the relevance of operational constraints are discussed. Firstly this relates to the IMO resolution MSC. 137(76) on manoeuvring. Recent draft guidelines by e.g. DNV GL indicate that the criteria on performance in zig-zag and turning circle manoeuvres therein also need to be met with wind propulsors engaged. Further, the combined heel and roll and the course keeping abilities of wind assisted ships, related to typical criteria are discussed. The implications of these constraints and the possibilities for testing are discussed.

14:00h - 14:20h **LNG powered dry bulk carrier**
A. Trakakis, Arista Shipping, GR; M. Ioannou, M. Penfold and E. Kariambas, American Bureau of Shipping, GR and UK; D. Antonopoulos, Wärtsilä
In recent years, marine engine exhaust emissions legislation has become increasingly stringent. The upcoming global fuel sulfur content limit of 0.5%, effective from the 1 January 2020, together with the existing ECA limits for fuel sulfur content of 0.1% and the Tier III NOx limits, impose significant challenges to the shipping industry. The options available to achieve compliance critically involve the selected engine technology and type(s) of fuel, two choices which then determine whether exhaust emission abatement technologies are necessary. LNG is one of the potential alternative fuel solutions to meet the specified IMO fuel sulfur content limits since it does not contain any sulfur. Furthermore, gas and DF engines utilizing the Otto combustion process can produce NOx emissions below the IMO Tier III limits. On a calorific value basis, LNG prices are lower than traditional marine fuel prices. However, there are still challenges for the application of LNG as a fuel, notably fuel containment, fuel preparation systems, additional CAPEX and the LNG bunkering infrastructure. Given its strong potential and despite the anticipated challenges, the use of LNG as a fuel is now extending beyond the application to LNG carriers, to other ship types such as bulk carriers and tankers. This paper discusses the challenges involved and how these were met, when considering LNG as fuel in an ocean-going dry bulk carrier and focuses on the main engine technologies and machinery space arrangement. The study was conducted by Arista Shipping, the American Bureau of Shipping (ABS) and Wärtsilä, based on a representative bulk carrier design, an 82,000 dwt Kamsarmax vessel, which was selected as the project platform due to its proven design and high cargo capacity. The study concentrated on the selection criteria and available technologies for the main engine and the respective machinery space arrangements, whilst taking into account the applicable Classification requirements, relevant statutory safety regulations (IGF code) and the shipowners operational requirements to deliver a highly efficient competitive solution, with increased reliability and redundancy characteristics. The selected propulsion arrangement included advanced W31 two-stage turbocharged 4-stroke medium speed DF engines from Wärtsilä driving a CPP through a reduction gearbox. The findings revealed that despite the higher CAPEX incurred for the application of LNG as a fuel, the payback period could potentially be a few years and a step forward in delivering a competitive merchant vessel with favorable total cost of ownership.

14:20h - 14:50h **Coffee**

14:50h - 15:10h **Role of Rim Driven Propulsors in Future Electric Ships**
Steven Fletcher, Senior Engineer, Frazer-Nash Consultancy Ltd, UK
Rim-driven propulsors could come to play an important role in the propulsion of future electric ships. RDPs are a novel and emerging electrical propulsion system that integrate an electric motor within a ducted propeller, resulting in a compact, electrically driven propulsion package. RDPs have huge potential benefits for a range of applications because they remove the need for conventional mechanical drivetrains and open up a wide range of alternative platform arrangements. This paper will discuss why electrical propulsion can be advantageous and the types of power levels required to help illustrate what RDP systems must be capable of, before offering further detail on RDP systems and discussion of the challenges associated with their future application on large commercial ships. Key areas of interest include the impact of such systems on ship architecture and electrical integration challenges.

15:10h - 15:30h **Hybrid energy and propulsion system for vessels in timetable operation**
Martin Einsiedler, SHIPTEC AG, Switzerland
The energy consumption of propulsion and all on board systems is becoming more and more into the fo-cus of attention in shipbuilding and operation. The target is to reduce the total energy required and emissions as well as a significant cost reduction in operation. After some ample and intensive analysis and measurements of multiple operational profiles of ships, it was determined that a new, hybrid propulsion system (similar to hybrid buses), will be the optimal solu-tion to reduce fuel consumption in timetable operation. This parallel hybrid system which incorporates propulsion as well as the general energy management of all energy consuming parts on board is composed of different components which are controlled by a dy-namic management system in such a way, that the distinct, transient processes can be smoothed out as much as possible. This allows the multiple diesel engines which are the main energy producers, to work at their most efficient operating point (or they may at times be shut off entirely due to battery buffers). The focus is set on considering the integration of the different systems, their optimal cooperation with each other and the required system dynamics. First substantiated calculations show that fuel consump-tion can be reduced by up to 17%. Also they show that, with the additional help of downsizing relevant components, the costs of operation can be reduced up to 40% (excl. crew costs). Within the framework of this paper, the project will be presented how the base system was developed, build and tested. Real measured values, collected during the first six regular operating months of the pilot vessel supports the paper with newest data.

15:30h - 15:50h **Design-side Innovation to Minimize the Environmental Footprint of a Ro/Pax Ferry**
Donald MacPherson, HydroComp, Inc., USA and Ioannis Bakas, NAP Engineering P.C., Greece
The statement of requirements for a recent Ro/Pax ferry design included a mandate from the client to investigate innovations focusing on the “footprint” of the vessel with regard to the ocean environment and fuel efficiency. The mandate was for innovations in both operation and design.
This presentation will discuss the design-side investigations and their outcomes. New calculations proved vital to the success of the project, including use of a new computationally-efficient resistance prediction method that assists in the search for drag reduction from hull form changes, multi-mode duty profile optimization, and propulsion analysis prediction LNG and dual-fuel consumption indices. The presentation will also address new environment-focused analyses that were developed especially for this project, including reduction in the ship’s carbon footprint with full duty assessment of CO_2 emissions, as well as lowering its acoustical impact using an initial design estimation of underwater radiated noise.

15:50h - 16:00h **General Discussion**

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POWER & PROPULSION ALTERNATIVES FOR SHIPS

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