The Royal Institution of Naval Architects

Power & Propulsion Alternatives for Ships

International Conference

Power & Propulsion Alternatives for Ships

23 January 2019,

RINA HQ, London, UK

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23rd JANUARY 2019

08:45 - 09:20 **Coffee and Registration.**

09:20 - 09:50 **Alternative fuels: Present and Future of Containment Technologies and Impact on Shipbuilding**
Fabrizio Cadenaro, Ed Fort, Lloyd's Register, Italy
In recent years there has been a growing move toward the adoption of Liquefied Natural Gas (LNG) as marine fuel and consideration of other fuels as alternatives to the traditional marine fuel oils, driven by the introduction of new environmental regulations. Such fuels have different properties and as a result different storage requirements to those associated with current marine fuels and are pushing the industry toward both the introduction of containment technologies already established within other sectors of industry and, where necessary, the development of new ones. Existing containment technologies are typically physical, based on storage at ambient temperature, storage at ambient pressure, storage at high pressure (compressed) or storage at low temperature (cryogenic) or a combination of such. Future containment technologies however may well include material based storage, exploiting chemical processes to absorb and release fuels carried in liquid or solid matrices. This paper provides an overview of such alternative fuels, the corresponding containment technologies and the implications for ships design and construction, based on the knowledge and experience gained by Lloyd's Register through collaboration with the industry in a wide variety of conceptual and demonstration projects involving the use of LNG, Ethane, Methanol and Hydrogen fuels and ultimately in assuring their design and construction and entry into Class.

09:50 - 10:20 **New Shuttle Tanker Concept**
Jon Nation, Wärtsilä Marine Solutions, UK
The new Shuttle Tanker concept that has been developed by the world's largest provider of shuttle tanker services; TEEKAY in close cooperation with Wärtsilä, will offer a new level of ecological and economical solutions by using Wärtsilä's high quality equipment and systems in new and innovating ways. The new Shuttle Tanker will have the following three features comparing to conventional shuttle tanker. Reduced emissions: VOC emissions from the cargo will be eliminated, the NOx from the engine exhaust will be reduced with 84% which is well below IMO Tier 3 levels, while the SOx emissions will be practically eliminated, and finally the particles will be reduced with more than 96%, thus resulting in an astonishing reduction of emissions. Operation flexibilities: an efficient use of the installed machinery and propulsion systems in the vessel secures an unmatched maneuvering capability while the built in system redundancies ensures an inherent system robustness when managing unexpected event. Improved economics: 22% reduction in total fuel consumption and with the use VOC as fuel, resulting in 50% reduction in bunkering needs, and combined with less running hours and hence lower maintenance costs for machinery. With electric main propulsion motors and 4-stroke DF generating sets as the only power plant onboard the vessel, flexibility and overlapping functionality is achieved. This power distribution concept is part of Wärtsilä Low Loss Hybrid concept reducing the total installed power on board from 26 to 23MW with further reductions in fuel consumption and efficiency of the vessel.To achieve full SECA and NECA compliance, the new Shuttle Tanker will be with LNG fuel system to enable operation in gas mode throughout the shuttle tanker operation with LNG as primary fuel for the engine.

10:20 - 10:50 **Modelling Alternative Propulsion Technologies for Merchant Vessels**
John Buckingham, David Pearson, BMT, UK
The planned IMO sulphur emissions limit will likely lead to price increases of low-sulphur distillate fuels in 2020 and further pressure to improve fuel efficiency. The IMO measures planned for 2023 to meet the 2050 IMO CO2 reduction target will formalise the need for improved fuel efficiency through Energy Saving Technologies (EST). Many EST have been available for many years: the challenge is to integrate them and match them to the ship's operating profile. The BMT VTAS project has developed an approach that seeks to demonstrate the merit of ESTs fitted to specific ships on specific voyages. Ship data is used to develop and align mathematical models for the hullform and the machinery that reflect the ship's behaviours. With many ships operating in slow-steaming mode, there is opportunity for wind-based devices to contribute a larger proportion of the required thrust. This provides scope to explore how these low engine loads affect fuel efficiency, the use of geared electric propulsion and the use of wild heat from engine jacket water and exhaust gases to generate power. Using the ship data from real ships on real voyages, the performance of a ship before and after the installation of an EST fit is modelled and the results compared to the known baseline. This paper presents the approach taken to use ship data to develop, inform and validate a mathematical ship model and then to develop this model to identify the fuel saving benefits of an EST fit.

10:50 - 11:10 **Coffee**

11:10 - 11:40 **Can Biofuels Help Provide Clean Propulsion for Shipping, Now and in the Future?**
Chester Lewis, Dr Ausilio Bauen, E4tech Ltd, UK
The shipping sector is increasingly under pressure at national and international level to reduce greenhouse gas emissions (GHG) and emissions affecting air quality (non-GHG). A range of alternative fuels exist that can tackle these issues. In particular, biofuels can provide large reductions in GHG and non-GHG emissions, with a range of solutions for decarbonisation in the short and longer term. They offer greater decarbonisation potential compared to fossil alternatives aimed at tackling air quality emissions (e.g. LNG). E4tech conducted an important study (in 2018) for the Dutch Biofuels Platform and the Port of Rotterdam, as part of the development of a roadmap for decarbonising shipping in the Netherlands. The biofuels analysed were hydro-treated vegetable oil (HVO – including from waste oils and fats), Fatty acid methyl ester (FAME), straight vegetable oil (SVO), ethanol (both conventional and advanced production processes), bio-methanol, bio-LNG, Fischer-Tropsch diesel (FT-diesel) and Upgraded Pyrolysis Oil (UPO). The study determined the most attractive biofuel options based on criteria such as GHG reduction potential, readiness of production, cost and compatibility with the current vessel fleet in each shipping sub-sector: deep-sea, short-sea and inland shipping (see figure below as an example). It also provided recommendation on coordinated interventions from the range of actors in shipping industry that can support the uptake of biofuels, overcoming a range of technical, economic and operational barriers to their use. The presentation will provide a synthesis of the project findings, focusing on why or why not different biofuel options are attractive, and requirements for future deployment.

11:40 - 12:10 **Perpetual Shipping with Renewable Power Stations enabling Hydrogen Fuelled Ships**
Jason Steward, DNV GL, Australia
"Perpetual Shipping" means eliminating carbon and decimating waste heat from ship propulsion. This paper will describe the technical constructs and economic benefits of the system. For over 100 years ships have been powered by combustion of fossil fuels. Great improvements in design and propulsion have increased transportation efficiency and reduced cost. For millennia wind has powered sailing vessels and land-based machines to mill grain or pump water. More recently offshore wind farms have evolved as a viable technology used to generate renewable power feeding land-based electricity grids. For centuries electrolysis has been known to decompose liquid water into oxygen and hydrogen gas. More recently a technology known as Power to Gas converts surplus electrical power by electrolysis of water into hydrogen and oxygen gas for fuel. The Hydrogen Challenger is a mobile hydrogen production vessel using a wind turbine that generates electricity from the electrolysis of water. The aim of Renewable Power Stations enabling Hydrogen Fuelled Shipping (the "System") is to decimate carbon emissions and waste heat from shipping. The aim is achieved by building large-scale hydrogen production platforms using offshore wind farms to create Renewable Power Stations (RPS) supplying "green hydrogen" as fuel. Instead of allocating the hydrogen to generate electrical power for disbursement via the shore-based power grid, the hydrogen is used in a fuel cell for ship propulsion. To revolutionise shipping, RPS are dotted strategically along the shipping lanes. Each HFS fills-up, or exchanges, a tank of compressed liquid hydrogen at the RPS.

12:10 - 12:40 **Examining Methanol as Alternative Marine Fuel for Indonesian Domestic Ships**
Eko Maja Priyanto, BKI, Indonesia
Aykut I Ölçer, Dimitrios Dalaklis, Fabio Ballini, World Maritime University, Sweden
The analysis in hand aims to provide insight and to explore the future potential of methanol as an alternative marine fuel for domestic ships in Indonesia. An overview of potential application, analysis of resources availability, and stakeholder readiness/overall views on the topic are provided; potential challenges are also identified and further examined. The potential performance of methanol technology is discussed and evaluated by two different perspectives: the shipowner perspective and the government one, through case studies of two passenger ships owned by PELNI: MV. Labobar and MV. Gunung Dempo. As shipowners tend to look closely at the industrial-economic aspects, an economic feasibility study is performed by developing a combinatorial scenario approach based on the combination of economic measures of merit (NPV and payback period) and technical scenario (main-pilot fuel set up); a few of the variables included in the calculation are: ship age, ship performance, and macroeconomy conditions. Regarding the government perspective, the issues of environmental protection and policy compliance are evaluated by examining six emission types (NOx, SOx, CO2, CH4, N2O, and PM). Additionally, since there is a trade-off situation in government subsidies between the government and shipowner interests, an optimization and sensitivity analysis is performed by utilizing a combinatorial scenario model to determine optimum methanol price and external variables influencing the decision to support the uptake of methanol technology in the Indonesian market. An important finding was that Indonesia has certain advantages/drivers to introduce methanol as marine fuel. However, methanol competitiveness is mainly dependent on ship performance and the price differences between methanol and MDO. Additionally, policy analysis through the optimization approach could be one of the government options in order to determine the optimum condition in establishing methanol as marine fuel. Finally, short, medium, and long term recommendations are also provided as the basis for future consideration.

12:40 - 13:30 **Lunch**

13:30 - 14:00 **Towards Electrification of Ro-Ro Passenger Fleet in the Adriatic Sea**
Maja Perčić, Ivica Ančić, Nikola Vladimir, University of Zagreb, Croatia
With the recent introduction of new requirements for ships energy efficiency within MARPOL Annex VI, as well as continuous rise of fuel price, there is a growing interest by both shipyards and shipowners to save the fuel. Even though the primary targets of the new regulation introduced by MEPC are large oceangoing vessels, the incentive to increase energy efficiency is also emphasized for ships engaged in short-sea shipping, particularly ro-ro passenger fleet. These ships operate in shorter routes, spend much more time in ports maneuvering or at berth, and hence pollute more port areas. Also, since these ships transport passengers, there is a greater public pressure through various public campaigns to make these ships more eco-friendly. Numerous technologies can be implemented to reduce ships environmental footprint, depending on ship size, routes, design speed, auxiliary systems etc. In this paper options to electrify ro-ro passenger fleet in the Adriatic Sea is presented. This includes the analysis of the current status, predictions on the fleet growth, as well as estimation of fuel consumption for various typical ship power system configurations. Based on this research various options for implementing hybrid electric propulsion can be compared by different criteria and the overall environmental benefit can be quantified.

14:00 - 14:30 **How to Reach Total Power Train Efficiency**
Juho Rekola, Hannu Jukola, Steerprop Ltd, Finland
All too often, when designing a purely hybrid or hybrid electric propulsion system, designers and suppliers spend most of their efforts focusing on the individual components of the system. They look for ways to make each of the multiple components as efficient as possible. The amount of power needed to for a generator is calculated in excess. What happens under the water? What exactly leads to hydrodynamic propulsion efficiency? It is not the efficiency of the components when viewed individually. This alone does not create the type of synergies that advanced propulsion efficiency requires to make a significant sustainable breakthrough. When making a shift to new and greener technologies, the approach instead should be to examine the broad picture – the entire drive train. Steerprop's approach is to consider all the critical components, such as the frequency converters, generators and propellers. We also look into the cooling and excitation auxiliary equipment – normally forgotten, although they play a significant role. We have created tools to help shipowners and design offices analyze the efficiency of the entire drive train to reach the best possible performance at sea. We have mastered exceptionally high hydrodynamic efficiency for any type of vessel. We embrace the use of permanent magnet machines to add to overall efficiency, lower operational losses and optimize the entire system. Every component counts to effectively move a vessel through the water. So, the best approach is to consider the entirety to reach total power train efficiency.

14:30 - 15:00 **Comparison of Diesel-Electric Propulsion with Hybrid Propulsion Plant on Cruise Ships Using System-Theoretic Process Analysis**
Victor Bolbot, Gerasimos Theotokatos, Dracos Vassalos, University of Strathclyde, UK
Cruise ship industry is rapidly developing, with both the vessels size and number constantly growing up, which renders ensuring the passengers, crew and ship safety a paramount necessity. Collision, contact and grounding are among the most frequent accidents on cruise ships with blackout and propulsion loss being included in the top 10 hazards leading to these accidents. Considering the potential consequences of such event, it is crucial to prevent these incidences. Diesel-Electric Propulsion (DEP) plants have been widely used for propulsion and power generation on cruise ships, while at the same time hybrid propulsion system is viewed as an alternative allowing better energy-efficiency performance, reduced emissions and increased fuel cost savings. Taking into account that the DEP is already a complex system it is important that the introduction of new components will not lead to new hazardous scenarios. Considering also that DEP is a software intensive system, it is important to identify all the potential software malfunctions that may lead to blackout. The aim of this study is to implement a more comprehensive hazard analysis for a cruise ship hybrid propulsion system by employing the System-Theoretic Process Analysis (STPA), a method that has proved robust in tackling the system software-intensive character. Based on the analysis results, comparison in terms of safety is implemented for hybrid and conventional propulsion system on cruise ships and safety recommendations for design and operation of hybrid propulsion system are provided.

15:00 - 15:20 **Coffee**

15:20 - 15:50 **Agile Power Management Systems - An Optimised Control Strategy Using Real-Time Simulation for Hybrid Marine Power Plants**
Chris Watts, Babcock International Group, UK
An Agile Power Management System for marine vessels is presented by a Babcock led consortium with the University of Warwick (WMG) and Potenza Technology Ltd. The aim of this Innovate-UK funded project is to take advances in automotive energy management techniques and develop a modular marine power management system, addressing the latest guidance and legislation for marine applications. The system employs novel power management algorithms developed using Hardware-in-the-Loop (HIL) modelling techniques. Capable of interfacing energy storage with multiple power sources and loads, the algorithms seek to maximise overall efficiency by improving prime-mover operational envelopes, hence reducing emissions and fuel consumption.The research aims to develop an Optimal Control Strategy (OCS) for hybrid marine power plants. The architecture of the researched marine power plant is briefly discussed and a simple plant model is generated. The OCS is developed based on equivalent fuel consumption minimisation considering the system states, such as generators' fuel consumption and dynamics, battery state of charge and power demands. The generators can be used to charge the batteries when power demand is low and then this battery energy can be deployed as necessary during periods of high power demand. Thus the generators are able to work under optimal operating conditions, conserving fuel and lowering emissions. The system is capable of operating in the highest fuel economy zone, without compromising overall performance. Finally, the applicability of the proposed OCS is validated through real-time simulations with a number of test cases using a HIL simulation platform.

15:50 - 16:20 **Investigation of Auxiliary Power Potentials of Solar Photovoltaic Applications on Dry Bulk Carrier Ships**
Wandifa Saidyleigh, Aykut I Ölçer, Raphael Baumler, World Maritime University, Sweden
The increase in world seaborne trade over the past decade due to global economic and population expansion has resulted in a corresponding increase of world shipping fleet with even greater size and power requirements. The bulk of these ships use cheap and widely available fossil fuels, mainly oil for operation but which has deleterious effects on the environment. In order to address environmental concerns in the shipping sector, the International Maritime Organization (IMO), responding to the global call to reduce greenhouse gases emissions from international shipping adopted technical and operational measures. These are to ensure efficient energy management on ships and have led to the application of many innovative technologies including the use of renewable energies and alternative fuels on ships to minimize fossil fuel consumption and reduce emissions. In order to achieve a substantial emissions reduction in international shipping, the potential applicability of a technology which utilizes a universal renewable energy resource on the largest ship type in international shipping is investigated in this research. It focuses on investigating the potential of Solar Photovoltaic technology on dry bulk carriers using a developed methodology based on Levelized Cost of Energy concept as the basis for comparison. The results of this research can be used to guide decision makers about the potentials of Solar Photovoltaic technology on dry bulk carriers in general whilst its developed methodology may be useful in the specific context for determining which ships and under what circumstances solar PV would be an optimal option.

16:20 - 16:50 **Modern Rotor Sail technology helps ships save fuel and reduce emissions - performance and experiences from recent installations**
Jukka Kuuskoski, Norsepower Oy Ltd, Finland
Norsepower's modern Rotor Sails are pioneering auxiliary wind propulsion for the global maritime industry. The Rotor Sail is a modernized Flettner rotor which has proven its performance in several years of operation in demanding conditions in the pilot project onboard the M/V Estraden, a 9,700DWT Ro-Ro carrier. The presentation will include a description of the tests completed in 2016 and results of the analysis to verify thrust and fuel saving performance. Installations on the Viking Line cruise ferry Viking Grace and Maersk Tankers LR2 tanker Maersk Pelican were both completed in 2018. They feature the larger models of the standard models designed by Norsepower. Viking Grace has one 24 m high Rotor Sail and the Maersk Pelican has two 30 m high Rotor Sails installed on their decks. The presentation will include a description of the ongoing test campaigns to verify thrust and fuel saving performance on the two vessels. The presentation will also describe Norsepower's Rotor Sail design and applicability for various ship types and operating regions. Examples of case studies are presented to indicated profitability of investment for ships operating in different routes.

16:50 - 17:20 **Case Study: Wind-Assisted Ship Propulsion Performance Prediction, Routing, and Economic Modelling**
Nico van der Kolk, Giovanni Bordogna, Paul Desprairies, TUDelft, the Netherlands
James Mason, University of Manchester, UK
Wind-assisted propulsion for commercial ships is again attracting attention as a response to increasingly stringent environmental regulations. It also represents a market opportunity, potentially increasing the perceived value of the shipped products. In this paper, a modelling for the performance of these hybrid ships is combined with a routing tool for voyage optimisation and an economic analysis to demonstrate commercial viability. The case study is performed for a trans-Atlantic route, with both EU and US markets complying well to windassist trade constraints and for which wind conditions are shown to be favourable. Wind-assist vessel modelling will include aerodynamic effects such as complex interaction effects occurring between the installed wind-propulsion systems and between the wind-propulsion systems and the ship itself. Hydrodynamic components include the increase in ship resistance due to heel and leeway angles, changes for the main propulsor efficiency, and changes in the added resistance in waves. Modelling for each hydrodynamic and aerodynamic effect is described and implemented in the performance prediction algorithm used for routing. The routing optimisation involves altering both the route and speed of the sailing commercial vessel to minimise the fuel consumption of the vessel and maximise the efficiency of the installed wind-propulsion systems, while respecting imposed commercial constraints. Voyage simulations are performed using hindcast weather data sets for wind and sea-state. The economics for the wind-assist case will be presented, including a discussion of the sensitivity to modelling choices for the vessel performance and for routing constraints.

17:20 - **General Discussion & Drinks Reception**

International Conference

POWER & PROPULSION ALTERNATIVES FOR SHIPS

23rd January 2019, RINA HQ, London, UK

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