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Influence of EEDI on Ship Design

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Influence of EEDI on Ship Design

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DAY 1 PAPERS:

08.30-09.00 **COFFEE & REGISTRATION**

09.05-09.40 **KEYNOTE,** *Tor Svensen, CEO, DNV GL Maritime*

09.40-10.15 **IMPROVING THE EEDI OF A SHIP - THERE'S MANY WAYS TO SOLVE AN EQUATION**

Frederik Gerhardt, SSPA Sweden AB, Sweden. Drawing on SSPA's large database of ships, a wealth of experience and a large number of model test results the paper explores several options for reducing the EEDI. Starting from the equation that defines the index we present and discuss four of the many ways to achieve such a reduction. 1: Reducing the power demand of the hull by optimising main parameters like length or beam while keeping deadweight and speed constant. 2: Reducing the power demand of a hull with fixed main parameters by means of hull form optimisation i.e. classical hydrodynamic improvements. 3: Increasing the product of speed and deadweight without increasing the power by means of main parameter optimisation. This is a multi-parameter optimisation. 4: Tailoring the sea margin component of the engine power to the needs of a ship under expected operating conditions. Based on sea keeping tests/calculations and weather statistics the required sea margin and thus the installed power can be specified more precisely. Using a practical example for each of the above options it is possible to estimate how much the EEDI can be reduced, which option seems to be most promising for what type of ship and what the general design implications are.

10.15-10.50 **VERIFICATION METHODS FOR SPEED TRIAL AND MINIMUM PROPULSION POWER FOR EEDI**

Ryuji Miyake, Takeshi Shimada, M. Abdul Rahim, A. Asok Kumar, Nippon Kaiji Kyokai (ClassNK), Japan. Amendments to MARPOL ANNEX VI, which made "Energy Efficiency Design Index (EEDI)" and the "Ship Efficiency Management Plan (SEEMP)" mandatory, have entered into force on 1 January 2013. EEDI verification is to be implemented through two stages: design stage and sea trial stage. In the sea trial stage, speed trial is carried out. "EEDI verification guidelines" require that speed correction, considering wind, current, wave, shallow water and displacement at speed trial, is to be made in accordance with "ITTC Recommended Procedure" or "ISO15016:2002". Work towards revising "ISO15016:2002" and harmonizing it with "ITTC Procedures" is being carried out in Japan. In order to support Shipbuilders, ClassNK has developed a software called "PrimeShip-GREEN/PSTA" used for the speed correction at speed trial in compliance with "ISO15016:2002". The software will be further updated once "ISO15016:2002" is officially revised. For bulk carriers, tankers, or combination carriers of 20,000DWT or above, to comply with EEDI requirements, it is required to have sufficient installed propulsion power in order to maintain the maneuverability in adverse weather conditions, in accordance with "Interim minimum propulsion power guidelines". ClassNK has also developed a software called "PrimeShip-GREEN/MinPower" used for the assessment of minimum propulsion power. In this paper, verification methods for speed trial and minimum propulsion power for EEDI are introduced. In addition, software programs developed by ClassNK, in order to support shipbuilders for EEDI verification, are also introduced.

10.50-11.20 **COFFEE**

11.20-11.55 **EEDI -2025**

D. Anink Scheepsbouw Nederland, R.P. Dallinga, J.H. de Jong & M. Verhulst MARIN. EEDI has stirred up a number of adjacent issues either with direct design consequences which have to be repaired by additional regulation or with result in changes in the design (process) in the long term. The paper will address a number of these issues. On the process side a long term role of the class as verifier of EEDI will affect the IP of both yards and design institutes and asks for a more specific role of class. At the end of the EEDI verification we have seen STAIMO (IMO based trials procedure) coming into existence which is essential to the success of EEDI more so when the future requirements on the lowering of the EEDI come into place. In particular for niches like small coastal vessels EEDI needed to head for exemptions for good reasons and the new regulations on MPR (Minimum Power Requirement) following the introduction of EEDI also needed (and still needs) a revision due to underestimation of operational consequences of the introduction of EEDI. On both subjects the Dutch Shipping community has performed studies to address the consequences of the EEDI implementation. By means of two examples possible influence of the EEDI reference line reductions on ship main dimensions will be shown. In the current phases EEDI requirements and economical motives go hand in hand; speed reduction is a very effective way of EEDI reduction.

11.55-12.30 **ENERGY EFFICIENT SAFE SHIP OPERATION (SHOPERA)**

A. Papanikolaou (NTUA), E. Bitner-Gregersen (DNV-GL), O. El Moctar (UDE), C. Guedes Soares (IST), T. Karayannis (LR), K. Koushan (MRTK), V. Shigunov (DNV-GL), G. Zaraphonitis (NTUA). There are serious concerns regarding the sufficiency of propulsion power and of steering devices to maintain the manoeuvrability of ships in adverse conditions, hence the safety of ships, assuming that the ship marginally passes the relevant EEDI criterion. This gave reason for additional considerations and studies by IACS, which were submitted to IMO (MEPC 64/4/13 and MEPC 64/INF7). Furthermore, whereas present EEDI regulations concern the limitation of toxic gas emissions by ship operation, what may be understood as a new constraint in ship design and operation, it is urgent to look holistically into integrated ship design and operational environments and implement multi-objective optimisation procedures optimising ship's powering while ensuring safe ship operation, but at the same time looking for the right balance between ship's efficiency and economy, safety and greenness.

12.30-13.30 **LUNCH**

13.30-14.05 **ENERGY EFFICIENCY OF INLAND WATERWAY SELF-PROPELLED CARGO SHIPS**

Aleksandar Simić, University of Belgrade, Serbia. The principal objective of this work is to establish a reliable tool for benchmarking energy efficiency and carbon emissions of inland waterway self-propelled cargo ships. According to the results of the analysis of 107 ships of the type considered here, EEDI for the sea-going ships cannot be applied for benchmarking of the inland waterway ships, due to a variety of reasons related to the conditions specific to inland waterway navigation. Therefore, a modification of existing approach is proposed – i.e. EEDI*. Namely, while IMO EEDI developed for the sea-going ships is based on constant and specified engine power (75% of installed engine power) at expected/achieved ship speed (reference speed), modified EEDI* proposed here for the inland waterway ships is based on constant and specified service speed at corresponding engine power (reference power) required for achieving that speed. Accordingly, reference curves (for different reference speeds) and corresponding reference surfaces for deep and shallow water (depth of 5 m) have been calculated and are presented in this work.

14.05-14.40 **DELTAMARIN – INFLUENCE OF EEDI ON SHIP DESIGN**

Joonatan Haukilehto, Deltamarin Ltd., Finland. This paper describes ship design office view on the Energy Efficiency Design Index (EEDI) based on extensive experience in developing and implementing the EEDI on multiple ship types. The most obvious limitations and effects on vessel performance are outlined. Deltamarin has contributed to EEDI development by conducting two large studies on the EEDI for European Maritime Safety Agency (EMSA) and participating in RoRo/RoPax EEDI Industry Forum (REIF), organized by Interferry. The first EEDI study for EMSA examined the applicability of EEDI as a whole, also comparing the vessels built in different areas of world to evaluate if there was a significant difference in the EEDI values between e.g. a tanker built in Japan or Europe. The second EEDI study for EMSA concentrated on EEDI applicability and refinement for RoRo, RoPax and specialized vessels. The main conclusions from the studies and development efforts are presented and the impacts on ship design and actual performance are analysed.

14.40-15.15 **SHIP DESIGN FOR SEA" VERSUS "SHIP DESIGN FOR EEDI", A CASE STUDY**

Gerco Hagesteijn, Senior project manager, MARIN, Pierre Crepier, Project Manager Ships, MARIN, The Netherlands. The DeFoS project aims at a "ship design for sea" approach where the ship is designed for a variation in loading and environmental conditions. To come to an ideal ship design, this should be optimised for the complete matrix of operational conditions for varying environmental conditions, loading conditions and ship speed. Within the DeFoS JIP, an EEDI case study was made using this design approach. An existing ship is re-designed for a variation in loading conditions, using the actual operational profile of this vessel. Two different designs will be compared. One of these designs is optimised for the EEDI condition (one speed and draught). The other design is optimised for a variation of speed and draughts which are obtained from the operational profiles of the vessel. For both of these designs, the EEDI and the energy consumption for a type for typical operational profile is calculated. In the hull optimization study, PARNASSOS explorer will used to test variations of hull forms to come to the best design. The results of this study are used check the necessity for a 'correction' of the EEDI based on the operational profile of the ship.

15.15-15.45 **COFFEE**

15.45-16.20 **INFLUENCE AND IMPACT OF THE EEDI ON THE DESIGN OF FUTURE LNG CARRIERS**

E. Ekanem Attah , R.W.G. Bucknall, Marine Research Group, Department of Mechanical Engineering, University College London, UK. This paper aims to examine three aspects with respect to the application of the EEDI to LNG Carriers (a) to review the EEDI of different LNG designs over time and compare them with new designs today with their alternative propulsions systems through analytical study (b) To examine the potential impact of the upcoming EEDI regulations to future LNG ship designs, its implementation limitations, and effectiveness in achieving a reduction in CO_2 emissions (c) To suggest recommendations on future regulatory amendments based upon these studies. This paper is written with both an academic and a practical viewpoint and is supported by extensive observations onboard current LNG Carriers.

16.20-16.55 **IMPLEMENTATION OF ENERGY EFFICIENCY DESIGN INDEX & ITS IMPACT ON THE DESIGN OF CONTAINER VESSELS**

S.M. Rashidul Hasan, Chittagong Dry Dock Limited, Bangladesh

The aim of this paper is to find the impact of EEDI on ship design parameters and hydrodynamics for container vessels. The EEDI is calculated with the current IMO formulation and guideline. Finally, the results are presented as the effect of the variations of ship design parameters such as Length, Beam, Draught and Prismatic Coefficient on EEDI and hydrodynamics of ship. Guide lines and suggestion have also been made based on the results to achieve the required EEDI. Since this index has been criticized right from the beginning, an effort is also made to analyse the criticism against the present EEDI formulation, guideline and reference line.

16.55- **GENERAL DISCUSSION & EVENING DRINKS RECEPTION**

DAY 2 PAPERS:

08.30-09.00 **COFFEE & REGISTRATION**

09.05-09.40 **IMPACT OF POWER REDUCTION ON SUSTAINED SPEED AND RELIABILITY**

R.P.Dallinga, R.Grin - MARIN, G.v.d.Bles, J.J.Nieuwenhuis - CONOSHIP. For several ship types the introduction of the EEDI will lead to a lower installed power. The related speed reduction will lead to an optimum hull form with a lower length and a higher block coefficient. Because these hull forms have a higher added resistance in waves, the subsequent speed loss, which is augmented by a reduced steepness of the resistance curve, materializes in a relatively large increase in trip duration and reduced reliability on a given route. Our contribution to the conference highlights the effect of the EEDI power reduction on the operational performance of a tanker. Based on an estimate of the evolution in hull form, the resistance and propulsion characteristics, the related increase in the added resistance and the impact of the increased speed loss on the trip duration and reliability are quantified on a typical European coastal route.

09.40-10.15 **EEDI CHALLENGES IN THE DESIGN OF LARGE SLOW-SPEED SHIPS**

Hans Richard Hansen, Ph.D, Low Carbon Shipping AS, Thomas Dinham-Peren, B.Sc, BMT Defence Services Ltd, UK. The paper describes some of the results of a project started by major tanker owner Teekay Corporation in 2007, which aimed to design large tankers with a minimum propulsion performance improvement of 10% relative to that of good present day designs. The design process used started from first principles rather than from established designs and conventional practices, and included building cost, operating cost and commercial attractiveness criteria. In the end extensive model tests in calm water, simulating the IMO required 'Speed Trial' condition, showed 25 to 30% propulsion improvements, satisfying the 2025 EEDI requirements. In contrast, a less comprehensive adaptation of existing designs is likely to result in relatively large speed reductions in heavy weather. This was given particular attention in the project, and the new designs, based on model tests in waves, compensate for this, giving improved speed keeping capability in heavy weather as well as improved fuel economy in the weather distributions encountered on actual tanker routes.

10.15-10.50 **EEDI FOR INTEGRATED POWER SYSTEMS**

Ivica Ančić, Ante Šestan, Nikola Vladimir, University of Zagreb, Croatia. After the extensive discussion in the Marine Environment Protection Committee (MEPC), Resolution MEPC.203(62) introducing the EEDI was adopted. New regulations intend to improve energy efficiency for ships and reduce the emissions of any substances that originate from fuel oil and its combustion process. MEPC fulfilled the objective set by the UN and adopted the new regulations on the CO2 emission from ships. Even though the new regulations should encourage the use of innovative energy efficient technologies, the EEDI in its current form is not applicable to innovative ship power systems. Innovative ship power system designs should also be properly evaluated so the optimal configuration can be identified and applied. This paper analyses how the EEDI in its current form is changed with the introduction of new elements in the ship power system. This change is compared to the change in the overall energy efficiency and the change in the CO2 emission. Ship with integrated power system is observed since it allows the easiest inclusion of different energy efficient technologies.

10.50-11.20 **COFFEE**

11.20-11.55 **A MARINE ENGINEERING PLANT MODEL TO EVALUATE A WASTE HEAT RECOVERY SYSTEM AND ITS INFLUENCE IN EEDI CALCULATIONS**

Joel R. Pérez Osses, University College London, UK/ Universidad Austral de Chile, Chile, Santiago Suarez de la Fuente, Alistair R. Greig, Richard W. G. Bucknall, University College London, UK. A Marine Engineering Plant (MEP) Energy Model of a large carrier which includes a propulsion system model using a 2-Stroke Low Speed Diesel Engine (LSDE) has been used to evaluate the efficiency technologies expression that includes the availability factor of innovative energy efficiency technology (feff(i)). This factor endorses the use of new technologies such as waste heat recovery systems (WHRS) to reduce the demand of power from the main and auxiliary engines achieving a reduction of CO2 emissions. The model is validated using data provided in the public domain and actual performance data. A WHRS using the available heat in the exhaust gas after the turbo compressor of the LSDE is coupled with the MEP Energy Model. The energy recovered is transformed, via a thermodynamic cycle, into electricity to help cover the ship demand. A multi-objective optimization controlling the pressure ratio and pinch point temperature difference will allow deeper understanding of the influence of the EEDI reduction and WHRS size. The baseline case is a water based Rankine cycle and this will be compared to different organic Rankine cycles. The paper concludes by making necessary recommendations for improvements to the efficiency technologies expression to reduce EEDI values and achieve more efficient ship designs.

11.55-12.30 **THE UTILIZATION OF PASSIVE DESIGN STRATEGIES WITHIN THE DESIGN PROCESS OF PASSENGER VESSELS OPERATING WITHIN THE MEDITERRANEAN TO SUPPORT EEDI COMPLIANCE**

S McCartan and C Kvilums, EBDIG-IRC, Department of Industrial Design, CSAD, Coventry University, UK. The architectural industry has developed integrative design tools, guidelines and legislation to stimulate the use of passive strategies in the reduction of emissions from the EU building stock, resulting in the reduction of lighting and HVAC loads. This is supported by international policies such as the 2002 Energy performance of buildings directive, which requires all new buildings from 2018 to produce more energy than they consume. This paper identifies the potential of Passive Design as a transfer of innovation from the architectural industry to reduce the auxiliary loads on cruise ships operating in the Mediterranean. A parametric analysis methodology is applied, which examines the holistic benefits of improved fabric, form, fenestration and lighting. An analysis of the results supports the evaluation of the environmental climate of operation as an integral part of the design process (bioclimatic design), resulting in significant economic and ecological savings.

12.30-13.30 **LUNCH**

13.30-14.05 **HEATING, VENTILATING AND AIR-CONDITIONING CAN ACCOUNT FOR 30% OF ENERGY CONSUMPTION, ESPECIALLY ON PASSENGER CRUISE SHIPS**

Sean Boden, Global OEM & Key Account Manager, Danfoss Hydronic Balancing & Control, Denmark. Typically, chilled water is produced centrally; pumps distribute it to technical rooms and cabins via pipes to fan coils, (heat exchangers), where the water absorbs heat from the rooms. Larger spaces use air handling units to cool large volumes of air which, using fans, are ducted to restaurants, casinos, etc. Most marine vessels still use traditional distribution designs, utilising 3-way valves, which simply bypass the heat exchanger when less cooling is needed, pumping the chilled water back to the chiller. The pumping is expensive and unnecessary; chiller efficiency is much reduced due to low delta-T syndrome. Hydronic balancing has been a requirement for many years, and all systems must be balanced at design flow. However, cooling and heating demand are variable, for 80% of time cooling demand is less than 25% and traditional manual systems cannot compensate, keeping costs closer to 100%.

14.05-14.40 **THE USE OF FLETTNER ROTORS IN EFFICIENT SHIP DESIGN**

David Pearson, BMT Defence Services, UK

Previously Flettner rotors were not an economic success due to the low price of bunker fuel. However, the technology garnered renewed interest when fuel prices rose in the early 1980's and the beginning of the 21st century. Since the introduction of the EEDI, their potential for net fuel and CO2 reductions prompted a number of recent studies into their use. For the most part however, these studies focus on the benefit from the rotors in very specific known conditions, disregarding certain ship motions and practical considerations which could affect the overall efficiency and effectiveness of the Flettner rotor. This paper presents a Flettner rotor performance model which considers the benefits provided to generic classes of ship across a wide range of variables, and assesses the suitability of the technology for the merchant fleet as a whole. The intention is not only to demonstrate the potential of Flettner rotors as a means of meeting new emissions and minimum efficiency targets for ships, but also their potential economic viability and attractiveness to ship owners.

14.40-15.10 **COFFEE**

15.10-15.45 **SHIP DESIGN AND EMISSIONS ABATEMENT OPTIONS CONSIDERING EEDI**

John Calleya, UCL Mechanical Engineering, University College London, UK. With no current policy to control operational CO2 emissions, EEDI remains the key policy lever available to control emissions of the fleet. However, there is no consensus on the likely consequences of the policy and some important questions remain: will it reduce CO2 emissions, will it have an effect on the profitability of new build ships and the existing fleet? There are differences between designing for EEDI, designing to maximise profit and designing for the lowest CO2 emissions. This paper describes on-going work carried out in the RCUK funded projects "Low Carbon Shipping - A Systems Approach" and "Shipping in Changing Climates". This involved the development of methods and software tools to examine ship emissions and economics both in terms of single design points and operational conditions. These tools have allowed the exploration of a range of scenarios regarding the future of ship design and how these relate to EEDI, CO2 emissions and economics.

15.45-16.20 **CONCEPT DESIGN OF DUAL-FUEL RIVER-SEA GOING 1000TEU CONTAINER SHIP ON THE YANGTZE RIVER**

Kai Li, Ming Chen, Yan Lin, Yu Yanyun, School of Naval Architecture and Ocean Engineering, Dalian University of Technology, China/ Ship CAD Engineering Center, Dalian University of Technology, China. With the worsening environment pollution, the design of ships is turning to use cleaner energy. This paper presents a concept design of dual-fuel river-sea going 1000TEU container ship on the Yangtze River. Aiming to save energy and lower CO2 emission, dual-fuel ME is selected on the basis of EEDI calculation and economic analysis. Moreover, the concept design also take factors such as hull optimization, waste heat recovery, into account. Direct evaluation of the weight and volume savings is inadequate; a baseline ship design must be firstly created to account for improvements. This total ship approach allows us to determine the net benefit from the energy saving measures. Net benefits are then compared to the baseline ship to produce interesting tradeoffs such as increased range versus increased payload or designing a smaller ship. Such total ship analysis is valuable as designers go on to answer such questions as the proper distribution system for a particular application, or to analyze the impact of specific technology advances. The final design comes out after net benefit evaluation.

16.20- **GENERAL DISCUSSION**

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