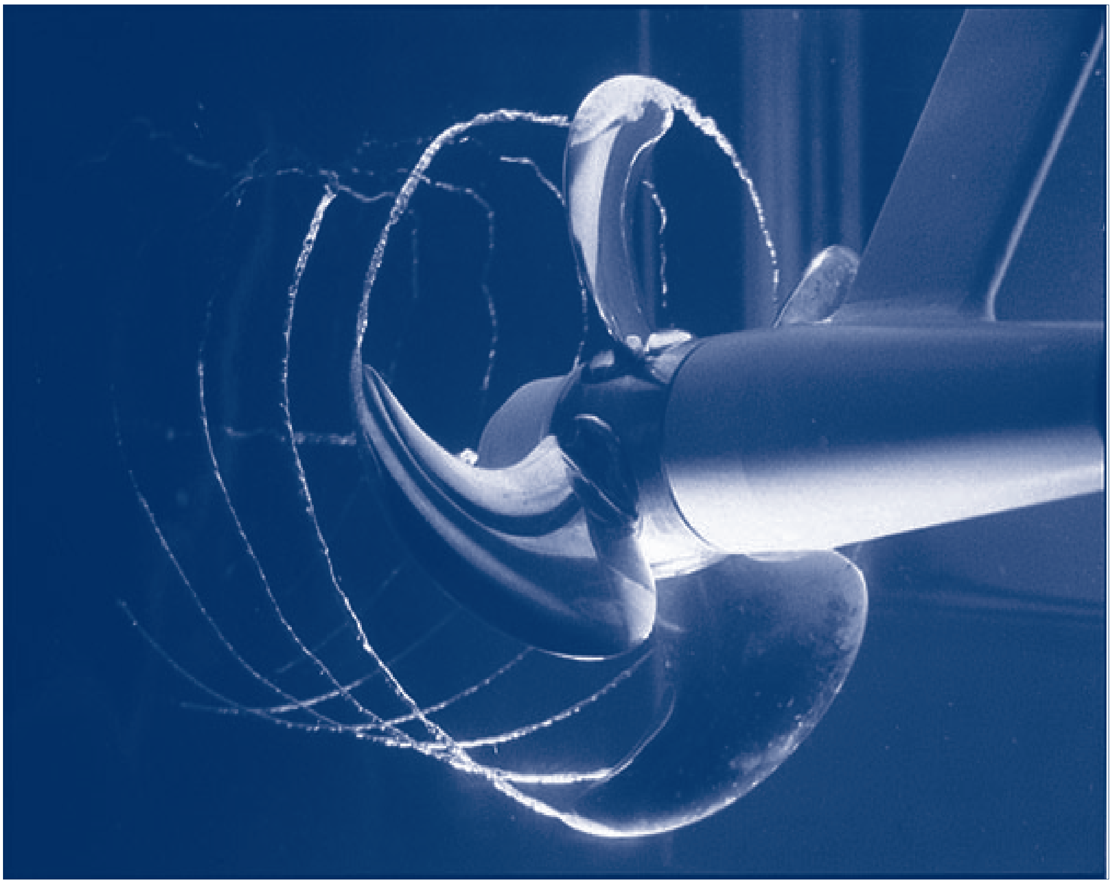
The Royal Institution of Naval Architects

Propellers & Impellers:
Research, Design, Construction and Application



International Conference

Propellers & Impellers:

Research, Design, Construction and Application

27-28 March 2019

RINA, HQ, London, UK

Supported:

NUMECA INTERNATIONAL

www.rina.org.uk/Propellers_2019

Call Catherine on +44 (0) 20 7235 4622 or email conference@rina.org.uk

27th MARCH 2019

08:55 - 09:30 Coffee and Registration.

09:30 - 10:05 KEYNOTE: ***John Carlton, Director of Maritime Studies, City, University of London, UK***

10:05 - 10:40 Usage of Digital Tools for Optimum Propeller Designs
Norbert Bulten, Wärtsilä Marine Solutions, Netherlands

The conventional propeller design process is experiencing quite significant developments in the last decade. The introduction of CFD simulations for open water performance simulations has grown to maturity and it is being used in the daily design cycle. Not only open water performance can be calculated accurately with commercial acceptable timeframes, but also the propeller-hull interaction.
A remarkable agreement between measured and calculated open water performance has been found for a large population of propellers when the laminar flow regime was selected. In case the performance of a ducted propeller is considered, open water performance aligns well with model scale CFD simulation based on a fully turbulent flow regime. When scaling to ship scale, a significantly larger efficiency is found, given the identical turbulent flow regime.
It should be realized that the propeller has to perform in actual operating conditions. Since these conditions have a much more dynamic content, due to for example vessel acceleration, manoeuvring, adverse weather, the complete propulsion lay-out needs to have sufficient capability to handle the dynamics. In order to get more insight in the dynamic effects in operation, integrated system simulation models are built to analyse the interaction between propeller and ship on the one hand and on interaction with drive-line and engine on the other hand.
In the paper the usage of digital tools in the different steps in the design process will be discussed, from isolated propeller performance, to performance in behind ship condition, to evaluation of dynamic operating conditions.

10:40 - 11:15 Coffee

11:15 - 11:50 Full Scale Analysis of Propeller Noise & Vibration with OpenFOAM
Endicott M. Fay, Cotty Fay Marine Design, UK

The issues of noise and vibration related to the propulsion system of vessels shines a bright light over the present day operation of sea going vessels. Some of the principal issues coming to the front are not new and are concerned with passenger and crew comfort which has been a touchstone for a decade or more. The most recent, more ominous issue is transmission of noise from transiting vessels and how this noise affects marine mammals. The tools used to analyze and define the expected levels of vibration and noise in the design phase are becoming more and more robust. The paper describes the use of computational fluid dynamics to predict the noise and vibration level of the propulsion system of the vessel.The analysis is carried out using the program OpenFOAM comparing the operating propeller performance coefficients with the openwater propeller coefficients. The paper also looks at the effects of cavitation, vessel trim and propeller loading on multiple full scale vessels. The loading, noise and vibration data will be quantified and compared to full scale vessel data for validation.

11:50 - 12:25 Numerical Study of Modification of Propeller Tip on Underwater Radiated Noise
Joe Danio, Indian Institute of Technology Madras, India

The Underwater Radiated Noise (URN) has significantly increased in the past 20 years and studies to reduce its impact have come to focus due to its impact on marine mammals. Ship borne noise being a major contributor to the URN and propeller its main source, efforts are being made to reduce the propeller noise without compromising on its efficiency. Study of cavitating noise has resulted in developing ways to prevent cavitation inception. The study of non cavitating noise is therefore of increased significance. Acoustic characteristics may be modified due to the variation in propeller geometry. This paper attempts to showcase the effect of modification at the propeller tip on the hydrodynamic performance and Sound Pressure Level (SPL). Rake angle at blade tip may cause changes in tip vortex, hydrodynamic performance and noise level. The two-step Ffowcs William and Hawkings (FW-H) equations are used to calculate the SPL from the pressure distribution at various points around the prop eller. Numerical results like SPL at various points in the downstream and propeller disk plane and hydrodynamic characteristics are presented and discussed.

12:25 - 13:25 Lunch

13:25 - 14:00 Numerical Estimation about Performance of CPP and Podded Propulsor on many Off-Design Conditions using RANS Approach
Kohei Himei, Nakashima Propeller Co. Ltd, Japan

When designing Controllable Pitch Propeller or Podded propulsor, the possible performances, especially the moment for rotating the blade or pod body on any off-design conditions, must be considered properly. The estimated result of that spindle moment directly leads to the selection of the hydraulic control system capacity. However, it is difficult to numerical estimate their values under wide range with high accuracy because the flow field around CPP's blade or pod body is so complicated.
On this paper, many CFD analyses carried out on wide range that cover with actual propeller operating condition which include off-design. In CPP, at several blade pitch angles, all advanced coefficients in first and forth quadrants were covered. Furthermore in podded propulsor, both pull propeller type and push one were modeled, 360 degree all steering angle at propeller design point were covered. Their analysis results about CPP and podded propulsor were in good agreement with results of model tests except for unrealistic operation condition.

14:00 - 14:35 RIM Driven Propellers: Optimization Based Design Approach Using RANS Calculations
Stefano Gaggero, University of Genoa, Italy

RIM driven propellers represent an unconventional, but underrated, propulsive solution which hydrodynamic design is still not obvious. Indeed, in the last years, most of the attention has been devoted to the efficient coupling with electric motors, since only recently the development of permanent magnets and compact stator/rotor arrangements allowed for the successful embedding of the driver directly inside the surrounding duct. From the hydrodynamic point of view, instead, analysis and, in particular, design strategies are not yet ripe. RIM propellers, in a certain sense, are “simpler” ducted configurations, without the burden of the blade tip/duct gap flow. They add, however, the complexity of the flow in the annulus of the duct ring, which drives the blades in place of the hub.
In this light of advanced design approaches for unconventional geometries, we propose a Simulation Based Design Optimization tool using RANS analyses of parametrically described geometries as a part of an automatic, multi-objective optimization loop. The SBDO is used to design a RIM driven propeller, with an accelerating type duct, with improved performance simultaneously in terms both of efficiency and cavitation inception at different (design and quasi-bollard pull) functioning conditions. The effectiveness of the design approach is verified by comparing the RIM propellers from the design by optimization activity with the performance of a reference conventional ducted propeller at the same functioning points.

14:35 - 15:10 Coffee

15:10 - 15:45 Numerical Study of Biomimetics Application to Ship Design
Subodh Chander, Allswater Marine, Canada

Biomimetics by definition is the imitation of the models, systems, and elements of nature for the purpose of solving complex human problems. Biomimetics has been widely used in aerospace industry for the efficient solution of aircraft design by mimicking the nature designs. Engineers have been studying and learning from natural world for modern and efficient design solutions.
Nova Scotia is well known for its humpback whale sightings. Despite their large size, they are known to swim in tight circles to prey. The advance maneuverability of humpback whales is due to its non-conventional flipper creating a tubercle effect. The research on this topic was inspired by work of marine biologists on humpback whales.
Tubercles effect has been studied and implemented on wind turbine and aircraft design to overcome the effects of stall and improved lift. With the growing ship industry, the need for improved maneuverability is increasing. This study discusses the implementation of tubercles on ship maneuvering devices i.e rudder. Initial study is done on standard aerofoil/hydrofoil designs at different angle of attack to compare the results with the available experimental/numerical data, using Computational Fluid Dynamics methods. Effect of using different turbulence model is investigated.
Further the design is modified to include the tubercles effect on the rudder, different turbulence schemes are investigated at varying angles of attack during the study.
Aim of this research is to investigate the lift-to-drag ratio for different amplitudes and wavelength of tubercles and its influence on the performance. Further effects of combining different tubercles on one foil shall be investigated. This study is done primarily using numerical methods.

15:45 - 16:20 Evaluation of Hydrodynamic Performance of Contra-Rotating Propellers (CRP) using OpenFOAM
Hrvoje Jasak, Wikki Ltd, UK
Luka Balatinec, University of Zagreb, Croatia

In this paper, numerical study of a contra-rotating propeller (CRP) with emphasis on propeller interactions is conducted, with an evaluation of the hydrodynamic performance coefficients of a CRP set. A series of transient and steady-state / frozen rotor simulations with the Multiple Reference Frame
Method -MRF were carried out using two different computational meshes. One mesh has a full propeller geometry and the second is a quarter-geometry with cyclic boundary conditions. Results of both the transient and steady-state simulations are analyzed and the hydrodynamic performance coefficients of the CRP set, as well as the coefficients of the individual propellers, are presented and compared with experimental. Numerical results of the transient simulations show good agreement with the experimental values, while the results of the steady-state MRF simulations show slight discrepancy from the experimental value, but follow the same trend seen in the experimental results. The harmonic balance method was used to evaluate the fluctuating component of thrust and torque and compared with the experimental data and transient simulation results.

16:20 - General Discussion and Evening Drinks

28th MARCH 2019.

08:55 - 09:25 Coffee and Registration

09:25 - 10:00 Propellers Geometry Modeling Through B-Splines Surfaces
Rodrigo Perez, Francisco Perez-Arribas, Marine Engineering School of the Technical University of Madrid, Spain

This work presents a new design methodology for modelling the blades of ship propellers using B-spline surfaces that are a standard tool in CAD and Naval Architecture software products.
Propeller blades of a ship are good examples of free form surfaces, designed specifically considering several parameters that control their performance. Traditional tools for surface design in CAD such as control point manipulation, are not appropriated for blade design, and the designers prefer to work with a collection of propeller parameters that ultimately represent its surface and that possess a clear hydrodynamic meaning.
This method uses common design parameters for the geometry of propellers and produces a final B-spline surface for the geometry of the blades that can be used for the visualization, calculations, and construction of the propeller.
The method starts with the definition of a 3D grid of points that form the propeller blades based on the 2D definition of a series of cross-sectional profiles at several radial locations. These 3D points consider the inclination and twist of the blades are given by rake and pitch angles, quite common in the design procedures, and also different propellers parameters such as skew and blade thickness distribution.
Propeller blades are very thin objects with great changes of curvature, and if standard B-spline techniques are used, they cannot be modelled well under a tolerance unless a large number of control points is used, producing very complex surfaces.
The method stresses the fitting of the blade's leading edge which has great effect on the propeller behavior and geometrically has a small curvature radius in comparison with the rest of the blades. The leading edge is difficult to reproduce with standard techniques.

10:00 - 10:35 Full Scale Performance of Gate Rudder
Noriyuki Sasaki, University of Strathclyde, UK
S. Kuribayashi, Kuribayashi Steam Co., Japan

This paper introduces a full scale performance obtained from a voyage data of a 2400 dwt container ship equipped with the world first GATE RUDDER®. The GATE RUDDER® is an innovative propulsion system which may not be categorized as a conventional energy saving device and it has not been even fully explored so far. The recent full-scale trials with this domestic container vessel have confirmed the superior performance of the GATE RUDDER® system which is 14% better compared with a conventional rudder system. After 9 months from her delivery, the voyage data revealed the fact that the difference observed in the speed trial was not fortunate and much larger difference 29% was found surprisingly.
In this paper, the full scale performance which is largely different from not only the model test but also the sea trial result will be investigated and the paper will conclude that the main reason of this discrepancy between sea trial results and navigation data is due to the difference of rudder resistance which appears during the frequent helm to keep the course controlled by auto-pilot.

10:35 - 11:10 The Importance of a Non-Deterministic Design Optimization for Predicting Real-Life Propeller Performances
Kevin Vidal, Benoit Mallol, Charles Hirsh, NUMECA International S.A., Belgium
Leo Poppelier, SipMarine, Netherlands

The manufacturing of propellers comes with geometrical variability, that lies within predefined tolerances established by standardized accuracy classes. Although controlled by these tolerances classes, the variation in the design might result in a degradation of the expected propeller behaviour.
In a classical deterministic optimization process, engineers improve a digital model, without taking into account those variations. Hence a new type of optimization method is recommended whereby the impact of the manufacturing tolerances, represented by statistical moments, are minimized, in addition to the design objectives.
This paper presents a robust non-deterministic optimization of a ducted marine propeller mounted on an inland vessel. In this test case, the statistical moments of the propeller efficiency are optimized while axial thrust is constrained and cavitation occurrence is considered. The nominal wake of the ship will be included in the propeller simulation and the geometrical tolerances are defined using the ISO S-class manufacturing accuracy. Eventually, the robust optima are compared with a deterministic optimum in order to enlighten the benefits of the non-deterministic design methodology.

11:10 - 11:45 Coffee

11:45 - 12:20 A Simple Electromechanical Controllable Pitch Propeller
Jordan McBain, Dogged Mechatronics LLC, UK

The author proposes a replacement to hydraulic actuation of CPP with an electromagnetic-actuator-like technology found in electric cylinders used for linear actuation. The invention, advanced in US Patent 20180171973A1, purports to deploy a ferromagnetic nut threadedly mated to a thread on the propeller's rotating shaft; the nut is rotated by electromagnets on the stator system and its resultant axial motion is employed to manipulate the blades' pitch. The nut and electromagnets effectively amount to a reluctance motor employed for pitch manipulation -above and beyond whatever prime mover is employed to rotate the propeller's shaft.

12:20 - 12:55 3D Printing for Marine Propellers
Michael Fletcher, Huntingdon Fusion Techniques , UK

The marine industry has been quick to embrace the 3D printing concept, particularly in the propeller manufacturing sector. The use of continuous liquid metal deposition under computer numerical control has created opportunities to produce complex shapes such as forgings and castings whilst avoiding the need for expensive tooling and the time delays in fabricating moulds.
Development work at Delft Technical University led to the production of the world's first metal deposited propeller in 2017 based on a Promarin design typically found on a Damen Stan Tug type 1606.
These deposition techniques, now more correctly called Wire and Arc Additive Manufacture (WAAM), require special measures to be taken to protect the hot and liquid metal from oxidation during deposition. It is crucial to prevent this oxidation since it leads to loss of mechanical and chemical properties and thus possible failure in service.
In order to ensure adequate inert gas coverage of complex items such as propellers during WAAM manufacture, flexible enclosures have been developed. These employ advanced engineering polymers, leak-tight seals and integrated inert gas control mechanisms to ensure complete freedom from oxygen in the protective environment.
This presentation describes the development and application of these enclosures.

12:55 - General Discussion & Lunch

International Conference

PROPELLERS & IMPELLERS: RESEARCH, DESIGN CONSTRUCTION AND APPLICATION

27-28 March 2019, RINA HQ, London, UK

To register, simply complete all sections of this form and return it with your payment to:

The Conference Department, RINA , 8-9 Northumberland Street London, WC2N 5DA
TEL: +44 (0)20 7235 4622
FAX: +44 (0)20 7259 5912
E-MAIL: conference@rina.org.uk

TITLE (Dr, Mr, Ms, Mrs, Eur Ing):

NAME (as it should appear on name badge):

POSITION:

COMPANY (as it should appear on name badge):

INVOICE ADDRESS:

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

CONTACT MAILING ADDRESS (if different):

POSTCODE:
COUNTRY:
TELEPHONE:
FAX:
E-MAIL:

PLEASE INDICATE REGISTRATION FEE & METHOD OF PAYMENT:

☐ MEMBER, ☐ NON MEMBER, ☐ CONCESSION, ☐ AUTHOR

I enclose a cheque for: £
(made payable to RINA)

Please send me an invoice for : £

Purchase Order Number:

Bank Transfer details enclosed for: £

Please debit my credit card by: £

Card Number: (Visa/Amex/Mastercard)

Expiry Date: **Signature:**

CVV:

REGISTRATION FEE	**By 27/02/19**	**After 27/02/19**
RINA MEMBERS:	**£670 + VAT = £804**	**£770 + VAT = £924**
NON-MEMBERS:	**£770 + VAT = £924**	**£870 + VAT = £1044**

CONCESSIONS: *(Retired/Students etc.)*	**£340 + VAT = £408**
PRINCIPAL AUTHOR	**£145 + VAT = £174**
ADDITIONAL AUTHOR	**£670 + VAT = £804**

The registration fee includes printed conference papers, lunch, refreshments, a USB of the papers and presentations after the conference.

CONFERENCE PAPERS
Delegates will receive a copy of the conference USB which will include the presentations, this will be posted out around 10-12 weeks after the conference.

Aditional copies of the conference papers will also be for sale after the event in both print and USB versions. If you would like to order copies, please fill in the relevant sections.

I am unable to attend the conference, please reserve me _______ set(s) of Conference proceedings

Papers **£120** (members) ☐ **£140** (non-members) ☐

USB **£120** (members) ☐ **£140** (non-members) ☐

For a full list of the Institution's Conference papers, USB and other technical publications please contact our Bookshop Assistant on +44 (0)20 7235 4622 or via e-mail at: publications@rina.org.uk

PAYMENTS
Payment must be made in pounds sterling by Eurocheque, cheque drawn on a bank with a UK branch address, credit card (VISA/Amex/Mastercard) or bank transfer. Please note RINA requires payment before the conference date.
Account Name: The Royal Institution of Naval Architects;
Account Number: 10042127; **Account Code:** 160016
Bank Address: Royal Bank of Scotland PLC, Belgravia Branch, 24 Grosvenor Place, London, SW1X 7HP, UK.
IBAN No: GB14RBOS16001610042127
SWIFT No: RBOSGB2L

*VAT: VAT will not be charged on any cancellation fee issued irrespective of the country the delegate resides in. Delegates from outside the UK may be entitled to reclaim this cost.

VENUE
The venue for the conference is: RINA HQ, 8-9 Northumberland Street, London, WC2N 5DA, UK

EVENING DRINKS RECEPTION
Following the end of the day (27/03/19), delegates are invited to attend an afternoon drinks reception at the conference venue.

ACCOMMODATION
Upon registration you will be provided with details of a hotel booking service offering reduced rate accommodation for conference participants.

CONTINUING PROFESSIONAL DEVELOPMENT
RINA Certificates of Attendance will be issued at the event, which contributes towards the Institution's Continuing Professional Development Scheme. For further details regarding the scheme please contact Giuseppe Gigantesco, Director, Professional Affairs on Tel: +44 (0)20 7235 4622 or e-mail: membership@rina.org.uk

STUDENT SPONSORSHIP
A number of sponsored places at this conference are available for Student Members of RINA. For more information, please contact Nick Cox, Professional Affairs, RINA on Tel: +44 (0)20 7235 4622 or e-mail:ncox@rina.org.uk.

PROMOTIONAL OPPORTUNITIES
Why not use this conference to promote your company's products and services? It provides an excellent opportunity to increase your profile and to network with a highly focused audience. We offer a number of cost effective options, including various conference sponsorship packages, exhibition space and literature distribution. If you are interested in any of these promotional opportunities please contact John Payten at JP Media Services, jpayten@jpmediaservices.com to discuss your individual requirements.

CANCELLATION CHARGES
Cancellations received in writing two weeks before the event takes place will be subject to administration charge of £200. Cancellations received after this time cannot be accepted and are subject to the full event fee. Delegates may be substituted; however, this must be sent in writing and confirmed with the conference Co-ordinator. It may be necessary for reasons beyond our control to alter the content and timing of the programme. In the unlikely event that RINA cancels the event for any reason, our liability is limited to the return of the registration fee.

PRIVACY
Personal data held by RINA will only be used in connection with RINA activities, and will not be passed to third parties for other use. Full details of RINA's Privacy Policy are available online.

☐ I wish to receive information on technical developments in or related to the maritime industry and on future RINA events. I understand that I may stop receiving such information at any time.

If you have any questions regarding this or any other RINA event please contact, our Conference Organiser on:

Tel: +44 (0)20 7235 4622 Fax: +44 (0)20 7259 5912
E-Mail: conference@rina.org.uk www.rina.org.uk/events