NANYANG TECHNOLOGICAL UNIVERSITY

Maritime Institute @ NTU

MARITIME INSTITUTE @ NTU PUBLIC SEMINAR

Added Resistance of Ships in Waves: Theoretical and Practical approaches

Professor Apostolos D. Papanikolaou
Director of Ship Design Laboratory of the School of Naval Architecture and Marine Engineering
National Technical University of Athens

Visiting Professor, School of Mechanical & Aerospace Engineering, Nanyang Technological University

Date: Thursday, 10 September 2015

Time: 6.00pm to 7.00pm
(registration commences at 5.30pm)

Venue: Lecture Theatre 6
North Spine Level 2
Nanyang Technological University
50 Nanyang Avenue, Singapore 639798

About the Topic:

When sailing in a seaway, the calm water resistance and powering of a ship is increased and this is accounted for in traditional ship design by some rough proportional increase of calm water resistance by about 20–40%. However, the accurate prediction of ship's resistance in waves is nowadays of increased importance, both for the designer and the shipowner/operator, since it greatly affects the selection of ship's engine/propulsion system and ship's performance in terms of sustainable service speed and fuel consumption in realistic sea conditions. Also, accurate and efficient predictions of the added resistance in natural seaways are necessary for the implementation of modern onboard ship routing systems.

The added resistance is a steady force of second-order with respect to the incident wave's amplitude and acting opposite to ship's forward speed in longitudinal direction. There are several alternative approaches to the added resistance problem; they can be generally classified into two main categories, namely far-field and near-field methods. The far-field methods are based on considerations of the diffracted and radiated wave energy and momentum flux at infinity, leading to the steady added resistance force by the total rate of momentum change. The near field method, on the other side, leads to the added resistance as the steady second-order force obtained by direct integration of the hydrodynamic, steady second-order pressure acting on the wetted ship surface. The latter can be calculated exactly from first order potential functions, and their derivatives.

With the continuous increase of ship sizes (in view of the economy of scale) the range of relative wave length to ship length λ/L of practical interest is being shifted to lower values. This makes the prediction of added resistance of ships in such ranges, which may be satisfactorily covered by simple, short wave, semi-empirical approximation formulas, more and more important. For instance, if we set the upper limit for a short wave approximation at $\lambda/L = 0.5$ (for head seas conditions) and assume ships of length larger than about 100m, it means that we can satisfactorily calculate the added resistance for these ships in waves up to about 50m in length, or corresponding period of close to 6 sec. The latter is a typical peak period of waves in many coastal and even pelagic open seas. When considering ships of length over about 250m, the limiting wave period for short waves rises to about 9 sec, which practically means that we can satisfactorily cover by the short wave approximation not only all coastal areas, but even a significant portion of open seas.

In the present lecture, we will first briefly outline advanced methods for calculating the added resistance in waves, like Maruo's far-field method in connection with the Kochin functions approach, as well as the near-field, direct pressure integration method, as implemented by self developed numerical codes of the Ship Design Laboratory of NTUA (Papanikolaou et al, 1987, Liu et al 2010). For the short waves range, we recommend simpler, semi-empirical methods, which are further developments (Liu-Papanikolaou, 2015) of the original methods of Faltinsen et al. (1980), Kuroda et al. (2008) and Tsujimoto et al. (2008). A wide range of case studies of different hull forms (slender and bulky) was used to validate the applicability and the accuracy of the developed and implemented methods in practice.

About the Speaker:

Apostolos D. Papanikolaou, born in Athens-Greece, studied Naval Architecture & Marine Engineering at the Technical University of Berlin (Germany), where he received the degrees of Dipl.-Ing. in 1973, Dr.-Ing. in 1977 and Habilitation (Lecturer) degree in 1981. He served as Tutor, Scientific Assistant, Research Associate and Lecturer (Privat-Dozent) at the Chair of Ship Theory and Ship Design of the Technical University of Berlin in the period 1969 to 1984, Associate Professor at the Department of Ocean Engineering of the University of Hawaii (USA) 1981/82 and 1984/85 and as Visiting Professor at the Departments of Naval Architecture and Ocean Engineering of the Universities of Osaka and Osaka Prefecture (Japan), Hamburg (Germany), Berlin (Germany), Hawaii (USA) and Strathclyde (UK) (1991/1993/1994/1999/2000/2008/2013). He was elected Assoc. Professor at NTUA in 1985 and was promoted to Full Professor in 1988. He is Head of the Ship Design Laboratory since the date of the foundation of the Laboratory in 1989 (www.naval.ntua.gr/sdl).

He is Principal Investigator of over 75 funded research projects and author/co-author of over 540 scientific publications dealing with the design and optimization of conventional and unconventional vessels, the hydrodynamic analysis and assessment of the calm water performance and the performance of ships in seaways, the logistics-based ship design, the stability and safety of ships and related regulatory developments of the International Maritime Organization. He received various international prize awards for his research work and scientific contributions to ship hydrodynamics, innovative ship design and safety assessment, more recently the Lloyds List 2009 Greek Shipping award on Technical Innovation in tanker design (jointly with Germanischer Lloyd), the prestigious *Dr. K. Davidson medal/award* of SNAME for outstanding achievement in ship research in 2010 and the European Champions Award for Senior Researchers in Waterborne Transport in 2014. He is Fellow and International Vice President of the Society of Naval Architects and Marine Engineers (SNAME), of the Royal Institution of Naval Architects (RINA), the Schiffbautechnische Gesellschaft (STG) and the Japan Society of Naval Architects and Ocean Engineers (JSNAOE).