Scale effect in the self-propulsion prediction for Ultra Large Container Ship with contra-rotating propellers

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Hanna Pruszko*, **Maciej Reichel** [δ†], **Krzysztof Czerski**[§], **Marek Necel**[§], **Julia Schmale**[‡] **and Sören Brüns**[‡]

* Gdańsk University of Technology,
ul. Gabriela Narutowiczan11/12, 80-233 Gdańsk, Poland,
e-mail: hanna.pruszko1@pg.edu.pl

[†]Foundation for Safety of Navigation and Environment Protection
14-200 Iława - Kamionka, Poland, e-mail:maciejr@portiława.com

[§]Seatech Engineering sp z o.o. ul. Plac Porozumienia Gdańskiego 1,
80-864 Gdańsk, Poland, e-mail: k.czerski@seatech.com.pl, m.necel@seatech.com.pl

[‡]Hamburgische Schiffbau-Versuchsanstalt GmbH,
Bramfelder Str. 164, 22305 Hamburg, Germany, e-mail: schmale@hsva.de, bruens@hsva.de

ABSTRACT

This article addresses the problem of the scale effect for an Ultra Large Container Ship (ULCS) with the novel twin-crp-pod propulsion system. Twin-crp-pod propulsion arrangement is an innovative solution that gains from three well-known systems: twin-propeller, contra-rotating propellers and pod propulsor.

It is well-known, that the scale effect has been widely investigated for ships with conventional propulsion systems. Nevertheless for ships with the crp-pod propulsion arrangement, due to the combination of shaft propeller and pod propulsor, the problem is a cutting-edge challenge and as such has never been investigated in detail.

To address this knowledge gap, CFD numerical simulations in various scales were performed, and this article presents the results of these calculations. The scope of simulations covered self-propulsion tests for a full-scale and model-scale Ultra Large Container Ship in calm water conditions. The model-scale calculations performed at scale 1: 37.416 were validated using towing test results. The self-propulsion simulations have been carried out similarly to towing tank tests following the British method. Calculations were performed for vessel design speed, the constant revolution of the shaft propeller and two different revolutions of the pod propeller.

CFD simulations were performed using an unsteady RANS approach. The finite volume method was applied to solve the governing equations of mass and momentum conservation, and STAR-CCM+ software was used. The sliding mesh approach with a rotating region around the local coordinate system was used to model the propeller directly. The flow was turbulent with the k-ω SST turbulence model applied. The second-order implicit temporal discretization scheme was applied.

The full-scale simulations have been compared with towing tank extrapolated results. The comparison covered the total resistance of the bare hull, wake fraction, relative rotational efficiency, thrust deduction and propeller revolution required to achieve the self-propulsion point.