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NUMERICAL ANALYSIS OF TURBULENT FLOW AROUND ENERGY SAVING PRE-SWIRL STATOR FOR FULL AND MODEL SCALE SHIPS

Sunho Park[1], Gwangho Oh[2], Shin Hyung Rhee[3]*, Bong-Yong Koo[4] and Hoseong Lee[4]

[1] Department of Ocean Engineering, Korea Maritime and Ocean University, Busan, Korea, 606-791, spark@kmou.ac.kr, oe.kmou.ac.kr
[2] NextFOAM Co., LTD., Seoul, Korea, 153-790, gwangeo@nextfoam.co.kr, www.nextfoam.co.kr
[3] Department of Naval Architecture and Ocean Engineering, Research Institute of Marine Systems Engineering, Seoul National University, Seoul, Korea, 141-742, Korea
shr@snu.ac.kr, snutt.snu.ac.kr
[4] American Bureau of Shipping, Busan, Korea, bkoo@eagle.co.kr, hlee@eagle.co.kr, www.eagle.org

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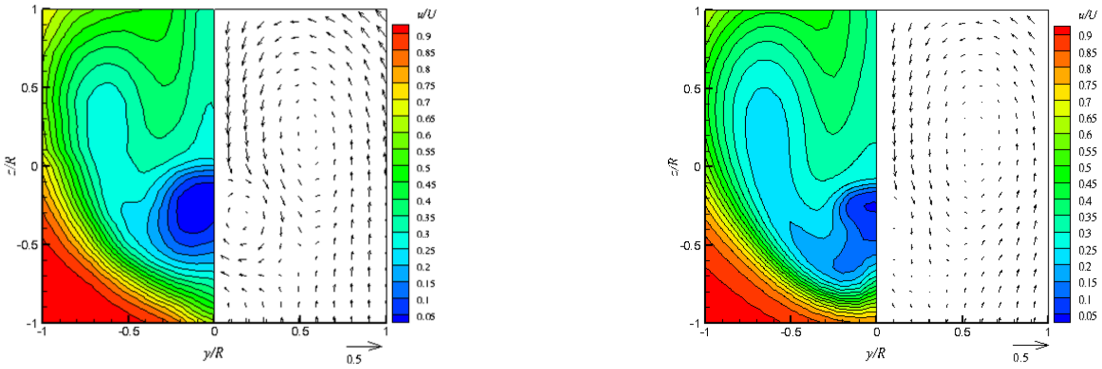
The present study focused on the turbulent flow around pre-swirl stator (PSS, Park et al., 2006). The objectives were therefore (1) to study the turbulent flow around energy saving pre-swirl stator and propeller and (2) to understand the influence of the Reynolds number on the propulsive performance of pre-swirl stator.

The KVLCC and PSS were selected as the object ship and energy saving device (ESD), respectively. The PSS was located in fron of the propeller and influenced on the propeller thrust. Thus, the reproducing of the nominal wake was important. Figure 1 (a) shows nominal wake in the left figure and projected velocity vectors at the propeller plane in the right figure measured by the Seoul National University Towing Tank (SNUTT). Figure 1 (b) shows computed nominal wake and projected velocity vector at the propeller plane. Low velocity hook flow was captured, and projected velcocity vector showed rising at the side and turning inside at the top in the measurement and computation. From the comparison of the nominal wake from the measurement and computation, the characteristics of the wake, such as low velocity hook and rotating flows, were well simulated in the comptation.

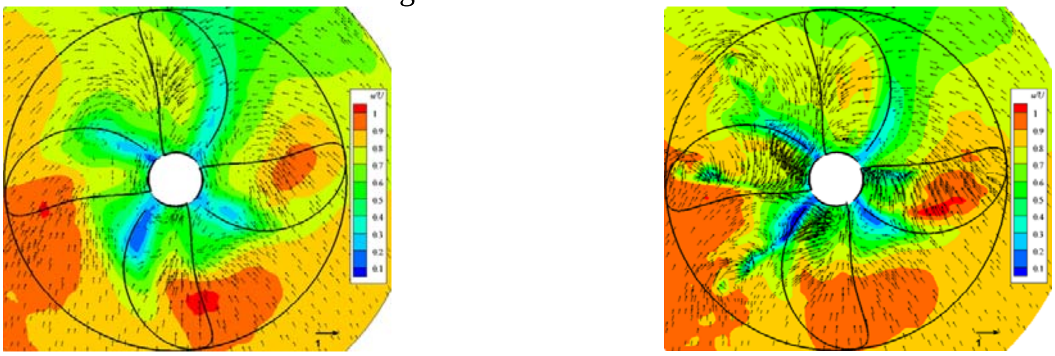
Figure 2 shows the x-velocity contours (*u/U*), and y- and z-velocity vectors at a wake plane with the propeller blade angles of 0^o. The wake plane indicates *x/LPP* of 0.0027, which is a middle location betwwen the propller and PSS. The PSS changed the velocity and pressure contours on the wake plane. The low x-velocity area was expanded due to the boundary layer of the PSS. In the starboard side, the y- and z- velocity vectors resembled those without the PSS. However, In the port side, directions of vectors were changed due to the PSS. Thus, flows was incoming to the propeller blade with high angle of attack, which was assisted to the thrust. Trailing vortices, which was generated at the tip of the PSS, were observed at the propeller blade angles of 90^o, 225^o, 270^o, and 315^o. Those vortices gave a bad effect on the cavitation of the propeller blade and hull vibration generated by the pressure fluctuation on the propeller blade. From the results, it was predicted that the changed rotational flow made high and low pressure levels on the pressure and suction sides of the propeller blade, respectively.

Figure 3 shows the x-velocity contours, and y- and z-velocity vectors at the wake plane with the propeller blade angles of 0°. In the computations of the full scale, the level of x-velocity increased because the bounary layer relatively decreased with the increasing Reynolds number. In particular, the area over the x-velocity of 1 increased. From the y- and z-velocity vectors, the flow was rising at the side and turning inside at the 0° propeller blade angle. Rotating flow in the starboard and port side was incoming to the propeller blade with high and low angles of attack, respectively, which resembed with the results of the model scale ship.



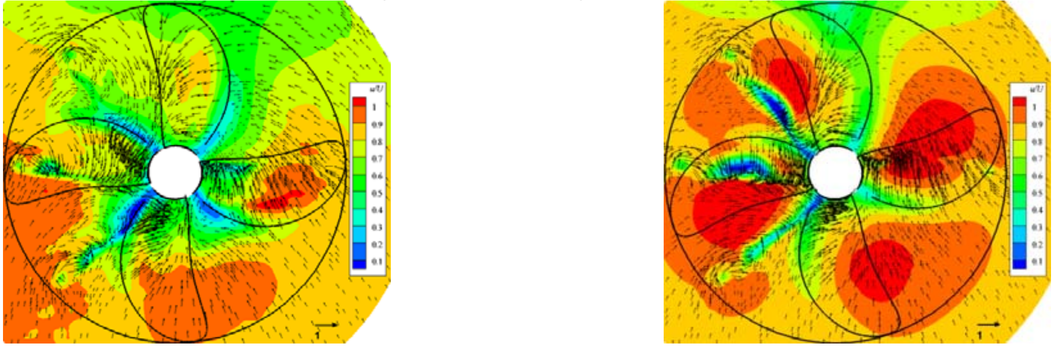
(a) Measurement (b) Present

Figure 1 Nominal wake.



(a) without PSS (b) with PSS

Figure 2 x-velocity contours and y- and z-velocity vectors.



(a) model scale ship with PSS (b) full scale ship with PSS

Figure 3 x-velocity contours and y- and z-velocity vectors for two scale ships.

REFERENCES

[1] J.S. Park, Y.B. Choi, S.P., Kim, I.P. Kim, Y.S. Hwang, J.J. Park and Y.S. Kim, Pre-swirl stator structure for low speed vessel. Korea patent, Patent number: 10-2006-0108472, 2006.