X International Conference on Computational Methods in Marine Engineering, MARINE 2023
June 27-29, 2023, Madrid, Spain

MOVING CONTACT LINE AND NO-SLIP BOUNDARY CONDITIONS FOR HIGH-SPEED PLANING HULLS[1]

ZHAOYUAN WANG* AND FREDERICK STERN*&

* IHR-Hydroscience & Engineering, University of Iowa, Iowa City, IA 52242, USA
&Correspondence: frederick-stern@uiowa.edu

ABSTRACT

The no-slip boundary condition (BC) is usually used at the solid surfaces for numerical simulations of viscous flows, which assumes that fluid velocity is zero relative to the solid surface. This assumption is accurate for most macroscopic flows but poses a problem for viscous flows with moving contact lines at the wall, e.g., the air-water interface on the ship surface will not move if the no-slip BC is used. For small scale flows, the slip BC with a finite slip length is usually used. The contact line movement is also dependent on the contact angles when surface tension force is dominant, but the mechanism is not fully understood. Most previous studies have been focused on small scale flows, such as flows within microfluidic or nanofluidic devices, and small bubbles/droplets. Few studies have been reported for large scale flows, such as ship flows. For ship flows, the Reynolds numbers are usually high and very small grid spacing is needed near the wall to resolve the boundary layer, where the numerical treatments used for the small-scale flows are not suitable. One of the issues caused by the no-slip BC is the numerical ventilation, which is especially serious for the high-speed small planing craft.

In this study, a numerical strategy to handle the no-slip BC and moving contact line problem for high-speed planing hulls is presented. A blanking distance from the solid surface is used (Wang and Stern, 2022) when solving the interface modeling equations, which is chosen based on the $y+$ values and the velocity profiles in the boundary layer. A series of numerical tests are conducted using a slamming plate and a high-speed planing step hull (Park et al., 2022). The numerical experiments show that if the blanking distance is $y+<30$ (inside the buffer and viscous sublayers), the air-water interface on wall will not be stable and numerical ventilation will occur. For the blanking distance $y+>30$ (outside the buffer layer), the air-water contact line is smooth and no air entrainment occur. It is suggested that blank distance needs to satisfy $30.0 < y+ < 200.0$ in consideration of accuracy and stability and a value of $y+ \sim 100.0$ can be used in practice. In the full paper, detailed numerical methods will be provided including results of numerical tests and application examples.

REFERENCES

Park, S., Wang, Z., Stern, F., Husser, N., Brizzolara, S., Morabito, M. and Lee, E., “Single-and two-phase CFD V&V for high-speed stepped planing hulls”, *Ocean Engineering*, Vol. **261**, pp.112047, (2022).

Wang, Z. and Stern, F., 2022. Volume-of-fluid based two-phase flow methods on structured multiblock and overset grids. *International Journal for Numerical Methods in Fluids*, Vol. **94**, pp. 557-582, (2022).

---

[1] This work is supported by the Office of Naval Research grants N00014-20-1-2259 and N00014-22-1-2413 under the administration of Dr. Robert Brizzolara.