XI International Conference on Computational Methods in Marine Engineering

Time-Dependent Forces on an Accelerating Flat Plate

Nicholas Copsey[1,*], Joseph Banks[1] and Melike Kurt[1]

[1] Faculty of Engineering and Physical Sciences, University of Southampton, Burgess Rd., Southampton SO16 7QF, UK
[*] nc4g13@soton.ac.uk

ABSTRACT

In this study our aim is to quantify the time-dependent forces acting on an accelerating body to understand the hydrodynamic forces acting on a swimmer's arm during a typical stroke. Previous work by Fernando et al.(2020) and Reijtenbagh et al.(2022) have shown conventional linear added mass alone does not make up the gap between quasi-steady forces and the measured forces for an accelerating bluff body. This suggests added mass has a time dependency or there is an additional acceleration-dependent force.

In this work, a flat plate accelerating perpendicular to its surface is simulated using a boundary data immersion method with an iLES solver in a 3D domain. These simulations explore and quantify the acceleration-dependent forces for a wide range of accelerations and Reynolds numbers. Accelerating from rest we explore a range of final Reynolds numbers from 7.4×10^3 to 1.1×10^6 and non-dimensional acceleration(A^*) from 8.5×10^{-4} to 19.

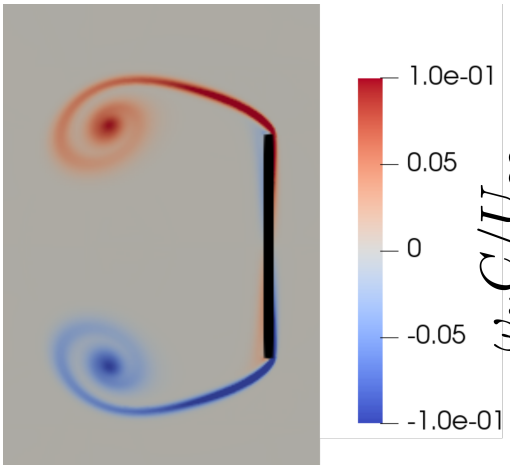

Figure 1: Starting vortices being shed from an accelerating plate.

Our results characterize the relationships which define the scaling of these acceleration-dependent forces. The goal is to use these scaling definitions to model the forces on any accelerating bluff body, supplementing quasi-steady analysis techniques and potential flow considerations for a range of applications for more accurate results.

References

J.N. Fernando, G.D. Weymouth, D.E. Rival. On the limits of added-mass theory in separated flows and with varying initial conditions. Journal of Fluids and Structures. Volume 93. 2020. 102835. ISSN 0889-9746. URL https://doi.org/10.1016/j.jfluidstructs.2019.102835.

Reijtenbagh J, Tummers MJ, Westerweel J. Investigation on the drag force and flow field of an accelerating plate. In12th International Symposium on Turbulence and Shear Flow Phenomena, TSFP 2022 2022.