ON THE POSSIBILITY TO COMPUTE SLOWLY-VARYING DRIFT IN A CFD SOLVER

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ABSTRACT
Slowly-varying drift is a phenomenon very familiar to offshore industry, but usually not so much relevant or discussed in naval industry. The classical theoretical background consists in considering a bichromatic wave composed of two regular wave trains of pulsations \( \omega_1 \) and \( \omega_2 \) evolving in the same direction and without any forward speed. The force which varies at low frequency \( (\omega_2 - \omega_1) \) is known as the slowly-varying drift force and is important in case of moored vessels because it may excite them at their natural periods. The equivalent application in the naval industry is related to maneuvering and added resistance in waves. However, as already indicated, up to the authors’ knowledge, there has not been much work on these issues in the past.

State-of-the-art potential flow tools predict well this slowly-varying drift at zero forward speed. However, with an additional forward speed or a strong current, traditional linear potential codes are outside the scope of their underlying hypothesis and cannot predict accurately the low frequency force. With the constant rise of CPU power and accuracy of CFD solvers, this problem may now be addressed in CFD. The results of foamStar, in-house OpenFOAM solver, will be shown with and without additional forward speed.

INTRODUCTION
The computation of slowly-varying drift on a structure is usually important only if the resonant natural periods of the system are very large and the corresponding damping is low. It is for example the case for moored FPSOs. Traditional potential flow methods are well validated for this kind of application without forward speed. Their use can be extended to the presence of small currents through the Aranha formula (Aranha, 1994) or through the so-called wave-current method (Nossen, Grue, & Palm, 1991, Chen & Malenica 1998). For the case without forward speed, the results of HydroStar, Bureau Veritas potential flow solver (Chen, 2004), will be used as a reference. However, HydroStar and other traditional potential flow tools reach their limitations for large currents or vessels with large forward speed.

As already mentioned, the correct assessment of slowly-varying drift at forward speed could be of particular importance for maneuvering and added resistance computations, especially if the forward speed can induce a large increase of the second order force (as suggested by the application case shown in this paper). To our knowledge, the effect of forward speed on slowly-varying drift is virtually an unexplored territory. Due to the large periods relative to second-order drifts and the small order of magnitude of second order amplitude compared to first order effects, CFD has long been regarded as an unrealistic option to deal with such a problem. However, continuous increase in CPU power and recent refinements in numerical settings for seakeeping computations make us think that CFD is mature enough to tackle this challenge.

The OpenFOAM software package (The OpenFOAM Foundation Ltd, s.d.) is a collection of C++ libraries which provide core functionalities for solving partial differential equations. It has been developed for about two decades (Weller, Tabor, Jasak, & Fureby, 1998), and has reached a good level of maturity and gathered a large user community. In this study, we used our in-house top level solver for seakeeping applications called “foamStar”. It is originally based on “interDyMFoam”, the classical OpenFOAM solver for two-phase incompressible flow. In “foamStar”, the mechanical module has been reorganized in order to take into account complex mechanical constraints and give the possibility to perform hydroelastic computations with a strong 2-way coupling with a finite element structural solver. Modifications include a stabilized fluid-structure interaction coupling and enhancements for wave absorption and generation technique. It has been validated for wave propagation, radiation and diffraction cases in (Monroy, Seng, & Malenica, 2016). Validation for seakeeping case of KCS Tokyo CFD workshop was also presented in (Monroy & Seng, 2017) where a comprehensive study on appropriate time schemes was carried out.

In order to investigate slowly varying drift, it is necessary to generate bichromatic wave. In the CFD solver, the target