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A Comparative Study on the Nonlinear Interaction Between a Focusing Wave and Cylinder Using State-of-the-art Solvers: Part A

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This paper presents ISOPE's 2020 comparative study on the interaction between focused waves and a fixed cylinder. The paper discusses the qualitative and quantitative comparisons between 20 different numerical solvers from various universities across the world for a fixed cylinder. The moving cylinder cases are reported in a companion paper as part B (Agarwal, Saincher, et al., 2021). The numerical solvers presented in this paper are the recent state of the art in the field, mostly developed in-house by various academic institutes. The majority of the participants used hybrid modeling (i.e., a combination of potential flow and Navier–Stokes solvers). The qualitative comparisons based on the wave probe and pressure probe time histories and spectral components between laminar, turbulent, and potential flow solvers are presented in this paper. Furthermore, the quantitative error analyses based on the overall relative error in peak and phase shifts in the wave probe and pressure probe of all the 20 different solvers are reported. The quantitative errors with respect to different spectral component energy levels (i.e., in primary, sub-, and superharmonic regions) capturing capability are reported. Thus, the paper discusses the maximum, minimum, and median relative errors present in recent solvers as regards application to industrial problems rather than attempting to find the best solver. Furthermore, recommendations are drawn based on the analysis.

INTRODUCTION

Recently, several numerical codes have been made available as open-source or commercial packages, and some have been developed in academia. These are based on a variety of underlying mathematical models encompassing both new and traditional computational methods, yet there still remains considerable uncertainty in their application and reliability. Many attempts have been made by researchers to collaborate and validate their in-house-developed codes. (See Clément, 1999; Loysel et al., 2012; Ransley et al., 2019, 2020; and Tanizawa and Clément, 2000.) The performance of these solvers is problem dependent. Although a given solver may prove to be the best choice for some applications, it may not perform well for other applications. Hence, these solvers need to be tested for a sufficiently wide range of applications.

In the present study, the laboratory measurements on focusing wave interactions with a fixed cylinder and a moving cylinder have been released for participants to compare with their numerical model. The objective of this comparative study is to (a) understand how well the recent state-of-the-art numerical solvers perform and what type of solvers the participants prefer for this application; (b) instead of finding a best solver, rather estimate overall maximum, minimum, and median errors that are present in these recent codes; (c) assess the overall performance of these solvers in capturing the primary, superharmonic, and subharmonic components, as well as the relative error in pressure and wave probe time history; and (d) evaluate the overall performance in simulating small-amplitude and large-amplitude focusing waves. Finally, a reasonable quantification of the "acceptable error" is provided to the numerical modeling community/users/developers as a guideline for future investigations; this is something that is

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