Prediction of roll motion using fully nonlinear potential flow and Ikeda’s method

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ABSTRACT

Getting the best possible accuracy with the lowest possible computational cost is an important factor in the early design stage of ships. Potential flow-based analysis presents such a solution for seakeeping analyses. The accuracy of roll motion in potential flow is however not so good, due to the large influence from viscous roll damping, which is missing in these calculations. This paper proposes a hybrid method, as a solution to this problem, where the viscous roll damping from Ikeda’s semi-empirical method is injected into an existing 3D unsteady fully nonlinear potential flow (FNPF) method. The hybrid method is investigated using roll decay tests with the KVLCC2 test case. This investigation shows that the accuracy of simulated roll motions is significantly improved and also shows good agreement with the corresponding roll decay model tests.

KEY WORDS: Roll-decay; Roll-damping; Ikeda’s method; Fully nonlinear potential flow (FNPF); Boundary element methods; KVLCC2.

INTRODUCTION

Inviscid potential flow calculations can be used to solve seakeeping problems at very low computational costs. These methods offer far cheaper alternatives than doing for instance model tests or URANS calculations. Potential flow calculations can therefore be used extensively during the early design stage of ships. The pitch and heave motions can be predicted with good accuracy, even with the older linear strip theory methods (Himeno, 1981). The roll motions will however not be very realistic in potential flow, due to high influence from viscous roll damping. This is very unfortunate as the roll motions is indeed an important response. The impact of roll motions can be seen from the APL China casualty in 1998, where a post-Panamax C11 class container ship lost almost a third of its containers (France et al., 2001). Another example is the container ship Svendborg Maersk, were 500 containers were lost overboard and 250 containers were damaged as a result of heavy roll motions during a passage from English Channel to Gibraltar (DMA, 2014). A lot of experimental research was conducted during the 1970s and 80s to separate the invicid and viscous roll damping. Semi-empirical formulas were developed to estimate the viscous parts, to be used together with the potential flow methods (Ikeda et al., 1978). The older linear methods can today be replaced by more advanced nonlinear potential flow methods. These newer methods still need some injection of semi-empirical viscous damping to give a fair representation of the roll motions. But is the separation of damping components still valid, considering that these older semi-empirical methods were developed in close connection to linear strip theory? (Falzarano et al., 2015) have shown that the separation of