TU Delft

Offshore & Dredging Engineering

Technische Universiteit Delft

Dynamic analysis of Backhoe dredgers

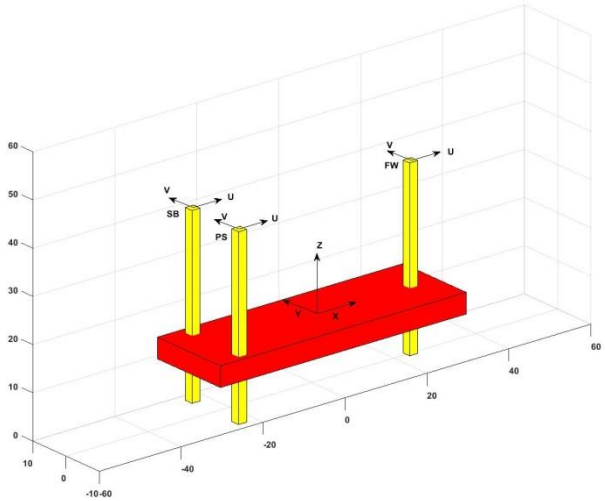
It is a well known fact that the international dredging industry is of major importance. As the dredging industry has made a significant contribution to the development of many world economies through the construction and maintenance of harbors, canals, and waterways. The construction and maintenance of waterways depths is a continuous process in many ports and harbors, as the bottom contours are constantly changing due to silting near the mouth of rivers. Moreover, the ship's become larger and draft requirements increase, ports need to deepen their channels to allow for deeper draft ships, to remain competitive with other ports.

Despite the evolving dredging market, a trend towards harsher environments can be observed. Harsher environments with higher currents, more wind and waves, will be the subject of future dredging operations and developments. As dredging contractors want to undertake larger waterworks even in coastal areas, their equipments had to be adopted for these conditions.One of this equipments is the backhoe dredger, which is a widely used tool in the dredging industry since the early 1900s.

In order to overcome the harsher environment advanced equipment is needed together with a thorough understanding of the processes involved during dredging operations with a backhoe dredger. In line with the recent trends, the use in harsher environments, ship and equipment builders like Royal IHC have to keep developing and expanding their knowledge. The increased competition from shipyards abroad resulted in the fact that it not sufficient to rely on commercial engineering software which is also accessible to competitors. Therefore IHC MTI has developed the computer program DODO, which is used to study the dynamic behaviour of vessels and components in waves under the influence of interaction with the soil or sea floor.

The current DODO model of the backhoe dredger is based on certain assumptions for the sake of simplicity and time. One of the most important assumptions made in the current model, is the introduction of an additional damping matrix to account for the spud-ship interaction. However, this damping matrix is still uncertain due to the fact that friction and impact are neglected and therefore additional research is required. Royal IHC has started a study with purpose of improving knowledge in some areas. The view has been introduced that a more complete review of the entire set of approximations, assumptions and simplifications of the current DODO backhoe model is required.

A new 3D model was build which was used to perform a non-linear, time domain analysis in which it was possible to account directly for all the significant effects due to dynamic and non-linear response. The model was used in order to identify the significance of the present non-linearities and various damping sources on the overall system behaviour. Furthermore, the model is used to obtain a linearized damping matrix, which can be implemented in the current DODO model and into a linear model.



In order to ensure for an equivalent dynamic behaviour between the nonlinear model and the linear model, the stiffness and damping coefficients for the nonlinear cases needed to be linearized. The linearization showed that spacing causes a higher equivalent stiffness. In addition, impact also results in higher stiffness coefficients. The linearization also showed that impact results in lower damping coefficients due to the used impact model.

The various damping sources were quantified using logarithmic decay method to determine the damping ratios. The methoed provided a reasonable damping ratio in exchange for (much) lower computational expenses. Furthermore, this method can be used to provide more of an insight on the damping behaviour of the ship in all six degrees of freedom due to the various damping sources.

Finally, the simulations results of the nonlinear model were compared with those of a linear model in which the linearized paramters are implemented. The linear model showed comparable deflections in comparison to the nonlinear model. However, when a single damping and stiffness matrix with complete linearized coefficients is introduced for the ship, the displacements and rotations in certain directions are overestimated.

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