Offshore & Dredging Engineering

Technische Universiteit Delft

Coupled crane vessel dynamics

Most, if not all, vessel new builds within the offshore heavy lifting industry are designed with specific characteristics (stability, dynamic response, transition speed etc.) in mind. Subsequently a crane is designed and supplemented to the vessel complying with the characteristics of the vessel. However, what happens if this design process is turned around? That is, for specific crane design and maximum lifting load, what is the optimum vessel geometry? If one would exactly know what the soul operational purpose of a new build vessel would be, designing a vessel in this manner could be more cost effective. This method of analysis would provide a different approach and possibly a different outcome to the design process.

A first and important step in this new design process is to define how/whether the geometric properties of a vessel are of influence on the response characteristics during lifting operations. This report provides a method of analysis to combine vessel response terms, obtained from hydrodynamic diffraction software, with the terms related to the crane load motion, defined through the Lagrangian method. An example vessel, namely the Lewek Connector, is chosen to analyze the model.

This coupled model of analysis has been compared with the current method of analysis, where the crane load is modeled as a lump loaded mass at the crane tip. The two separate model set-ups are evaluated within the frequency domain, focusing on the resonance frequency, maximum excitation at the resonance frequency and the effective motion of the system. The coupled system provides a better representation of reality compared to the current lump loaded system.

Using the coupled set-up, a model has been created enabling the user to alter the geometric properties of a vessel. Either the length, width, and/or depth of the vessel can be changed. All parameters (Center of gravity/buoyancy, radii of gyration, mass, draft) linked to the geometry of the vessel are calculated within the model. Altering the vessel geometry of the example vessel will in fact make the model imaginary and nonexistent in real life, hence there is no existing vessel with the altered Lewek Connector's geometry.

It has been shown that the swaying of the crane motion only affects the vessel motion within roll. The crane load will not affect the pitch motion, even for increasingly small vessel sizes dynamic coupled motion within pitch does not occur. The inertia forces generated by the swaying crane load are not large enough to force the pitch motion to exert any coupled behavior. Due to the model set-up, with a single large crane at the aft of the vessel, the static pitch excitation increases for increasingly smaller vessels.

It has been shown that swaying of the crane load will have a greater influence on the roll motion for increasingly smaller vessels. However, the damping of the crane load highly dictates the maximum occurring motion. Further research must include any form of CFD analysis and/or structural damping analysis in order to determine the occurring crane load damping.

Both resonance frequency related to the vessel motion as well as the resonance frequency related to the swaying crane load motion are dependent on the vessel geometry. Therefore it cannot be assumed the crane load will resonate at the natural frequency of a freely swaying pendulum that's only dependent on the crane cable length.

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