Offshore & Dredging Engineering

Technische Universiteit Delft

Workability increase using tugger control

For the offshore market an increase in renewable projects can be observed. The technological innovations are continuously decreasing the costs of renewable projects. Especially offshore wind is getting more cost effective, and is receiving a lot of attention. However, with the growth of the sector, new challenges arise. Water depths are increasing, soil parameters worsening and greater distances from shore need to be overcome. Whereas prices of installation are under pressure. This drives the market towards larger and more innovative installation vessels. A trend can be observed towards monohull craning vessels which combine a large crane with a large storage space on deck. During lifting the monohull vessel experiences large motions of the lifting configuration at even small wave loading. The large motions are mainly the result of resonance within the system, which results in large crane forces. It is these forces which decreases the vessels work-ability. Applying damping to the system is a way to counter the resonance. The tugger winches can be used to apply damping to the lifting configuration.

The aim of the thesis is to investigate the potential damping effect of a tugger damping system for the Bokalift 1 during a jacket lifting operation. With special emphasis on the effect of different control systems of the tugger winches. Two different models are used in the thesis to research the effects of tugger damping on the dynamic behavior of the lifting configuration. Namely, a simple 2D matlab model, and a more extensive 3D Orcaflex model.

The Orcaflexmodel is build for researching the effects of tugger damping and different control systems. Comparing the responses of the model to airy waves loading. To have control in both longitudinal and transverse direction boomwinches on the crane are used, in combination with deckwinches. Which are located on both ends of the deck. The hydro static properties of the model are calculated with the program GHs. The hydro dynamic properties are calculated with the help of the AQWA.

The matlab model is used to enable quick research on the effects of tugger damping and different control systems. The model is based on a 5 degree of freedom (DOF) mass-spring-damper-system. The equations of motion (EOM) are derived using the lagrange formalism with help of the program Maplesoft. The model is validated with help of proven software Orcaflex.

Seven different control systems are made and tested in the matlabmodel. The control systems are examined in two different simulations. Firstly the roll motion is studied when the model is subjected to wave loading. Secondly the damping capabilities for the lifting configuration with initial displacement are tested. The first analysis shows the PID controller has the highest roll motion reduction of the jacket. Linear control system scores higher than quadratic. The results from the second analysis shows that stepwise controller takes the shortest to fully damp the lifting configuration.

Following on the results of the 2D model analysis the 3D model will further inspect the effect of tugger winches for the linear, quadratic, and PID controller. A model analysis shows there are 4 important modes within the wave excitation range. The combination of these modes results in the highest crane forces at a wave period of 5.5s. The linear and quadratic control system are once again compared, only now in the 3d model. The assessment shows the linear model as more efficient in reducing the crane tip forces. Lastly the linear and PID control systems are compared towards each other and a modelwithout tugger damping. Based on the results, the linear control system increases the total forces on the crane. Where as the PID reduces all forces.

It is shown that tugger damping does not necessarily decrease forces acting on the crane tip for head on waves. From the tested control system the PID controller reduces the forces most effectively and efficiently. However the effect of the PID controller depends on the loading wave frequency and for which it is tuned.

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