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Multibody Constrained Dynamics of Y-Method Installation System for a Large Scale Subsea Equipment

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Abstract : The lowering of subsea equipment into the deep waters is a challenging job due to the harsh offshore environment. Many researchers have introduced various installation systems to deploy the payload safely into the deep oceans. In general practice, dual floating vessels are not employed owing to the prevalent safety risks and hazards caused by ever-increasing dynamical effects sourced by mutual interaction between the bodies. However, while keeping in the view of the optimal grounds, such as economical one, the Y-method, the two conventional tugboats supporting the equipment by the two independent strands connected to a tri-plate above the equipment, has been employed to study multibody dynamics of the dual barge lifting operations. In this study, the two tugboats and the suspended payload (Y-method) are deployed for the lowering of subsea equipment into the deep waters as a multibody dynamic system. The two-wire ropes are used for the lifting and installation operation by this Y-method installation system. 6-dof (degree of freedom) for each body are considered to establish coupled 18-dof multibody model by embedding technique or velocity transformation technique. The fundamental and prompt advantage of this technique is that the constraint forces can be eliminated directly, and no extra computational effort is required for the elimination of the constraint forces. The inertial frame of reference is taken at the surface of the water as the time-independent frame of reference, and the floating frames of reference are introduced in each body as the time-dependent frames of reference in order to formulate the velocity transformation matrix. The local transformation of the generalized coordinates to the inertial frame of reference is executed by applying the Euler Angle approach. The spherical joints are articulated amongst the multibody as the kinematic joints. The hydrodynamic force, the two-strand forces, the hydrostatic force, and the mooring forces are taken into consideration as the external forces. The radiation force of the hydrodynamic force is obtained by employing the Cummins equation. The wave exciting part of the hydrodynamic force is obtained by using force response amplitude operators (RAOs) that are obtained by the commercial solver ‘OpenFOAM’. The strand force is obtained by considering the wire rope as an elastic spring. The nonlinear hydrostatic force is obtained by the pressure integration technique at each time step of the wave movement. The mooring forces are evaluated by using Faltinsen analytical approach. ‘The Runge Kutta Method’ of Fourth-Order is employed to evaluate the coupled equations of motion obtained for 18-dof multibody model. The results are correlated with the simulated Orcaflex Model. Moreover, the results from Orcaflex Model are compared with the MOSES Model from previous studies. The MBDS of single barge lifting operation from the former studies are compared with the MBDS of the established dual barge lifting operation. The dynamics of the dual barge lifting operation are found larger in magnitude as compared to the single barge lifting operation. It is noticed that the traction at the top connection point of the cable decreases with the increase in the length, and it becomes almost constant after passing through the splash zone.

Keywords : dual barge lifting operation, Y-method, multibody dynamics, shipbuilding, installation of subsea equipment, shipbuilding
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