Ocean Engineering 167 (2018) 65–76

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Review

Review of the multibody dynamics in the applications of ships and offshore structures

Hye-Won Lee[a], Myung-Il Roh[b,*]

[a] Department of Naval Architecture and Ocean Engineering & Research Institute of Marine Systems Engineering, Seoul National University, Republic of Korea
[b] Department of Naval Architecture and Ocean Engineering, And Research Institute of Marine Systems Engineering, Seoul National University, Republic of Korea

ARTICLE INFO

Keywords:
Multibody dynamics
Physics-based simulation
Ship and offshore structures

ABSTRACT

A review of the multibody dynamics in the applications of ships and offshore structures is presented in this study. As the processes for the design and production of ships and offshore structures become various and complicated, some physics-based simulations that are based on multibody dynamics have been performed in the ship and offshore industries. Due to the characteristics of the processes, some physical components such as connections and collisions should be taken into account to reflect real situations. In this paper, the physical components for multibody dynamics that should be considered for the design and production of ships and offshore structures are presented. Then, the studies on the physics-based simulations for the design, production, and installation processes and the decommissioning procedure are reviewed. Lastly, several research directions are discussed in the conclusion.

1. Introduction

The demand regarding the physics-based simulations for the design and production of ships and offshore structures is consistently increasing so that the potential risks can be checked in advance. For example, as the process for the production of such structures in the shipyard becomes more diverse and complicated, the performance of simulations that have not been tried previously are required. Furthermore, to improve the safety and efficiency of the process, a detailed modeling for the simulation is necessary to reflect real situations accurately, which is impossible with conventional modeling methods.

The general processes for ships and offshore structures can be classified into the following three procedures according to the purpose of the simulation: design, production, and installation (or decommissioning). Figs. 1–3 show examples of each procedure for which simulations are required. As is presented, the processes for ships and offshore structures can be represented as a multibody system, which consists of several bodies that are connected by joints or wire ropes. Therefore, a physics-based simulation that is based on multibody dynamics should be performed.

In the ship and offshore industries, a simplified model is mostly used to analyze the dynamic response of a given system. For example, Fig. 4 shows simplified and realistic models of a floating crane that lifts a block. The simplified model that is shown in Fig. 4 (a) includes only the crane barge and the block that are connected by one wire rope, which has the equivalent stiffness to a group of wire ropes in (b). The realistic multibody model of Fig. 4 (b) contains hooks and block loaders with additional, multiple wire ropes. For the same condition, the weight and the inertia of the floating barge in the simplified model are same as those of the floating crane including jibs in the realistic model. In the simplified model, the wire rope is connected to the barge to the point that is fixed to the local coordinate of the barge. The block weight is 5000 t, and the wave condition is set at a wave height of 1.0 m, a wave period of 10 s, and a heading angle of 90°. Table 1 shows a comparison of the results according to two models. The error percentage was calculated based on the realistic-model method. The sway, roll, and yaw motions of the floating crane are major differences due to the heading angle of the wave. As is presented, the result shows major differences due to the modeling effect. Although the mass and the inertia of the block are the same, all of the block motions except for the heave show major differences. This result implies that it is necessary to perform the motion analysis based on a multibody-system realistic model.

Multibody dynamics is a broad field of study under active research. In the ship and offshore industries, due to the characteristics of the complicated processes and the environmental conditions, several physical components should be considered, as shown in Figs. 1–3. Firstly, due to the oceanic environment, external forces such as waves,

* Corresponding author. Department of Naval Architecture and Ocean Engineering, and Research Institute of Marine Systems Engineering, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Republic of Korea.
E-mail address: miroh@snu.ac.kr (M.-I. Roh).

https://doi.org/10.1016/j.oceaneng.2018.08.022
Received 2 March 2018; Received in revised form 26 June 2018; Accepted 9 August 2018

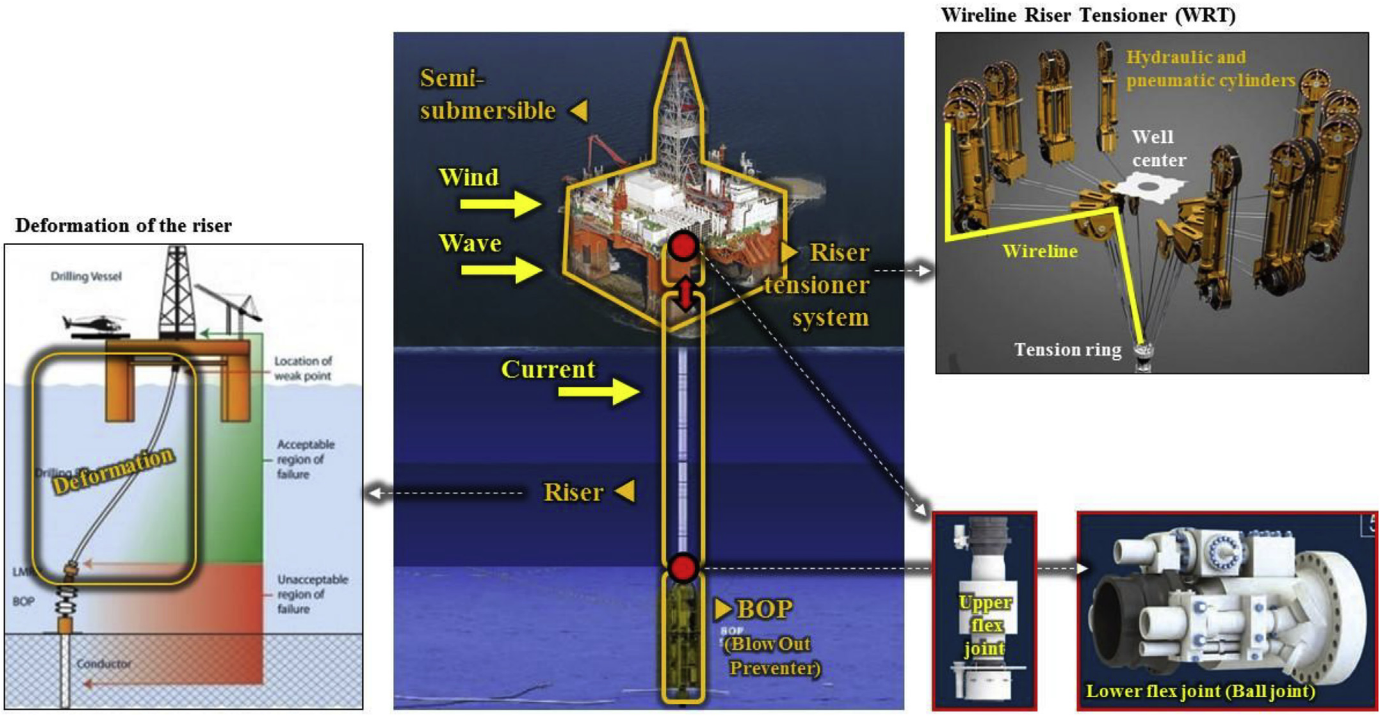

Fig. 1. Example of the design of a riser tensioner system in a semisubmersible rig.

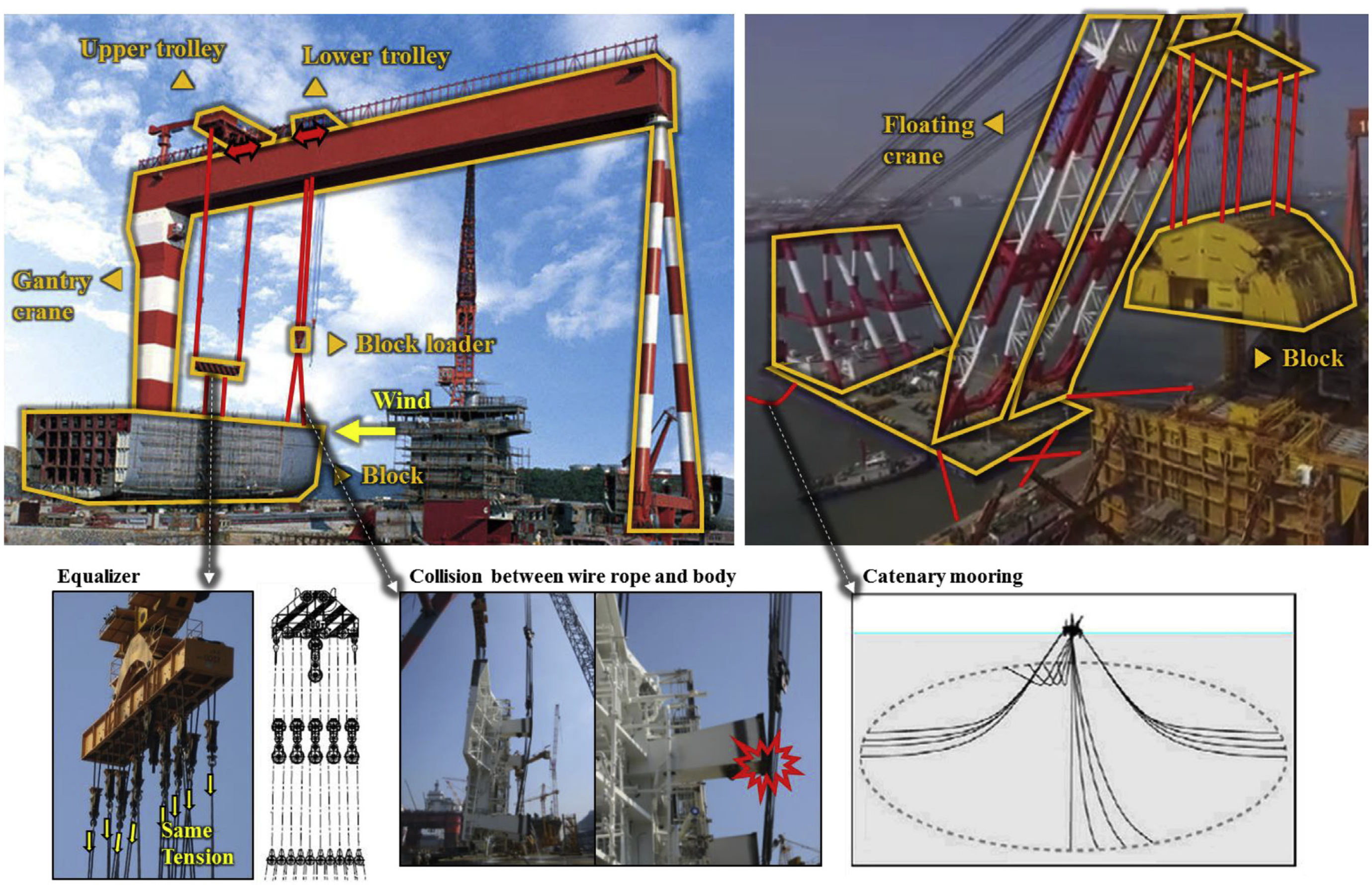

Fig. 2. Example of the production of ships and offshore structures using a gantry and floating crane.