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Development and validation of a simulation-based safety evaluation program for a mega floating crane

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ABSTRACT

The motions of the mega floating crane and the lifted module must be evaluated in advance, to determine whether they satisfy the safety criteria or not. Due to the limitations of the existing dynamic analysis programs, we develop a differentiated program that is dedicated to the mega floating crane. This program is focused on reducing modeling time, while increasing modeling accuracy. Furthermore, it can model the block loader that distributes the tension in wire ropes between the lifted module and the block loader equally, and link beams that are used to connect hooks by hinge joints. The equations of motion based on multibody system dynamics are derived. Wave, wind, and current are included as external environmental loads. A direct volume calculation method below the water plane is adopted to find the buoyant force and center of buoyancy. External loads are verified by commercial program. Finally, the simulation results of the module erection are validated by comparison with the measurement of real operation.

1. Introduction

A floating crane is normally used to lift a block or a module in the shipbuilding industry. Due to its huge lifting capacity at one time compared to cranes on land, the number of operations by the floating crane has recently been increasing. Fig. 1 shows a picture of the mega floating crane whose lifting capacity is 10,000 t.

The mega floating crane is composed of a barge, two jibs, and eight hooks. Table 1 shows its principal particulars.

Because the floating crane is affected by environmental conditions, such as wind, wave and current, the dynamic effect of the lifting block should be considered. Therefore, unlike cranes on land, the motion of the floating crane must be checked in advance, to determine whether the operation is safe or not. For this, some dynamic analysis programs have been used to check the criteria. However, the existing programs have some limitations.

Before operation, the owner or classification society requires safety evaluation. Fig. 2 shows the overall safety evaluation procedure of the mega floating crane operation.

The production engineer requests dynamic analysis from the analyzer in the other team, which is usually a research department. The analyzer selects the appropriate program to be able to solve the requested problem. Based on the basic data and hydro results, the analyzer models the floating crane and other factors, and then runs the program. Finally, the analyzer summarizes the results, and creates reports that include tables and graphs. Therefore, it takes considerable time to get analysis results, and the production engineer depends on the analyzer in the other team.

Furthermore, it may be necessary before the operation for the field workers to urgently determine whether or not the work can be performed, in consideration of the weather conditions. In such a case, it is difficult to request advice from the analyzer, because there is not sufficient time. Therefore, according to the internal guideline of the shipyard, the production engineer decides on the availability of the crane operation. Fig. 3 shows the decision making procedure according to the internal guidelines explained in this paragraph.

Meanwhile, it is impossible for existing programs to support some items of mechanical equipment, which are essential to model the mega floating crane. The first item of equipment is the link beam that is used to connect two hooks by a hinge joint, as shown in Fig. 4.

Another item of equipment is the block loader. It is installed under the hook to connect multiple wire ropes between the block and the hook. The other purpose of the block loader is to distribute tensions to all wires equally. This is done by several fixed and mov-

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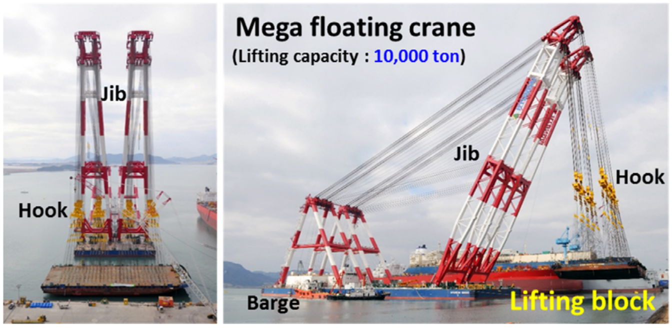

Fig. 1. A picture of the mega floating crane.

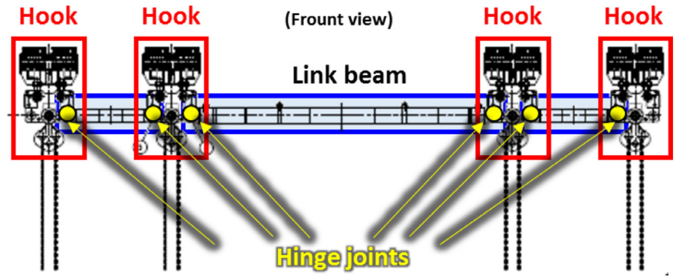

Fig. 4. Front view of hooks, link beams and hinge joints.

ing pulleys, which are components of the block loader, and are connected by one wire rope, as shown in Fig. 5.

The existing programs used in the research department do not support the link beam with hinge joints, and the function of the block loader described above. Therefore, they have to use a simplified model that gives less accuracy.

To overcome these limitations in the shipbuilding industry, we develop a differentiated program that is dedicated to the mega floating crane. Fig. 6 shows the main view of the developed program and its configuration. It is developed in C# programing language and Windows Presentation Foundation (WPF), and contains many user-friendly functions.

The developed program in this study allows the production engineer to execute the dynamic analysis him- or herself, and reduces modeling time and effort. Moreover, it supports mechanical equipment, such as the link beams and block loaders, for more accuracy. Fig. 7 summarizes the usage of the developed program in this study.

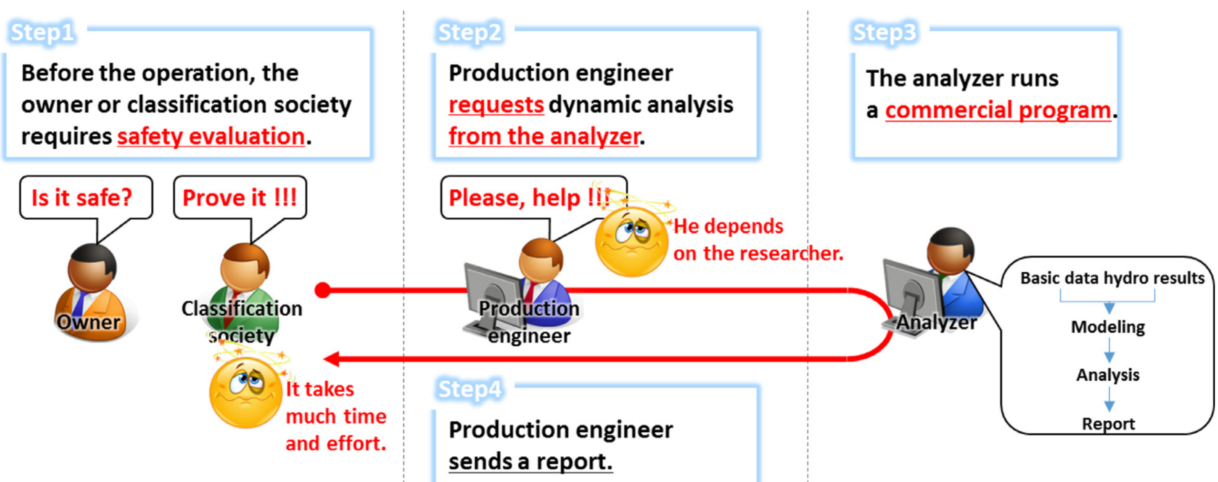

Fig. 2. Safety evaluation procedure of the mega floating crane operation.

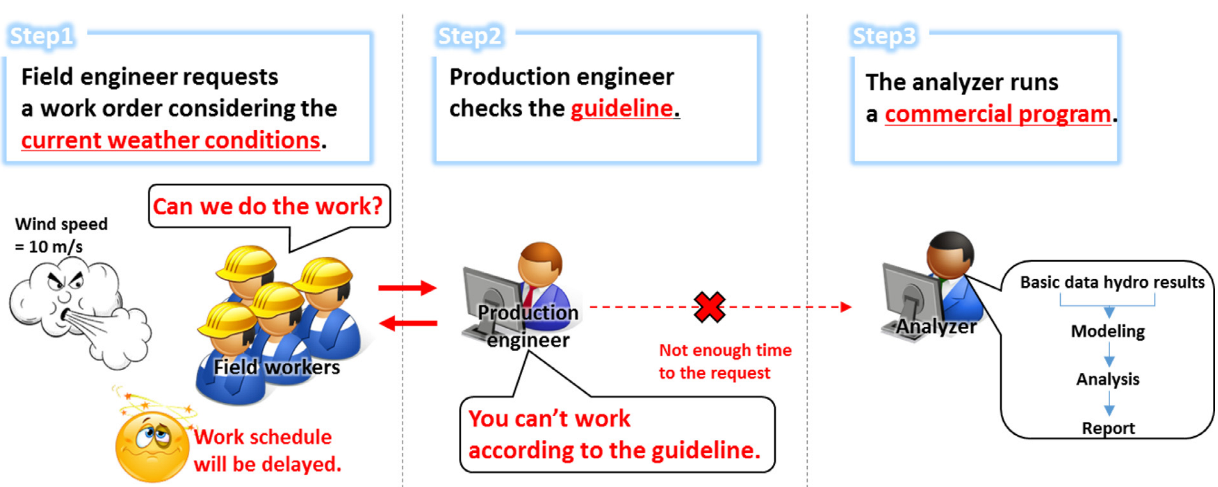

Fig. 3. Decision making procedure according to the internal guideline.