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Development of a Training Simulator for Dynamic Reentry Operations of a Riser Pipe Hanged off

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ABSTRACT
The paper is concerned with a reentry control problem of moving a riser pipe hanged off and positioning its LMRP just above a BOP. The difficulty of the manual control motivates us to develop a training simulator for dynamic reentry operations of a riser pipe hanged off, in order to assist a reentry operator based on dynamic control theory and virtual reality technology. The paper shows how such a training simulator is developed and discusses about a guidance method.

KEY WORDS: Riser Pipe, Reentry Operation, Training Simulator

INTRODUCTION

In Sept. 2007, the deep sea drilling vessel 'Chikyu' began drilling operations in the Kumano Basin area of the Nankai Trough for the start of IODP (Integrated Ocean Drilling Program). As introduced in Curewitz, Kuramoto, Kawamura (2006), the vessel is a state-of-the-art drilling platform that can reach geological targets previously inaccessible to scientific drilling. This is equipped with a drilling derrick, a fully integrated riser drilling system and BOP (Blow-Out Preventer), and a highly automated drill floor system that runs efficiently and safely with a small number of operating personnel. As for important technologies in order to make a long expedition possible by 'Chikyu', Takagawa (2002) pointed out DPS (Dynamic Positioning System), AHC (Active Heave Compensator) and flee-away capabilities.

The paper is concerned with a reentry control problem of moving a riser pipe hanged off and positioning its LMRP (Lower Marine Riser Package) just above a BOP as shown in Fig.1. This reentry operation is necessary as a part of flee-away capability. In general, in such a reentry operation, it is required for a drill operator to incorporate ROV (Remotely Operated Vehicle) operations for observing the bottom of a riser pipe into DPS operations for a mother vessel taking account of the riser dynamics. The reentry operations anytime result in time-absorbing works because of the difficulty of estimating the riser behavior which comes from the 'noncollocation' between the actuator (vessel) and the sensor (ROV). This motivates us to develop a training simulator for dynamic reentry operations of a riser pipe hanged off, in order to assist a reentry operator based on dynamic control theory and virtual reality technology.

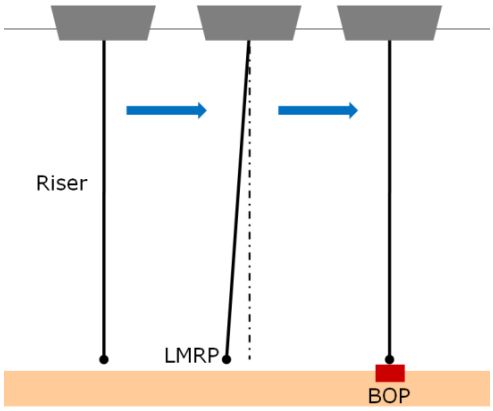

Figure 1 Reentry Control of Riser Hanged Off

In the paper, we assume the ROV operations are conducted perfectly, which means that the distance between LMRP and BOP is measured precisely in real time. Then, it is possible to feed the error back to the DPS command. Thus, the operator should consult with the DPS commands produced by an automatic feedback controller (a good reentry guide). The paper focuses on generating the guidance signal to give the DPS commands for reentry operation under a constant current from the viewpoint of LQI (Linear Quadratic with Integral) control, for example, Kajiwara(2000). The LQI control is expected to predict the riser dynamics using only the information of the distance between LMRP and BOP.

The paper is organized as follows. In the next chapter, firstly, an experimental model of a riser pipe is introduced as a controlled object. Secondly, an equilibrium state under a constant current is simulated based on its mathematical model together with the mode shapes. LQI controller is designed using a linear mathematical model in state space representation. In the third chapter, a framework for the training simulator for reentry control is proposed based on HILS (Hardware-In-the-Loop Simulation) approach, where three PCs are used to constitute a closed loop system together. In the forth chapter, several results are shown using the training simulator. The operator guidance based on LQI control is achieved successfully.