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Model Experiments of Reentry Control Based on Riser Pipe Dynamics

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ABSTRACT

The paper is concerned with a reentry control problem of moving a riser pipe hanged off and positioning its lower end just above a target. The difficulty of the manual control motivates us to design an automatic control system for dynamic reentry in current. A motion equation of a riser pipe model in current is derived via modal analysis. Then LQI (Linear Quadratic with Integral action) control methodology is applied to obtain an appropriate reentry controller. Experimental successful results on reentry control are shown.

KEY WORDS: Riser Pipe, Reentry Control, LQI Control

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 a highly automated drill floor system that runs efficiently and safely with a small number of operating personnel. As for the 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 the lower BOP (Blow Out Preventer) as shown in Fig.1, where LMRP is the upper part of BOP. This reentry operation is necessary as one of flee-away capabilities in the bad weather when the moderate weather serves. Then it must be conducted such that the crush between LMRP and BOP is avoided. 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. The reentry operations in current anytime result in time-absorbing works because of the difficulty of estimating the behaviour of a flexible and long riser even if the distance between LMRP and BOP is measured with accuracy.

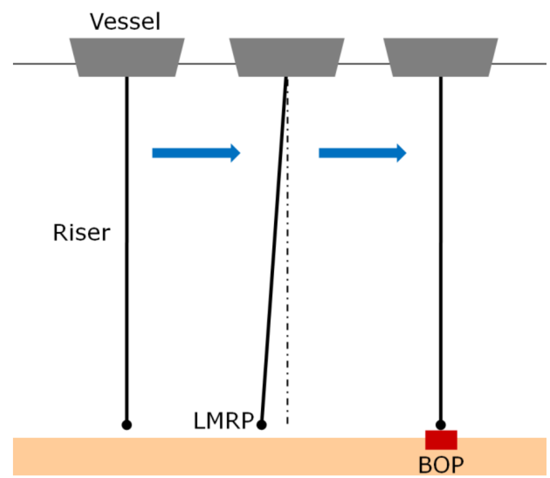

Figure 1 Reentry Control of Riser Hanged Off

This motivates us to develop an automatic controller for dynamic reentry operations of a riser pipe hanged off, based on the LQI (Linear Quadratic with Integral action) control methodology, for example, Kajiwara (2000). 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 paper focuses on generating the DPS commands for reentry operation in current. This is a merit from the practical viewpoint because we can utilize the existing DPS without replacing it by a new one.

In the paper, an experimental model of a riser pipe is introduced as a controlled object. An equilibrium state in constant current on the upper half of the riser model is simulated based on its motion equation together with the mode shapes. LQI controller is designed using a linear mathematical model in state space representation, such that the 'noncollocation' between the actuator (vessel) and the sensor (ROV) does not bring instability such as a spillover. The integral action in LQI control is expected to cancel out the effect by unknown but constant current using only the information of the distance between LMRP and BOP. Experimental successful results on reentry control are shown.