On Vibration Control of Flexible Pipes in Ocean Drilling System

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ABSTRACT

The paper is concerned with a reentry control problem in ocean drilling system with a flexible riser pipe. In the reentry operation, it is necessary to move the flexible riser pipe to a target position as fast as possible not to excite unstable vibration. Then there is a possibility to improve the control performance by scheduling control gains according to moving velocity, because the motion of flexible riser strongly depends upon the hydrodynamic drag force proportional to squared velocity. In the paper, a gain scheduling controller for an experimental model is designed using LPV (Linear Parameter Varying) control method. Then the effectiveness of the LPV control is shown through numerical simulation and model experiment.

KEY WORDS: riser, reentry problem, LPV control.

INTRODUCTION

In Japan, a drilling vessel "Chikyu" has been in service that can drill to 7000m below the seabed at about 2500m water depth. It is equipped with a riser drilling system which has achieved success in oceanic oil drilling. In the case of bad weather, such as typhoon, the vessel holding a drilling pipe must detach its lower end from the seabed platform, leave for a safer sea, and then return again to the original position when whether serves. Reentry operation is necessary to connect the lower end of pipe to the platform. Although the drilling pipe is made of rigid material and its diameter is tens of centimeters, it has characteristics as a flexible structure due to its long length. Human operation might spend half a day because of the difficulty of predicting the flexible behavior. Therefore it is strongly desired to develop a control system to support such a reentry operation.

DERIVATION OF LPV MODEL

In the paper, we treat an experimental setup for reentry control system design as shown in Figure 1 and Figure 2, where O-XZ is a space-fixed reference coordinate system, and o-xyz is a coordinate system which is fixed at the pipe's centerline. We describe the motion of this system using the position $r$ of the upper end of the pipe, the rotational angle $\theta$ of the pipe, and the lateral deflection $w$ of the pipe. For simplicity, we assume that the pipe with circular cross section is treated as an Euler-Bernoulli beam. The pipe in still water is assumed to receive both drag force and additional inertia force. The former is proportional to the