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Maximum Stress and Fatigue Strength of Drill Pipe in Presence of Strong Ocean Current

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Strong ocean currents increase the maximum stress on drill pipe during deployment. Consideration of slip crush is important when evaluating maximum stress, and strong currents influence fatigue strength. Drill pipe may be rotated while constantly bent during normal operation in areas with strong currents. This paper describes the evaluation of the strength, including maximum stress and fatigue strength, of the actual planned drill string configurations to be used under the strong current conditions in the Nankai Trough.

INTRODUCTION

The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has constructed the scientific deep-sea drilling vessel *Chikyu* (Inoue et al., 2006). The *Chikyu*'s first scientific drilling operations took place in the Nankai Trough, which has a harsh drilling environment because of the continual strong currents, sometimes reaching 4 km or more on the surface. The maximum bending stress of the drill pipe must be evaluated because strong currents subject the pipe to increased bending stress. When evaluating the maximum stress, it is important to take into account the hoop stress exerted on the drill pipe at the uppermost part of the drill string and caused by conventional handling tool slips. The strong current also influences the fatigue strength of the drill pipe, because the drill string is rotated in a constantly bent condition.

MAXIMUM STRESS

Axial Stress

The waves in the Nankai Trough were assumed to be characterized by a JONSWAP spectrum with a gamma factor of 1.0, significant wave height of 4.83 m, and a peak period of 10.4 s. Short-crested waves were applied using a typical cosine-squared spreading function, and a wave heading of 30° was assumed. Then the 3 different drill string configurations were analyzed for axial dynamic response related to the vessel's heaving motion using SPLIS, a Mitsubishi Heavy Industries' in-house software program (Ozaki, 1993), and we obtained the short-term predicted tension response in irregular waves per unit wave height under the assumptions conditions (Inoue et al., 2008).

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Bending Stress

One of the main purposes of the strength evaluation described in this paper is to investigate the fluctuation of the bending stress during deployment. In addition to the current, the motion of the vessel contributes to the bending moment. According to the roll and pitch motions in short-crested waves as well as trim and heel in the operations, the analysis of the bending stress during deployment took place under the condition where the vessel was inclined 3° astern (Inoue et al., 2008).

The drill string is bent at the lower end of the guide horn during deployment when the total length of the drill string deployed is small. In this situation, the drag forcing the drill string is small, as the area exposed to the current is small. On the other hand, when a greater portion of the drill string is deployed, the greater tension will increase the bending stiffness and reduce bending. This means that the drag due to the current compared to the tension due to the weight may be a factor in determining the length of deployed drill string at which the maximum bending stress occurs.

Maximum Stress

It is assumed that the drill string is subject to a combination of axial static stress, axial dynamic stress, and bending stress. The maximum stress is obtained from a combination of these 3 factors, and the total stress level is obtained by adding the overpull margin to the maximum stress. Table 1 shows the results, which indicate that the maximum stresses in all cases were less than the yield stresses.

SLIP-CRUSHING CONSIDERATIONS

The importance of considering slip crushing was first highlighted in the 1950s. More detailed investigations (Sathuvalli, 2002; Paslay et al., 2006) have taken place more recently. Casner devised a set of slip-crushing constants for manual slips. However, because power slips with cylinders used to activate and put