

Fatigue Strength Evaluation of Drill Pipe Constantly Bent in Strong Current

Tomoya Inoue¹, Masahiko Ozaki², Tsuyoshi Miyazaki², Makoto Nishigaki³, Koji Setta³

¹Advanced Marine Technology Research Program, JAMSTEC
Yokosuka, Japan

²Engineering Department, JAMSTEC
Yokohama, Japan

³Nagasaki Research & Development Center, Mitsubishi Heavy Industries, Ltd.
Nagasaki, Japan

ABSTRACT

During drilling operation in strong current, drill string will be constantly bent. And the drilling operation by rotating the drill string will lead a bending stress to a cyclic stress. Consequently it may cause the fatigue damage. Fatigue strength curve expressed with moment M and the number of cycles to failure N is obtained from the fatigue test. And it is modified by applying the modified Goodman diagram concept considering an axial stress which is always exerted. The moment distribution of drill pipe is analyzed under the assumption that the drill string is inclined in a certain angle due to the current. Then, fatigue damage level can be obtained by expressing with cumulative damage ratio.

KEY WORDS: Drill pipe; fatigue strength; average stress; modified Goodman diagram; cumulative damage.

INTRODUCTION

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) constructed the scientific deep-sea drilling vessel Chikyu - Japanese word for Earth. Chikyu was designed to be capable of operating in water depths up to 2,500 m for riser drilling and 7,000 m for riserless drilling and also drilling down to 10,000 m total vertical depth for both riser and riserless drillings (Inoue, Nishigaki, Setta and Wada, 2006). Chikyu was also designed to enable continuous coring and recovering scientifically worthy core samples (Inoue, Wada, Kyo and Miyazaki, 2006).

The first scientific drilling of Chikyu under the international organization IODP (Integrated Ocean Drilling Program) has commenced at the Nankai trough located beneath the ocean off the southwest coast of Japan since September 2007. The main purpose of the expedition at the Nankai trough is to drill deep into the Earth to observe the earthquake mechanisms because there is one of the most active earthquake zones. However, it is recognized that the Nankai trough is a harsh environment area for drilling operation because the strong current due to Kuroshio (Black Stream) always runs there. The current speed will be around 4 knots on surface or more at times. The strong current will increase a bending stress. So, strength evaluation of

the drill pipe corresponding to the maximum stress was conducted (Inoue, Nishigaki, Setta, Terada and Ozaki, 2007; Inoue, Nishigaki, Setta and Terada, 2008; Inoue, Ozaki, Miyazaki, Nishigaki and Setta, 2008).

The strong current will also affect fatigue strength of the drill pipe because the drill string is constantly bent and rotated under this condition. This means that the drill pipe is subjected to cyclic stresses.

Fatigue damage investigation was originally done for the drill pipe passing through dog-legs (Lubinski, 1961; Hansford and Lubinski, 1966). Generally the drill pipe will not be constantly bent at any structure on board in normal operation. However, vessel motions will result in bending of the drill pipe which causes the cyclic stress. So, Hansford and Lubinski (1964 and 1970) investigated influence of vessel motions on the drill pipe fatigue failure. On the other hand, during drilling operation at the Nankai trough the drill pipe is assumed to be constantly bent at a structure due to the strong current as described above. It will be severe condition.

Fatigue failure of the drill pipe has recently been discussed for specific severe wells (Sathuvalli, Payne and Liversay, 2005; Plessis, Wright, Aranas, Jellison and Muradov, 2006). It is important to investigate the fatigue failure for the drilling operation at the Nankai trough as well.



Fig. 1 Scientific deep-sea drilling vessel Chikyu