Effects of coating and lubrication on fretting fatigue properties of oil-well pipe material

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Introduction. Due to the recent introduction of an advanced oil-well development technology in which the drilling and installation of pipes are simultaneously done, the pipes receive a rotating and bending fatigue loading. As a result, characterization of the fatigue properties of the pipes has become necessary. Since the pipes are connected by a threaded joint, the thread is the critical part of the connected pipes in terms of fatigue strength.

The surface of the thread is coated by manganese phosphate for ease of tightening. In addition, grease is also used for the tightening. According to the result of a full-scale fatigue test(1), the coating and lubrication improved the fatigue strength of the threaded joint. The objective of this study is to gain a better understanding of the effects the manganese phosphate coating and grease lubrication have on the fatigue strength of the thread joint for oil-well pipes.

Experimental procedure. A bridge-pad type fretting fatigue test was carried out. Two kinds of contact pads with different pad lengths, Lp, were used. The material of the test piece and pad was API L80 oilfield pipe steel. The surface of the pad was coated by manganese phosphate. The grease was API modified thread compound. The contact pressures, pc, were 50 MPa. The fretting fatigue test was carried out with a stress ratio of -1 at a loading frequency of 15 Hz at 20 ℃.

Results and discussion. Figure 1 shows the S-N curves for the Lp = 25-mm contact pad. At a relatively high stress amplitude, there were no significant effects by both the coating and lubricant on the fretting fatigue life. At the relatively low stress amplitude, the effect of the coating was not seen, however, the lubricant showed a remarkable effect to extend the fatigue life.

Figure 2 shows the changes in the tangential force coefficient, φ, with an increase in the number of cycles. Regarding the 25 mm pad, when the stress amplitude, σa, was 205 MPa, the coating had no significant effect on φ regardless of with or without lubrication. The lubrication initially achieved a lower φ, but the φ rapidly increased with an increase in the fretting cycles. At σa = 145 MPa, the φ for the non-lubrication tests showed a behavior similar to that at σa = 205 MPa. For the greased tests, the φ of the uncoated test also rapidly increased. On the other hand, the φ of the coated specimen remained low. Based on an analysis of Fig. 2 (a), we found the function of the coating occurred with the lubrication. To verify this consideration, an additional fretting fatigue test using a 12.5-mm pad was carried out.

The objective of the using the short length pad was to reduce the relative slip amount. We expected that less slip reduces the extrusion of the grease from the contacting surface which results in maintaining the lubrication. The results are also shown in Fig. 1. At σa = 205 MPa, the fretting fatigue lives of the lubricated specimens were significantly extended. The fretting fatigue life of the coated specimen had a longer life under the lubrication. As shown in Fig. 2 (c), the φ of the 12.5 mm pad with lubrication is remained low. This is the reason for the extended life.

Conclusion
Manganese phosphate coating has an effect to improve fretting fatigue strength under lubrication.

References
(1) Oku Y., Tribology International, 108, (2017) 111-120