# TRIBOFILM FORMATION PROCESS FROM ZNDTP ON MANGANESE PHOSPHATE COATINGS WITH DIFFERENT SURFACE ROUGHNESS OF UNDERLYING STEEL

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## KEYWORDS

***Lubricant additives; Tribofilms and 3rd bodies; Coatings, Manganese phosphate coating***

## ABSTRACT

Application of manganese phosphate (MnP) coating to steel materials for gears is under consideration for higher surface pressure and efficiency of hydraulic pumps for construction machinery. Since MnP coating mainly consists of Hureaulite ($Mn_5(PO_3(OH))_2(PO_4)_2 \cdot 4H_2O$) having high oil retention performance and lower hardness than the steel materials, the coating is sacrificially worn away in exchange for the substrate, and make the surface smooth during friction. This can bring about improvement of initial conformability of the surface, resulting in higher antiwear performance and galling resistance of the steel materials. On the other hand, zinc dialkyl dithiophosphate (ZnDTP), widely used as an antiwear additive in gear oil, can improve friction and wear characteristics by forming a thick polyphosphate-based tribofilm on the steel surface during friction. Since MnP-coated surface has a different physicochemical structure from the underlying steel surface, the understanding regarding formation mechanism of a tribofilm derived from ZnDTP on the MnP-coated surface are still unclear. In this study, by focusing on the fact that surface roughness of the underlying steel could bring about differences not only in the amount of residual MnP coating and also in the formation of the tribofilm, the friction and wear characteristics of the MnP coatings with ZnDTP-formulated oil were investigated using two kinds of the underlying steels with different surface roughness.

In this study, friction tests were conducted using the laboratory-developed pin-on-disk tribometer not only for measurement of friction between pin and disk specimens but also for formation of tribofilms on the wear track of both specimens from ZnDTP-formulated oil. Chrome molybdenum steel (JIS-SCM420H), subjected to carburizing treatment, was used for both specimens. The disk specimen (ϕ28×ϕ15×t=3mm) was polished to make an isotropically smooth surface with Ra of 0.07 μm (assigned as PO). The MnP coating mainly composed of Hureaulite were applied to both the disk with smooth surface (Ra=0.4 μm, PO+MnP) and the disk subjected to shot-peeing (Ra=1.0 μm, SP+MnP), and thickness of the coating is approximately 2.5 μm. The pin (ϕ14mm, t=11mm, R=54.7mm) was used for a counter specimen. After the friction test was performed, both specimens were applied to several kinds of surface analyses to evaluate both the residual amount of MnP coatings and the formation of ZnDTP tribofilm.

Figures 1 show the relation between the thickness of tribofilm formed from ZnDTP and the amount of MnP loss during the test, obtained with PO+MnP and SP+MnP. The relation exhibited the opposite behavior by addition of roughness to the underlying steel surface; while PO+MnP exhibited the high amount of MnP loss, it provided the thicker tribofilm as the sliding distance increased. This indicated that the formation of tribofilm from ZnDTP on the MnP-coated surface was promoted as the amount of MnP loss increased and then the underlying steel surface was exposed.

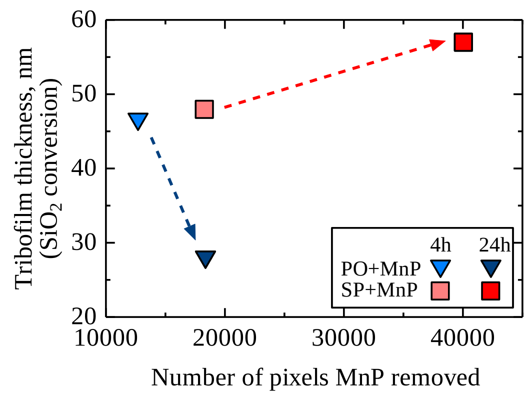


Fig.1 Relation between the amount of MnP coating loss and ZnDTP-derived tribofilm thickness

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