# The effect of Friction on Micropitting

Mao Ueda[1, 2)*], Benjamin Wainwright[1)], Hugh Spikes[1)] and Amir Kadiric[1)]

[1)]Tribology Group, Department of Mechanical Engineering, Imperial College London, United Kingdom
[2)] Technology Centre Research & Development Team, Shell Lubricants Japan K.K., Japan
*Corresponding author: m.ueda18@imperial.ac.uk

This study aims to design an experimental methodology to investigate the effects of friction on micropitting in isolation from other influencing factors, particularly the changes of counterface roughness which can occur through mild wear which is known to have a significant influence on micropitting itself. Presented results can help in designing oil formulations that can extend component lifetimes both wear and microptting damage through controlling tribofilm growth and friction.

**Keywords (from 3 to 5 max):** micropitting, rolling contact fatigue, friction, ZDDP, MoDTC

## 1. Introduction

Micropitting is a type of surface fatigue damage caused by stress fluctuations due to asperity interactions in rolling-sliding contacts. Many of the relevant mechanisms are poorly understood hindering the production of design criteria. This is particularly true of the influence of friction on micropitting. The primary reason for this is the difficulty of isolating the effects of friction from other relevant factors in microptting experiments. This study aims to address this by utilising an experimental methodology designed to investigate the effects of friction in isolation from other influencing factors, particularly the changes of counterface roughness which can occur through mild wear which is known to have a significant influence on micropitting itself [1]. The findings provide a new understanding of the impact of friction on micropitting and suggests the mechanism of micropitting occurrence.

## 2. Methods

We employ the MTM-SLIM method with relevant modifications, as described in detail in our previous study [1], to generate micropitting damage on the MTM ball. This method allows the evolution of friction, micropitting, counterface roughness and tribofilm thickness to be monitored in parallel. Friction was controlled by adding relevant quantities of MoDTC friction modifier to the oil. To control wear, a highly effective ZDDP additive was used as described in [1]. However, addition of MoDTC can hinder the effectiveness of ZDDP leading to undesired reduction of counterface roughness during the test. This makes it impossible to separate the effects of friction from those of wear. To isolate the two effects, we employ two test procedures. In the first, oil containing both ZDDP and MoDTC was used from the beginning of the test. In the second, oil with only ZDDP was used until 0.1 million cycles and was then replaced with an oil containing both ZDDP and MoDTC. MoDTC concentrations of 0, 50, 100, 200 and 500 ppm Mo were studied. This procedure was designed to minimise the wear of the counterface roughness due to MoDTC introduction. All tests were run for 8 million contact cycles.

## 3. Results and Discussion

Although friction and micropitting decreased by adding more than 50 ppm of MoDTC to ZDDP oil from the beginning of the tests, counterface roughness was also reduced. This was shown to be due to MoDTC hindering the growth of the ZDDP anti-wear film in the early stages, thus promoting wear. When MoDTC was added only after 0.1M cycles, friction still decreased from 0.1 to between 0.04 and 0.05 (depending on Mo concentration) for the reminder of the test, but now an effective ZDDP anti-wear film also formed and survived throughout the test, preventing excessive wear of the counterface. Thus, the effects of friction were isolated from those of wear. Fig. 1 shows the percentage of micropitted area on the MTM ball wear track at different concentrations of MoDTC. It is evident that micropitted area was reduced by a factor of 5 in tests where friction was ~0.04 (500 ppm Mo) compared to those where friction was 0.1 (no MoDTC). The paper will present further results to support this finding and discuss the observations in terms of mechanism of micropitting.

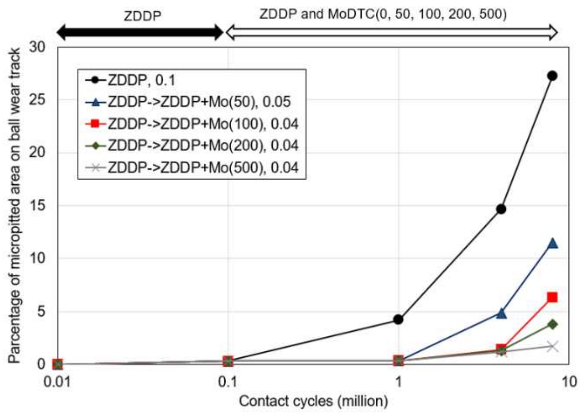


Figure 1. Measured percentage of micropitted area on ball with different MoDTC concentrations added after 0.1 million cycles. Inside bracket shows the friction coefficient at 0.2 million cycles

## 4. References

[1] Ueda, M. et al., “In-situ observations of the effect of the ZDDP tribofilm growth on micropitting” *Tribology International* 138 (2019): 342-352.