# Wear and sulphur chemistry of the tribolayer

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## 1. Introduction

In the piston-ring cylinder-liner tribosystem, the friction and wear behaviour is thought to be closely connected to the formation of a tribolayer. Lubricant additives, or their decomposition products, together with the native oxide layer and the metal substrate, form a protective layer. For steel surfaces, Martin et al describe the formation of short and/or long-chain polyphosphates as part of the tribolayers [1].

An important factor influencing the tribolayer formation and composition, is the lubricant used during the tribological testing. Differences in lubricant additivation [2] and condition (i.e. aged or fresh) [3][4] directly affect the tribolayer and subsequently also friction and wear behaviour.

A previous investigation of the authors [4] describes the connection between the steady-state wear rates and tribolayer thicknesses for model tests with fresh and aged lubricants. The present paper will go into more detail concerning the composition of the tribolayer. A special focus is laid on the sulphur chemistry in the wear zone, which was also found to be correlated to the steady-state wear rate.

## 2. Methods

A series of wear tests were carried out using a piston-ring cylinder-liner geometry in a reciprocating tribometer. During the test, both wear and friction were monitored continuously. Wear was measured using the radioisotope concentration (RIC) method [5], which uses radioactive isotopes to determine the amount of wear throughout the tests.

The tribotests were lubricated using two types of fully formulated engine oil (Oil A and Oil C). Both oils were used in fresh and artificially aged conditions. Details about the chemical aspects of the lubricants and the aging procedures can be found in Besser et al [6].

After the tribological tests, the wear zone was analysed with x-ray photoelectron spectroscopy (XPS), producing information about the chemical composition of the surface.

## 3. Results

The XPS analysis of the worn surface of the cylinder liners reveals some interesting aspects concerning the sulphur chemistry. Sulphides were found on all cylinder liners, whereas forms of sulphates were found predominantly on the liners lubricated with aged oils. The ratio between the sulphides and sulphates on the surface can be seen in Fig. 1.

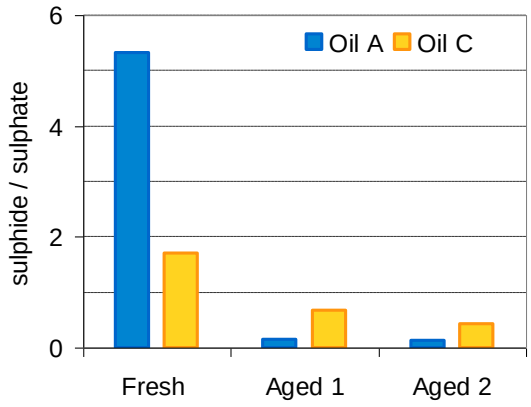


Fig.1 Sulphide to sulphate ratio on worn surface of cylinder liners

Differences were also found for the different types of lubricant: those samples used with Oil A have calcium sulphates present in the worn area, whereas those lubricated with Oil C result in zinc sulphates.

The steady-state wear rates of the piston rings were found to be higher for tests with fresh oils, than for the respective aged counterparts [4]. This correlates with the ratio of sulphide and sulphates on the surface: a lower wear rate is accompanied by a lower sulphide to sulphate ratio.

## 4. References

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