INTRODUCTION

Sliding contact between materials frequently involves surface plastic deformation, being particularly common during running in, even for lubricated contacts. The subsequent behaviour can be separated into three categories, as defined by Kapoor and Johnson [1]: elastic shakedown, plastic shakedown and ratchetting. Which mechanism is followed depends on both extrinsic (load, state of lubrication etc) and intrinsic (material property) factors. The intrinsic factors depend strongly on the modification of surface structure by the wear process, in particular, work hardening, local chemical reactions and defect evolution. Our current understanding of these changes is poor, in particular, there is a dearth of data [2] on worn surface mechanical properties. There is virtually nothing on the worn surface microstructure for lubricated contacts. This paper will consider the current status of the understanding, with particular attention to a detailed understanding of surface microstructural change through transmission electron microscopy.

EXPERIMENTAL

Testing was undertaken in a range of pure sliding configurations, including pin-on-disc and pin-on-ring configurations, in both dry and lubricated conditions. Sliding speeds were ~1 m/s for all tests, with loads in the range 6 - 160 N. A range of materials are reported, both commercial and produced in the laboratory; full details are given elsewhere [2 - 4].

RESULTS AND DISCUSSION

The surface deformation behaviour under dry and lubricated (mineral oil) conditions was studied for a Al-12 %Si alloy, worn in a tri-pin-on-disc machine against grey cast iron at 1 m/s. Cross-sectional TEM indicated that the change in microstructure of the Al-Si below the worn surface was the same, comprising fracture and fragmentation of the Si, high strain deformation of the matrix, and transfer of Fe from the counterface. Two major differences were present between the dry and lubricated sliding cases. Firstly, as expected, the total depth of deformation was always greater for the dry sliding case, Table 1, associated with a finer subgrain size at the worn surface, Fig. 1. Secondly, the extent of transfer of iron from the counterface to the Al-Si alloy was consistently greater for the dry sliding case.

A similar study was performed for spray cast Al-21%Si-5%Fe-2%Ni alloy tested in pure sliding against an M2 tool steel counterface, lubricated with a similar mineral oil. In this material, the α-Al grain size was ~1 µm, an order of magnitude finer than the Al-12%Si alloy. Interestingly, no surface deformation by dislocation flow could be detected. However, Si particle rearrangement occurred, with the worn surface being richer in particles than in the starting microstructure. Some adhesion between the surfaces was detected, through the presence of Fe rich particles on the worn surface, largely only detected in the TEM. Thus, the greater material hardness and reduced grain size had substantially reduced the extent of surface deformation. However, transfer of Fe from the counterface had occurred in a similar manner to the Al-12%Si alloy, despite the substantially harder M2 tool steel counterface used in this case. The presentation of this work will also compare the behaviour of Al alloys with ferrous materials, worn under similar conditions.

CONCLUSION

No fundamental difference in worn surface microstructural evolution was found when comparing lubricated and dry sliding conditions, although the extent of surface damage is reduced by lubrication.

REFERENCES