7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Galling Alleviation in Press Hardening through Surface Engineering and Lubrication

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In press hardening, the transfer of material from the Al-Si steel sheet coating onto the tool surface is a critical problem. Ways to alleviate it includes optimisation of surface topography, tool steel composition, and coatings. The aim of this study is to explore two strategies for alleviating galling; PVD coatings without aluminium, and the use of a lubricant. The tribological tests were performed using a hot strip drawing tribometer. PVD coatings without aluminium reduce material transfer. The material transfer is mainly related to chemical affinity. For uncoated tool steel, material transfer decreased in case of an inorganic potassium salt-based lubricant.

Keywords: High temperature; friction; wear; hot stamping

1. Introduction

The most common wear mode in press hardening is the transfer of the Al-Si coating onto the tool surface. The galling mechanisms are reported to be a combination of adhesive material transfer and compaction of wear debris on to the tool surface [1]. Coatings with Al has shown increased adhesion [2,3] but material transfer can be prevented by reducing the metallurgical compatibility with the Fe-Al-Si intermetallics on the workpiece coating, or by introducing a lubricant to prevent direct contact between the interacting surfaces. The aim of this work is to explore the potential of two strategies for alleviating galling in press hardening; PVD coatings without aluminium as a constituent in dry conditions, and the use of a lubricant together with an uncoated hot forming tool steel.

2. Methods

Pre-hardened hot work tool steel (30CrMo6) with a hardness of 440 ± 1 $HV_{0.01}$ were polished and plasma nitrided prior to coating with AlCrN and CrWN. Uncoated hot work tool steel specimens for lubricated tests were plasma nitrided and with a hardness of 52 HRC. The counter surface was Al-Si coated 22MnB5 sheet strips. The tribological tests were carried out using a hot strip drawing tribometer which is described in [4]. Tests parameters for PVD coatings were: 5 and 10 MPa, 0.1 m/s, sliding distance 0.5 and 0.075 m, strip temperature 700 °C. For lubricated tests, the lubricant was applied on the pins and dried in an oven at 100 °C for 20 min. Lubricant was also applied between each test using a brush. A sliding distance of 5 x 0.2 m was used (new steel strips for each test).

3. Results and discussion

The initial friction is slightly higher and the sliding distance until steady state friction is longer for CrWN compared to AlCrN. The steady state friction is the same for both PVD coatings and is governed by formation of a FeAlSi transfer layer on the PVD coating. The PVD coating with aluminium clearly experience more material transfer and increasing the contact pressure results in increased transfer, Figure 1.

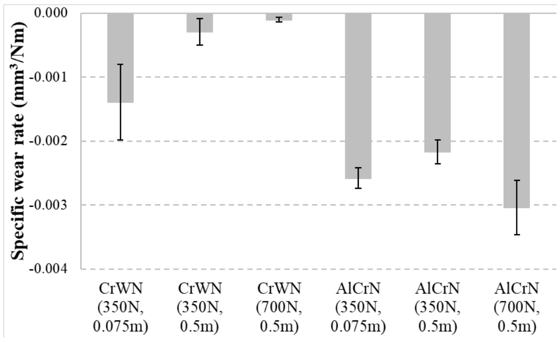

Figure 1: Specific wear rate for CrWN and AlCrN coatings sliding against Al-Si coated 22MnB5 steel.

The fully formulated Potassium salt-based lubricant showed a repeatable friction behaviour. The organic lubricant showed a higher initial friction but less variation during sliding. The inorganic lubricant presented an even more stable behaviour over the whole sliding distance. Transfer of Fe-Al-Si intermetallics is the main wear mechanism in both dry and lubricated tests. The presence of a lubricant appears to prevent compaction of wear particles in to larger transfer layers.

4. Conclusions

- Transfer of Al-Si onto PVD coatings at high temperatures occurs irrespective of coating composition.
- A PVD coating without aluminium shows less transfer of Al-Si.
- The friction level is reduced when using lubricants compared to dry sliding and the lowest friction was found in case of an organic lubricant.
- The presence of a lubricant during sliding results in less compaction of FeAlSi wear debris

5. References

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