# Tribology in Press Hardening

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**Abstract**

The increasing demand for light-weight components, especially in the automotive and transportation sector, is the driving force for the rapid expansion of hot sheet metal forming technologies. In automotive industry, a large number of safety and structural components for the body-in-white are formed using press hardening. This process allows forming of complex shaped components while controlling their microstructure and mechanical properties. Tribology plays an important role in this process as it affects the durability of forming dies and tools, quality of the produced parts and the overall productivity. The tribological challenges include: friction control, enhancement of the durability of forming tools; minimization/alleviation of galling of tools and surface damage on the produced parts. This keynote presentation focusses on recent tribological studies pertaining to press hardening undertaken by the authors in recent years. The objectives of these studies have been to investigate the effect of tool surface roughness and surface engineering on the friction and wear response. Further, the influence of tool steel composition and tool temperature has also been investigated. The experimental work was carried out using a hot strip tribometer capable of simulating the tribological contact conditions in the press hardening process.

The results have shown that the frictional stability is contact pressure dependent in case of uncoated tool steel and uncoated ultra-high strength boron steel (UHSS). A high contact pressure resulted in more stable friction behaviour. In case of Al-Si coated UHSS, the tool steel surface roughness was found to directly affect the material transfer. A rough surface resulted in increased galling. Hard PVD coatings (AlCrN) were prone to severe adhesive wear and unstable friction whereas post-oxidised plasma nitrided tool steel resulted in minimal galling and stable friction. The chemical composition of uncoated tool steels was also found to have an effect on friction and material. Oxidation of the tool steel during heating resulted in stable friction behaviour due to formation of transfer layers consisting of oxidised debris and Al-Si fragments. This effect was more pronounced for some tool steels. The temperature of the work-piece material was also found to influence the frictional stability and the wear mechanisms in case of tool steel - Al-Si coated UHSS. In general, severe material transfer and high friction was observed at the highest temperature of the work-piece material (~900˚C) due to surface melting of the Al-Si coating and degradation of mechanical properties.

***Keywords:*** press hardening; friction; wear; material transfer; hot strip tribometer

# 高强钢热冲压成形过程中的摩擦问题研究

摘要：随着汽车和运输行业对于轻质零件的需求逐渐上升，钢板热成形技术迅速得到推广应用。在汽车行业，白车身中的大量的安全件和结构件都通过热成形得到，热成形技术是指在成形复杂零部件的同时控制其微观组织和力学性能。摩擦在热成形过程中起着重要的作用，它影响着成形模具的耐用性，零件的质量以及部件的尺寸精度。在热成形过程中的摩擦学挑战包括：摩擦控制，成形模具耐用性，减小或缓和模具表面的擦伤以及零部件表面损伤。本文主要报告作者近几年来在热成形摩擦方面的相关研究。这些研究的目的是探索模具表面粗糙度以及表面工程对于摩擦磨损的影响机理。进一步地，研究了模具钢的化学组成和模具温度对于摩擦摩擦磨损的影响。通过带状拉伸热摩擦实验机来物理仿真真实热成形条件下模具与坯料的接触状况。试验结果表明，表面未镀层模具和非涂层高强板的摩擦稳定性取决于表面压力状况，表面接触压强越大，摩擦行为稳定性越高。对于Al-Si涂层高强钢板，模具表面粗糙度直接影响材料的转移，表面粗糙度越大，擦伤拉毛越明显。模具表面镀硬质PVD涂层（AlCrN）会造成严重的粘滞磨损以及不稳定的摩擦行为，而模具表面通过后续氧化等离子渗氮处理则能显著减少粘滞磨损并使摩擦行为较为稳定。表面未镀层的模具钢化学组成对摩擦和高强钢材料也会造成影响，模具钢表面的氧化颗粒和Al-Si碎片组成的传输层会使得摩擦行为更加稳定，这种影响对于某些模具钢会更加明显。Al-Si涂层板的温度也会影响摩擦稳定性以及磨损机理。总得来说，当高强钢板料温度最高达到900℃时，由于Al-Si涂层的融化以及基体的软化会造成严重的材料转移和较高的摩擦因子。

关键字：热成形；摩擦；磨损；材料转移；带状热摩擦试验机