Material transfer mechanisms between aluminum alloy and tool steel during dry sliding at elevated temperatures

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Hot stamping of high-strength aluminum alloys allows for increased formability, decreased springback and the possibility of integrating age-hardening heat treatments into the process. However, material transfer is a critical factor in tool damage, as aluminum is highly prone to adhesion. The transferred aluminum can lead to galling (severe form of adhesive wear), which can result in damage of the formed aluminum alloy components. In the current literature, most of the studies are performed at room temperature, while the works in high temperature focus mainly on the resulting transfer thickness, coefficient of friction behavior and wear of the materials. In this context, the aim of this work is to investigate the mechanisms behind the occurrence of aluminum transfer onto tool steel during dry sliding at high temperatures. For that, a hot strip drawing tribometer was used to slide Caldie® tool steel pins against 6082 aluminum alloy strips. The tests were performed at room temperature, 300°C, 400°C and 500°C. The tool steel pins were tested with two different surface conditions: ground and polished. The sliding speed was 100 mm/s, the sliding distance was 100 mm, and the contact pressure was 10 MPa. Material transfer characterization was performed mainly through scanning electron microscopy. It was seen that surface topography features from machining (ground tool steel) as well as carbides (polished tool steel) act as initiation sites for the transfer to occur. More aluminum will be prone to adhere onto the initially transferred material. Temperature influences the growth mechanisms of the aluminum transfer layers, as thermal softening of the aluminum alloy is the dominant factor in determining the growth direction during sliding. At lower temperatures, entrapment and build-up of transferred material towards the leading edge were more dominant, resulting in thicker and more localized transfer layers. At higher temperatures, smearing and/or shearing of the transferred material along the sliding direction was dominant, leading to thinner and more spread-out transfer layers.

Keywords: material transfer mechanisms, high temperature, hot forming of aluminum alloys, unlubricated contacts

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