Minimising aluminium transfer at high temperature: synergy between lubrication and surface engineering

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Aluminium alloys are gaining interest for applications as automotive structural components. High strength alloys (such as the 6XXX and 7XXX series) offer interesting strength-to-weight ratios as compared to steel. Various forming processes have emerged in the past years to enable manufacturing of components with complex shape and tight tolerances . These high-strength Al alloys exhibit their full mechanical properties after precipitation hardening, which can be achieved in-situ while forming through hot stamping followed by an ageing treatment. In addition to their increased formability as well as reduced springback, forming aluminium components at high temperature is thus a preferred method. However, phenomena such as severe material transfer (also referred to as galling), oxidation and material softening make hot forming processes tribologically challenging. To date, the need for frequent maintenance of the dies as well as the reduced quality of the formed components hinders productivity. To alleviate these tribological challenges, lubrication and surface engineering techniques are promising. The role of surface topography is also quite unknown under lubricated conditions, where mechanical retention of the lubricant is to be balanced with the ploughing action of surface asperities in the sliding contact. Various PVD coatings (such as e.g. Diamond Like Carbon and CrN-based) and surface treatments have also showed promising anti-galling properties when sliding against Al at room temperature and under dry conditions. The aim of the present study is thus to investigate the effect of various lubricants combined with surface engineering methods on the tribological behaviour of tool steels (TS) sliding against Al alloys at high temperature. The tests were carried out in a hot strip drawing tribometer, representative of two different forming methods: hot stamping with non-heated tool steel sliding against hot Al (AA6010S at 500°C) and hot metal gas forming (HMGF) with hot tool steel (500°C) against hot Al (AA6063 at 500°C). Four different lubrication strategies and two different TS in four different conditions (uncoated, post-oxidised and with two PVD coatings) were tested depending on the forming process. The preliminary results show a high dependency of the lubricant effectiveness in the contact as well as its bonding to the surface on the friction and wear behaviour. When a proper synergy occurred between the lubricant and the TS material in the contact, low friction and stable wear behaviour were observed.

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