Micromechanical modelling of the effect of carbides in cold forming tools on friction and workpiece surface deformation

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The surface roughness and mechanical properties of materials in cold forming process affect the frictional behavior of the workpiece and forming tool. Considering the dependency of the surface roughness characterization on the sampling length, it is very difficult to decouple the contribution of the material from the effects of surface finish. To develop new materials and surface finish with enhanced tribological behavior, it is critical to understand the contribution of material and surface roughness to the frictional behavior. This requires multi-scale characterization process which enable accounting for the dependency on material- and contact surface- length.

In the current study, a microstructure-based finite element model of contact was developed to study the effect of the microstructure of cold forming tool on the frictional behavior in dry contact with AA6082-T4 aluminum workpiece. The cold forming tool was composed of hard carbide particles dispersed in a martensitic steel matrix. The forming tool is assumed to be in dry contact with aluminum. Due to the presence of hard carbide particles in the steel, the polishing process of the forming tool is a challenging task resulting in varied characteristics of the surface roughness. To account for the influences of carbide, the microstructure based finite element model was used to represent the different contact areas seen in the production process and roughness profiles. The interface between aluminum alloy and tool steel was explicitly divided into two contact areas representing aluminum-carbides and aluminum-martensite interfaces. The geometrical aspects of the tool steel micro-surface were represented in the model to account for their effects on the friction coefficient. Based on the results from the simulations, the distance between the summit of carbide and the surface of the steel matrix was found to be the most influencing parameter on the friction due to its effect on the surface deformation of aluminum. Lower volume fraction of carbides has increased surface deformation and friction due to the increased distance between carbide particles and lowering the contribution from the carbide area to the contact. These effects were found to be pressure depending, where increased pressure amplify the effect of these parameters.

Keywords: Friction, Microstructure-based modelling of contact, Aluminum-Carbides interfaces, Contact surface deformation

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