Adhesion reducing surface modifications on aluminum processing tools

Hanno Paschke[1], Martin Weber[1], Julius Peddinghaus[2], Kai Brunotte[2], Martin Lauth[3], Olexandr Grydin[3]

[1]Fraunhofer Institute for Surface Engineering and Thin Films IST, 44145 Dortmund, Germany

[2]Institute of Forming Technology and Machines, Leibniz Universität Hannover, 30823 Garbsen, Germany

[3]Department of Materials Science, Paderborn University, 33098 Paderborn, Germany

Hanno.Paschke@ist.fraunhofer.de

During the processing of aluminum, distinct wear patterns often show up, characterizing the predominant role of adhesive mechanisms appearing on the tool surfaces. The focus of the presented work lies on the description of the observed wear and the extended knowledge gained for the reduction of wear during hot and cold processing of aluminum. Most recent projects were dealing with aluminum forming in cold and warm forging, twin roll casting, die casting and hot extrusion molding of aluminum. In particular, the modification of the tool surface by various methods of plasma surface engineering can make a significant contribution to the reduction of wear.

The paper discusses the observed wear mechanisms, with respect to the adhesion, which are showing on industrial model tools and on processing tools as well. It is possible, that distinct procedures provoke the change of the microstructure of the steel-based tools surfaces and are forming intermetallic phases with aluminum. This is responsible for the ongoing sticking of material and build-up mechanisms. On the other hand, reduced melting temperatures of these phases cause the disintegration of the tool surfaces.

From available results of the wear analysis on industrially used tools and dies, wear-reducing concepts were derived based on effective coating systems and different diffusion treatments. In special, these are coating systems based on modified DLC, nanostructured multi-element systems with boron and vanadium doped chromium nitrides. The diffusion treatment to boride the tool surfaces, reveals promising results in every type of production field. Another aspect, in addition to the surfaces and edge layer modifications, is the topography of the tools and dies in combination with different cooling and separation lubricants. In order to ensure an optimal cooling lubricant connection and a homogeneous, closed lubricant film to reduce adhesion, adapted surface qualities should be set. Additionally, the collective load present in the production has to be considered and in detail the resulting wear mechanisms are differing for the specific processing systems. Wear protection concepts developed to reduce adhesive buildup also have to minimize abrasive wear and avoid mechanical crack initiation. Thus, combination processes consisting of diffusion treatment and coatings are constructive.

The presented work shows solutions of wear protection based on surface and surface layer modifications tested under different industrial conditions. With the help of this information, companies can request specific treatment processes from various providers and increase the service life of the used shaping tool components.