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Experimental and theoretical investigation of the microstructure of aluminum alloys during extrusion

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ABSTRACT

The purpose of this work is the modeling and simulation of the material behavior of aluminum alloys during extrusion processes. In particular, attention is here focused on Al-Mg-Si alloys of the 6000 series, which are characterized by providing a maximum of ductility and Al-Zn-Mg alloys of the 7000 series, which show better hardness properties but reduced ductility. During extrusion the material behavior is governed by the process of dynamic recovery, whereas static recrystallization is the dominating process during cooling.

The material properties of the produced parts strongly depend on the resulting microstructure. The microstructure developement during extrusion is influenced by several interacting microphysical phenomena such as subgrain evolution, dislocation motion and recrystallisation.

The Electron Back Scattering Defraction (EBSD) method is used with several experimental specimens on different process conditions to determine microstructure properties such as subgrain size and grain misorientation. These properties are analysed statistically for a later comparision with simulation results. Furthermore the EBSD data is used to produce a microstructure picture of the specimen. A graphical optimization reduces measurment errors and distinguishs the grain boundaries. The software OOF2 (OOF: Finite Element Analysis of Microstructures) then generates a FEM mesh adaptive to the grain boundaries from the optimized picture to represent the material microstructure.

The FEM simulation is done with the commercial software ABAQUS. During the simulation the state quantities subgrain size, grain misorientation and additionally the dislocation density are implemented as internal state variables. The general material model is based on the role of free energy which is stored in the material during the extrusion process.