Prediction of flow curves for aluminium alloys using genetic programming

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Abstract. An in-depth understanding of material flow behaviour is crucial for numerical simulation of plastic deformation processes. In this work, an algorithm of genetic programming called *Symbolic Regression Method* is used to model flow stress curves. In contrast to classical regression methods that fit parameters to an equation of a given form, symbolic regression searches for both numerical parameters and the equation form simultaneously; therefore, no prior assumption on a flow model is required. This identification process is done by generating and adapting equations iteratively based on genetic algorithms. The derived constitutive model is applied to analyse two aluminium wrought alloys: a conventional AA6082 and modified Cu-containing AA7000 alloy. The required dataset for the genetic algorithm was created by a series of hot compression tests performed at temperatures between 350 °C and 500 °C and a strain rate from 10^{-3} to 10 s^{-1} using a deformation dilatometer. The measured data, experimental set-up parameters as well as the material process history and its chemical composition are stored in a SQL database using a python™ script. Since raw measured data contain some noise and measurement errors, e.g. specimens heating due to plastic dissipation at high deformation rates, an in-house Flow Stress Analysis Toolkit is used to minimize the noise, compensate temperature due to plastic dissipation and calculate the flow stress-strain curves. The obtained results represent a data-based free-form constitutive model and are compared to a physics-based model, which describes the flow stress in terms of mean dislocation density. A reasonable agreement between the two approaches, as well as with the experimental data, is achieved.