Development of a flow curve based material model of aluminium alloys in the semi-solid state

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Abstract. Current research activities at the Institute for Metal Forming Technology (IFU), University of Stuttgart are focusing on the numerical simulation of thixoforging processes of lightweight materials and development of material models required for simulation. In this context, research work reported about in this paper deals with newest developments of a flow curve based material model for characterizing the flow behaviour of aluminium alloys in the semi-solid state. For prediction objectives of die filling during thixoforging processes both CFD and FEM based simulations can be used. In CFD simulation different viscosity models are used, among which the Carreau model, for example is particularly suitable for characterizing the flow behavior of semi-solid metal materials having liquid fractions beyond 40 %. However, for lower fractions of liquid phase the Carreau model predicts an inaccurate flow behavior and thus incorrect die fillings. A common approach to adequately model the flow behavior of materials in the semi solid state below 40 % liquid fraction is to use FEM. Therefore, the flow behaviour of the semi-solid metal materials has to be characterized by specific flow curves. In order to obtain such, compression tests were performed in the semi-solid state applying different strain rates in the temperature range corresponding to 0 and 40 % liquid fraction by using the thermomechanical simulator Gleeble 3800c. Afterwards, a new material model for predicting the flow behaviour of aluminium alloys in the semi-solid state was developed on the basis of these flow curves. This empirical material model takes the effect of the liquid fraction as well as other essential factors such as the stress/strain relationship, strain rate and temperature level into account. The developed material model shows suitable prediction precision of the semi-solid flow behavior of aluminium alloys and was validated in this paper for the aluminium alloys AlSi7Mg0,3 and AlMgSi1.