Physical and Numerical Multi-Scale Modeling of Wire Drawing of Biocompatible Mg Alloys in Heated Dies Accounting for Recrystallization and Fracture

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ABSTRACT

The paper deals with a modeling of manufacturing process of wire of MgCa08 and AL36 alloys used as biocompatible soluble threads for medical applications [1]. A new manufacturing process of thin wires made of biocompatible Mg alloys, including drawing in heated dies, was developed by Authors [2]. In drawing process with heated die, wire is preheated in a furnace and then deformed. Drawing with recrystallization is the basic condition of the process. This allows for multi-pass drawing without intermediate annealing. The purpose of the paper was development of a two-scale mathematical model of recrystallization for biocompatible Mg alloys, its implementation into the finite element method (FEM) code, simulations of wire drawing and experimental verification of the model.

The first part of the work focused on the development of the FEM model of wire drawing process of Mg alloys in heated die. The fracture criterion was implemented into FEM code to eliminate the possibility of damage [3]. The goal of the second part of the work was development and calibration of recrystallization models. Since the final diameter of wire below 0.1 mm, which is comparable with grain size, accounting of the microstructure evolution in the model is essential for the accuracy of simulations. For this reason the problem was considered in the macro scale (by using JMAK model) and in the micro scale by using the frontal cellular automata (FCA) model. Simulation results confirmed usefulness of FCA-based and JMAK-based models for prediction of microstructure development and for selection of rational technological conditions of thin wire drawing of MgCa08 alloy. Recrystallization models were calibrated on the basis of flow curves and stress relaxation tests performed for the MgCa08 and AL36 alloys on physical simulator GLEEBLE 3800. The developed recrystallization model combined with the fracture model in one pass allowed to predict the fracture of the wire in a multi-pass process. Experimental wire drawing on drawing bench was the final stage of the work performed to validate the models.

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Acknowledgements: Financial assistance from the National Science Center of Poland, project no. 2012/05/B/ST8/01797 is acknowledged.