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MULTI SCALE MODELLING AND OPTIMIZATION OF PRODUCTION CHAINS BASED ON METAL FORMING

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ABSTRACT

The ever-changing global market is facing modern manufacturers into a state of continuous adaptation to meet new customer expectations. In metal forming the problem of obtaining required exploitation properties of products is crucial. Such parameters as eg. fatigue resistance, wear resistance and thermal resistance, but also environmental and recycling problems, are crucial for both increasing the safety by extending the life cycle of product and for meeting the environment protection requirements. On the other hand, the life cycle of products becomes shorter due to rise and fall of demand and to increasing demand for customized products. In order to meet such market pressures, modern manufacturing systems have to be intelligent and flexible, what can be achieved mainly by the feedback of information from the product to the manufacturing stage.

The impact of the product life cycle can be twofold. It can influence planning and organization of the production system, which has to become flexible, reconfigurable and cost efficient. The second aspect of the impact of the product life cycle, which is the topic of the present paper, is accounting for the product exploitation properties at the stage of the manufacturing technology design. Development of such an intelligent system, which uses optimization techniques with the objective function composed of required product properties, needs simulation models, which are capable of prediction of material microstructure and properties during manufacturing.

The preliminary version of the optimization strategy, which can be applied in such a system, was presented in Authors earlier publications [1]. That approach used conventional closed form equations describing microstructure evolution and materials properties, which were the essential part of the objective function. In the present approach the multi scale CAFE model, which combines finite elements with cellular automata, is applied to predict microstructure evolution. The basic principle of the CAFE model for dynamic recrystallization is presented in Figure 1 and the detailed description can be found in [2]. The capabilities of the CAFE model to predict not only the average microstructural parameters, but also distribution of those parameters in sampling points in the material, are presented in Figure 2. Implementation of the CAFE approach into the optimization technique allowed additional microstructural parameters, such as grain size distribution, to be included into the cost function. At the present stage

of research the multi stage process is represented by multi stage plane strain compression test. Product microstructure is optimized with respect to the test parameters, which are optimization variables. Demonstration of the role of the multi scale approach to modelling manufacturing chains is one of the objectives of the work. The correlation between the test parameters and the microstructure of the product is analyzed. Finally, the optimization problem, which in the future would be the base of intelligent manufacturing, is formulated.

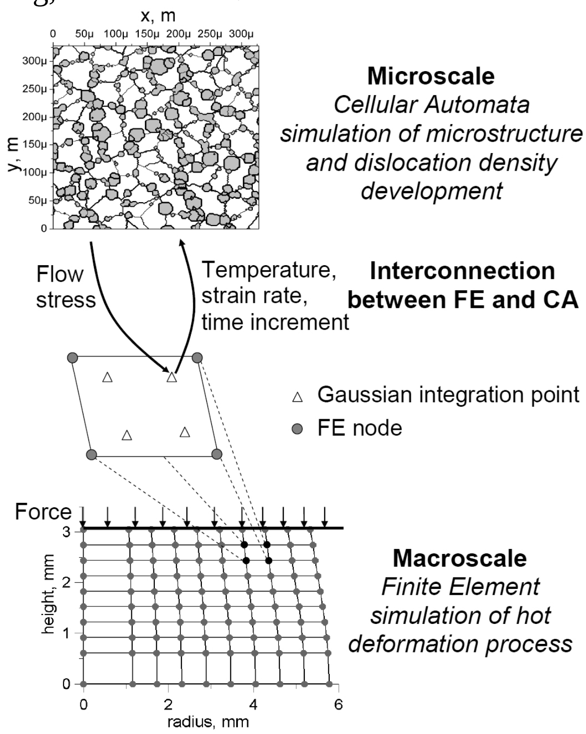

Figure 1. Idea of the CAFE model of hot forming process. Influence of dynamic recrystallization phenomenon on flow stress and evolution of microstructure is taken into account by micro-scale CA simulation. [2].

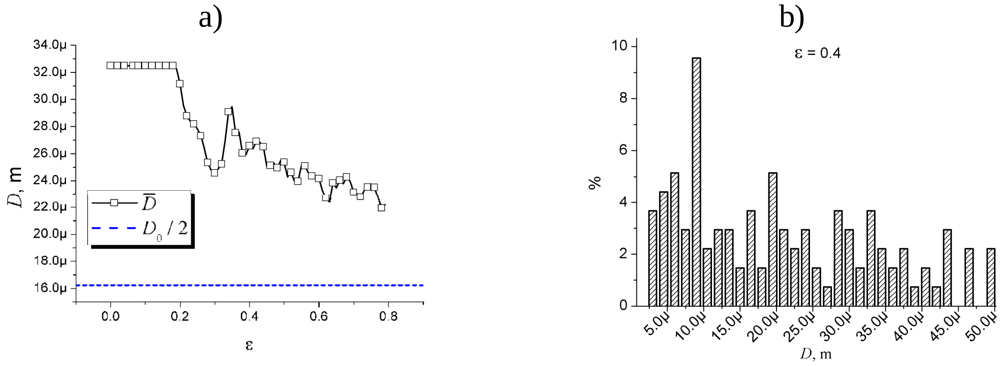

Figure 2. Influence of DRX on the microstructure predicted by the CAFE model: a) changes of the average grain size; b) grain size distribution at selected strain

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