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TOOL FOR MODELLING OF DEFORMATION MECHANISMS BASED ON DIGITAL REPRESENTATION OF MICROSTRUCTURE

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ABSTRACT

The computer simulation programs based on fundamental physics laws became more and more sophisticated and accurate in description of the material behaviour under deformation conditions. That contributes to the general knowledge about the microstuctural phenomena that occur during metal processing, e.g. hardening, recovery, and both dynamic and static recrystallization. However, to create the direct link between those phenomena and the macroscopic material behavior, the microstructure has to be taken into account during simulation in an explicit manner.

This work is part of the research focused on the creation of the complex modelling platform called Digital Material Representation (DMR) system [1]. The main objective of the DMR system is creation of the digital representation of microstructure with its features i.e. grains, grain orientations, inclusions, cracks, different phases etc. that are represented explicitly. The digital microstructure is used during numerical simulations based on the conventional Finite Element (FE) approach [2], as well as based on the alternative methods e.g. the multi scale Cellular Automata Finite Element (CAFE) approach [3]. The more precise the DMR is applied, the more realistic results of calculations regarding material behaviour are obtained. Thus, various methods of generation of the initial microstructure were investigated e.g. Voronoi tessellation, CA method, sphere growth algorithm or automatic image analysis methods [4]. The latter method was used in the proposition presented in this paper.

The main aim of this work is the fully automatic procedure of preparation of the initial microstructure for further numerical simulations. This is based on processing of the commonly used optical microscopy images that are easily accessible. The input images are analyzed with the dedicated algorithms before application of the numerical modelling methods. The first step of image processing is focused on data filtering to remove superimposed noise and detect borders between particular grains. In this case the following algorithms are applied: DP denoising procedure [5] and Canny Detector method [6]. Afterwards, the detected borders are filled and the grains area are separated from the input image (Fig. 1a,b).

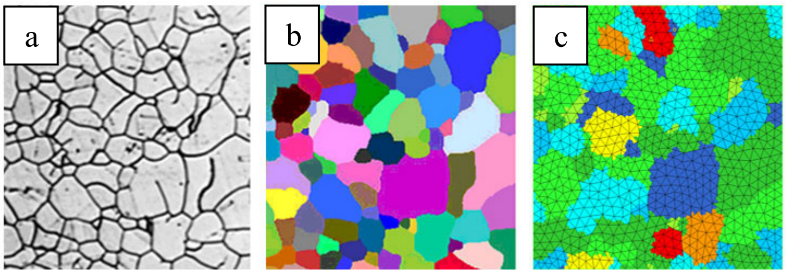

Fig. 1. Optical microscope results, after image processing and example of meshing.

These results are then imported into the FE Forge2 software and generation of the triangular mesh is performed (Fig. 1c). Particular groups of mesh nodes are located inside separated grains. The specific rheological model is assigned to each grain in Fig. 1b,c, what corresponds to the differences in the grain orientations. The simulations of the behavior and interactions of particular grains in the policrystaline aggregate were then performed. Sample was deformed in the plane strain channel die compression and the differences in distribution in the strain field were analysed (Fig. 2).

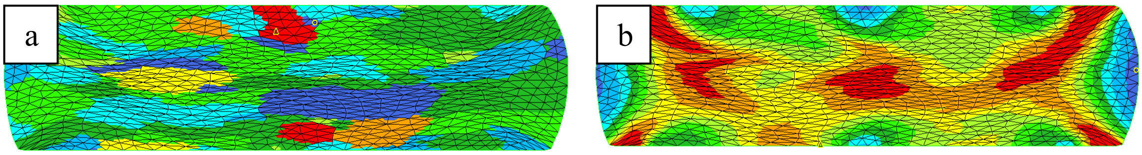

Fig. 2. Results of simulations – grains (a) and strain distribution (b).

This approach provide the flexible numerical tool, that can be helpful in the study on i.e. influence of inhomogeneous grains distribution, grain size or inclusions on the final sample shape and corresponding strain, stress or temperature distributions. Results of this work extend predictive capabilities of the DMR system and allow to simulate more precisely processes, where differences in microstructure play significant role, e.g. micro forming.

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