11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

DEVELOPMENT OF THE DIGITAL MATERIAL REPRESENTATION MODEL WITH TWIN BOUNDARIES

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Key Words: *Instructions, Multiphysics Problems, Applications, Computing Methods.*

The FE method is the main tool used in industry to simulate large scale forming processes and it gives good results. Plastometric tests at various deformation conditions (temperatures, strain rates, etc.) combined with an inverse analysis to eliminate various heterogeneities are usually performed to obtain accurate flow stress data necessary for the FE analysis. Since large scale problems containing bilions of grains are usually considered, the major assumtion of this approach is that behavior and interaction of particular grains is homogenized in the form of a single flow stress model [1]. This procedure is well established and widely used to improve and develop new manufacturing cycles composed of processes of rolling, forging, stamping, etc.

However, recently observed fast development of modern metallic materials (Advanced High Strength Steels, Aluminium, Magnesium, Titanium alloys etc. [2]) that are characterized by elevated material properties, which are the results of sophisticated microstructures with combination of e.g. large grains, small grains, inclusions, precipitates, twin, phases etc. is a challenge imposing significant changes to this commonly used approach.

New numerical methodologies are needed to meet this challenge and provide accurate description of material behavior also at the microstructure level. The Digital Material Representation (DMR), which is the subject of the present work, is one of the possible solutions. The main objective of the developed DMR system is to create the digital microstructure with its features (grains, sub grains, grain boundaries, etc.) presented explicitly. Authors previous research on development of digital material representation models of single phase polycrystalline metallic materials can be found in [3].

Present work focuses on extension of the capabilities of the digital material representation model developed in [3] with the possibility to generate polycrystalline microstructures including twin grain boundaries on the basis of the modified cellular automata grain growth model. Twin boundary occurs in the grain when two separate crystal lattices share series of the same lattice points in a symmetrical manner. Microstructure generation tool capable of obtaining features within subsequent grains that represent annealing and deformation twins is in detail presented within the paper. Procedure of assigning properties, mesh generation and finally example of numerical simulation of deformation process on the basis of the developed DMR model are also demonstrated. Example of such digital model obtained with the developed methodology is presented in Figure 1.

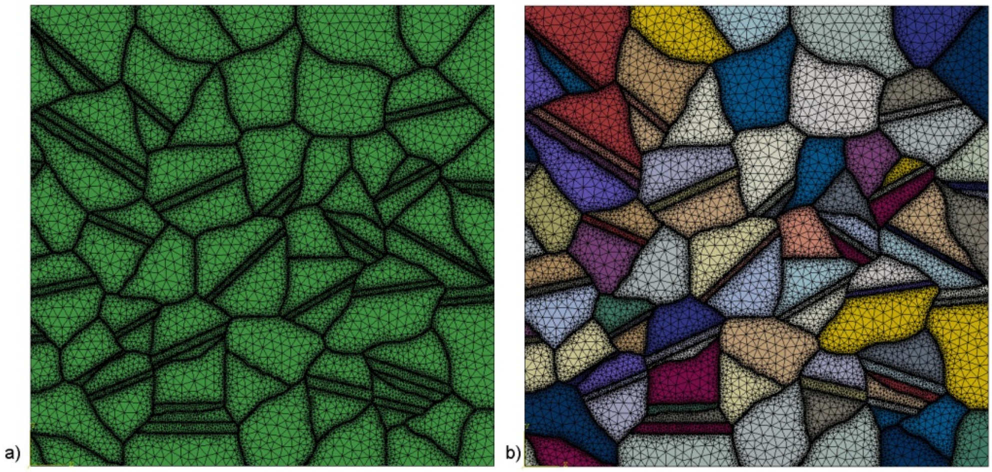

Figure 1. Example of digital material representation model with annealing twin features.

As a result proposed model gives the possibility to explicitly model influence of twin boundaries on material behaviour and its inhomogenities at the microstructure level. Numerical modelling will be realized on the basis of the crystal plasticity finite element approach. Additionally developed DMR can be used as a part of the multi scale model that can provide information on global and local material behavior.

Acknowledgment. Financial support of the NCBiR, project no. PBS1/A5/0/2012, is acknowledged.

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