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On Thermo-Mechanical Processing Interpretation by Introducing Microstructure Dependent Local Behavior.

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Abstract – Thermo-mechanical processing is analyzed by dealing with a few case studies and addressing the current capabilities of introducing microstructure features during their large scale modeling. The main goal of the current research program is the design of economic ways of abstracting complex microstructural data and microstructure development processes to be introduced on simulation models. We explore phase transformations and variant selection together with hardening mechanisms and development of dislocation arrays. They are alternatively applied to model materials under simple deformation paths and also to technological problems like deep drawing of low carbon steels.

Complex processing technologies are applied to man made materials to achieve desired material properties. Either new high technology materials or old industrial materials are known to be ruled by same physical principles. Their processing share the common characteristics of embracing many steps, usually spanning through different temperatures, phase transformations, deformation paths, etc.. Simultaneously, they show microscopic and macroscopic characteristics stemming from the very same concatenated application of those processes. Understanding of the complex interaction between different processes and dimensional levels is intended by applying multi-scale and whole-through-processing modeling. One of the gaps to be bridged on the current understanding of materials processes is the one going from the mesoscopic scale to the atomic scale. Dislocation Dynamics and first principle or ab-initio models are the state of the art in modeling techniques. However they are still difficult to introduce, either by their computational costs or some lack of understanding. In the current presentation we will show a few case studies and modeling tactics aiming to introduce microstructure information and recover microstructural data from computational modeling of material processing [1-3].

We will present two case studies: a) one dealing with the understanding of grain fragmentation on deformation of FCC materials and b) the other on the application of different micromechanical deformation models, phase transformation and recystallization computer codes to simulate the whole through processing of low carbon deep drawing steels (LCS). In fact, the second case will take advantage of the many developments and improvements already introduced in micromechanical self consistent models.

The first case study will show the possibility of introducing GNDA like defects (Geometrically Necessary Dislocation Arrays) by using only velocity gradient continuity equations among neighboring grains. The misorientation angles among the created fragments show a distribution function in quite good agreement with experiments. By using a proper physically based anisotropic hardening law the dislocations can be classified in different sets alternatively originating different dislocation arrays: Taylor arrays, Incidental Dislocation Boundaries (IDB) and GNDBs.

The second case study explores the concatenated application of that microstructure development simulation and phase transformation and recrystallization codes to the problem of production of LCS. The stored energies, due to the particular hardening laws introduced in the model, are used with the purpose of variant selection during the phase transformation process. Further steps use the calculated misorientations, after the low temperature deformation, as a measure of grain boundary mobility during recrystallization, together with the stored energy as a driving force for nucleation.

In both cases the results are compared with experimental data showing a quite good agreement. We discuss on the advantages of introducing micromechanical calculus vs. ad-hoc microstructure development hypothesis.

References

[1] M.P. Butrón-Guillén, C.S. Da Costa Viana, J.J. Jonas, Metall. and Mat. Trans. A, 28A (1997) 1755-1768.
[2] A. Roatta, A. L. Fourty and R. E. Bolmaro. Metall. Mat. Trans. A, 40, 5 (2009) 1210-1218.
[3] A. Fourty, J.W. Signorelli and R.E. Bolmaro. Ceramic Transactions. 201(2009) 735-744.