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Micromechanical Simulation Approach of Dual Phase Steel Artificial Microstructure Using Random Field Model

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Abstract. In this study, a random field (RF) model with a Gaussian kernel was applied to generate an artificial microstructure of dual phase (DP) steels. Micrographs obtained from Scanning Electron Microscopy (SEM) were analyzed using image processing software to extract the grain size and the volume fraction of each phase. Based on watershed (Ws) segmentation and quantitative analysis, the real and artificial microstructures were compared by analyzing grain features related the solidity, grain size and aspect ratio (the proportional relationship between its width and its height). Consequently, this approach allows to simulate the overall stress-strain behavior of the analyzed microstructures. As a result, it was shown that the strain localization starts to develop at the ferrite/martensite interface and that the RF model could replicate the micromechanical behavior of DP steels.

Introduction

DP steels are frequently used for large parts of automotive industry, because they are characterized by high mechanical properties such as UTS (Ultimate Tensile Strength), low YS (Yielding Strength), a homogenous macroscopic plastic flow, low density and low manufacturing cost. These significant features provide the high performance of advanced high strength steel (AHSS) in service [1]. Furthermore, the distinguished microstructure in these alloys plays a fundamental role in enhancing their performances. This is because it depends strongly on the soft and continuous ferritic matrix which may interact by a hard-martensitic phase, dispersed as islands shapes. As a result of the high ductility of the ferrite and the high strength of martensite [2], the overall behavior of the microstructure is controlled by phase fraction as well as morphology of the martensite islands that can be described by stereological parameters (such as size and aspect ratio), and mainly by the carbon content [3–4].

Accordingly, the last decade has seen a tremendous interest in enhancing the mechanical properties of DP steels using micromechanical simulations of Representative Volume Element (RVE). Sun *et al* [5] concluded the application a local plasticity theory on RVEs that were generated from real SEM micrographs, the failure was a result plastic strain localization rather than MVC (Micro Void Coalescence).

The challenge in modeling the different effects of the microstructure parameters is generating a model that could replicate the real microstructure with controllable parameters. For this purpose, there are mainly two approaches: (1) the first is to use real SEM/EBSD (Electron Backscatter Diffraction) data to generate a CAD (Computer Aided Design) model; (2) the second approach is to use existing models to generate artificial microstructures that mimics the real ones. There are many of these models for this purpose, checkerboard, circles and Voronoi tessellation, which takes into consideration several parameters such as volume fraction and grain size, one model that hasn't yet been discussed for this application is the random field model (RF) [6].