Comparison of different polycrystalline unitcells for the description of macroscopic yield curves

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ABSTRACT

In modern engineering applications, high-tech steel play an important role due to their enhanced material properties, such as high strength and good formability. These material properties originate in the microstructural composition of the material. In the case of dual-phase (DP) steel, the microstructure consists of two phases, martensitic inclusions in a ferritic matrix material. Focusing on each of these consitutents, a polycrystalline microstructure governed by the inner- and inter-granular mechanisms [1] is observed which needs to be accounted for a realistic description of the material. Generally, the overall material behavior can be described using homogenization techniques, where the FE²-method has been shown to be a suitable tool, see e.g. [2], [3]. Therein, a microscopic boundary value problem (bvp) is used to describe the behavior of the microstructure at every Gauss point of a macroscopic bvp instead of using a phenomenological material model. This circumvents the need for sophisticated macroscopic material descriptions which takes into account various microstructural features in order to resemble the microstructural behavior appropriately. Due to the modeling of the microscopic material behavior directly based on the microstructure, the FE²-method can also locate effects on the microscale, such as areas of high stress, which are known to be points of failure initiation. Despite these benefits, the computational effort needed increases drastically, when complex macroscopic bvps are considered and realistic descriptions of microstructure morphologies are used. The use of statistically similar RVEs has been shown to be a suitable tool to lower the computational effort, see [4].

We focus on a rate dependent single crystal plasticity model, [5], [6], for a detailed description of the polycrystalline structure of the DP steel phases. It will be used here to describe polycrystals in the framework of the FE²-method. Periodic polycrystalline unitcells will be compared regarding their behavior in biaxial tension tests in order to construct macroscopic yield curves, cp. [7]. Several numerical examples will be presented for fcc and bcc unitcells.

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