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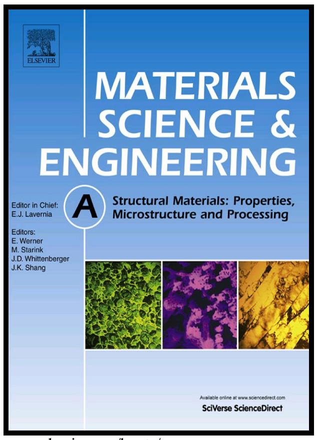

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Micromechanics-based modeling of stress–strain and fracture behavior of heat-treated boron steels for hot stamping process

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Abstract

In the automotive industry, hot stamped parts with tailored properties have shown advantageous safety performance. Such components are produced by applying different heat treatment conditions after forming for different zones in order to obtain various combinations of hard and soft microstructures. In this work, pure martensitic, pure bainitic, and three martensitic/bainitic phase microstructures were initially generated from the boron steel grade 22MnB5 by a two-step quenching procedure in which different holding times in the bainitic temperature range were varied. Increased phase fraction of bainite due to longer holding time led to decreased yield and tensile strength; however, elongation and resulting energy absorbability became significantly higher. To describe mechanical properties and failure behavior of hot stamped parts containing multiphase microstructures, influences of microstructure characteristics should be considered on the micro-scale. Using modeling, 2-D representative volume elements (RVE) were generated from observed real microstructures and flow curves of the individual single phases were defined, taking into account a dislocation theory based model and local chemical compositions. Then, effective stress–strain curves of the heat-treated boron steels were calculated by using the isostrain and non-isostrain methods and compared with tensile test results. Regarding fracture behavior, damage curves of fully martensitic and bainitic structures were determined by means of tensile tests of different notched samples and a