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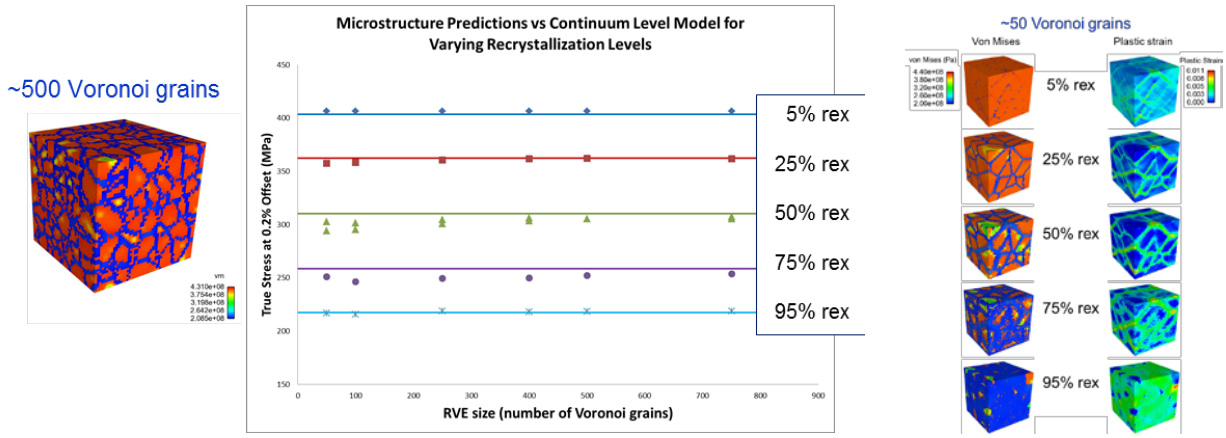
Homogenization of Partially Recrystallized Microstructures

Contributed by Arthur Brown (aabrown@sandia.gov), Stephanie Pitts (WSU), John Emery (Sandia), and Joe Bishop (Sandia)

A continuum-level material model for recrystallization, BCJ_MEM, is currently used to predict the response of steel during forging and welding processes for gas transfer system (GTS) components. The model tracks the evolution of recrystallized and unrecrystallized volume fractions, and uses a volume averaging assumption to predict the homogenized strength. As part of the Predicting Performance Margins (PPM) project, we asked whether the homogenization approach is sufficiently accurate by explicitly modeling realistic partially recrystallized microstructures in finite element. A method of creating meshes with the "necklace" structure typical of recrystallization initiation in 304L stainless steel was first developed, and the responses of the partially recrystallized microstructures were modeled with Sierra/SM. Representative volume elements of varying sizes were used to homogenize the response of polycrystalline structures with differing values for the fraction of recrystallized material. This direct comparison verified the continuum mechanics assumption by comparing material response at different lengthscales. The results provide confidence in the volume averaging assumption of the continuum-level model and in the application of the model for partially recrystallized microstructures that can exist in the heat-affected zones of GTS welds. PPM is jointly funded by ASC PEM, RTBF, and ESC



The figures show the von Mises stress and equivalent plastic strain in meshes with varying levels of recrystallization. In the plot, the lines represent the continuum-level model, whereas the symbols are homogenized responses from individual simulations of different microstructures.

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