On the control of microstructural degrees of freedom in deformation processes [1]

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ABSTRACT

The high cost of manufacturing critical components can be greatly reduced with the development of mathematically and physically sound computational methodologies for multi-scale process design and control. We present our recent developments in expanding the design space in forming processes by including microstructural degrees of freedom as a design variable in addition to macro-constraints in forming. We have developed a multi-length scale continuum sensitivity method for thermo-elasto-visco-plasticity combined with microstructure evolution in polycrystalline materials. In particular, sensitivities of fields dependent on microstructural degrees of freedom are exactly defined and an averaging principle (linking hypothesis) is developed to compute sensitivity fields at the macroscopic level. These computed sensitivities are used within a gradient-based optimization framework for the computational design of metal forming processes for polycrystalline materials. The effectiveness of the developed design techniques are demonstrated with examples involving control of distribution of elastic and plastic properties in the final product by tailoring the final microstructures.

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