# A microstructure-based model for describing the material properties of Al–Zn alloys during high pressure torsion

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Several techniques of severe plastic deformation (SPD) have been developed to improve the mechanical properties of metals. Among these techniques, HPT (Fig.1) is especially effective to introduce extremely large strains on materials leading to exceptional grain refinement. In the present work, the material properties of the super saturated solid solution Al–30wt%Zn alloy deformed under HPT have been studied. It has been determined that HPT leads to a strong softening process at the initial stage of plastic deformation (Fig.2). To explain observed material behavior, the microstructural evolution during plastic deformation has been experimentally studied. It has shown that the fundamental phenomena of the process are solid solution decomposition, Orowan looping and dislocation density evolution. The material properties are dictated at the beginning of plastic deformation by the decomposition of supersaturated solid solution and after saturation strain by saturation grain size. Such a material behavior is captured by a new model called MBWG that is based on strain induced diffusivity of Zn in Al grains and the evolution of the dislocation mean free path with plastic strain. The model considers the material properties to be determined by the gradual increase in the mean free path of dislocations resulting from precipitation and diffusion of Zn atoms towards the grain boundaries. The calculated results by MBWG model present a good agreement with experiment. This model shows the capability to describe both the softening and saturation processes. The calculated shear stress evolution is mostly contributed by the solid solution shear stress. This suggests that the decomposition of super saturated solid solution plays the dominated role in the material properties of Al–30wt%Zn alloy. The MBWG model allows evaluate the contribution of the different strengthening mechanisms during the deformation and it can be adapted to other softening processes during plastic deformation.

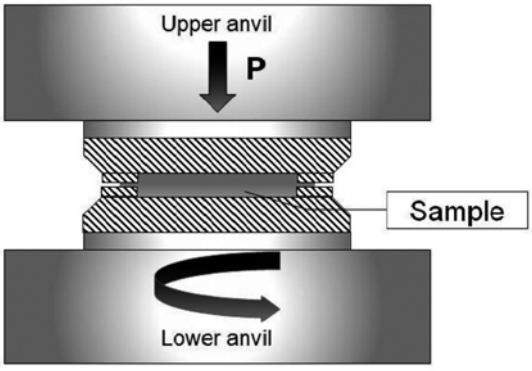


**FIGURE 1**
Schematic illustration of quasi-constrained HPT setup.

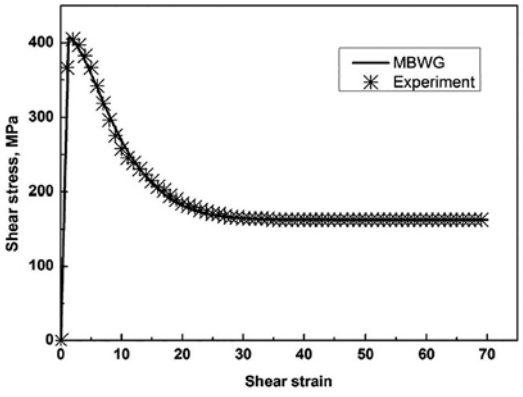


**FIGURE 2**
Comparison between the predicted and experimental shear strain-shear stress curves.