Residual Effects of Ultrasonic-assisted Compression Testing on Pure Copper

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Abstract. Due to the rising demand for miniaturization micro and meso forming processes become more and more important. Scaling down in workpiece geometries facilitates product usage, enables an increased function integrity as well as weight and volume reduction. However, stress concentration due to small contact zones between tool and workpiece is a major challenge that leads to severe tool loads. One approach to reduce the process forces considerably is superimposing the tool movement with ultrasonic vibration. Although the immediate occurring force and mean stress reduction were first discovered in 1955 by Langenecker and Blaha and are known phenomena, underlying effects of ultrasonic-based material softening remain object of current research. Prominent theories explaining the acoustic softening are stress superposition as well as surface and volume effects. By carrying out ultrasonic-assisted compression tests with 20 kHz oscillation frequency on pure copper this study intends to determine permanently altered material characteristics. Therefore compression testing with varying oscillation interval as well as amplitude is conducted and force-displacement-curves are analyzed. In comparison with conventional upsetting, impact on strain hardening due to the unique presence of ultrasonic-assistance is identified and correlated with the aforementioned process parameters. Moreover, metallographic analyses support former findings. The examination of lattice deformation as well as grain refinement enables a conclusion regarding strain hardening. In this way, temporary process-related and permanent material-induced effects are separated.