On the measurement of yield strength by spherical indentation

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Abstract

Over the past 10 years, a number of investigators have proposed methods to measure the yield strength of metals using instrumented indentation experiments performed with a sphere [1-4]. Most of these proposed methods have yet to be rigorously verified experimentally. The objective of this work is to contribute to the experimental verification by testing four contemporary models against their ability to accurately determine the yield strength of the aluminum alloy 6061-T6. The four models selected for this review are those of Ma et al., Cao and Lu, Yu and Blanchard, and Field and Swain [1-4]. The tensile and indentation samples were taken from the same 3.175 mm thick sheet and the surface of the indentation sample was given the best possible mechanical polish. The indentation experiments were performed using a 90 degree diamond cone with a mechanically polished radius of 385 nm. The procedures proposed by Ma et al., and Cao and Lu were inconsistent with the experimental observations and could not be implemented. Yu and Blanchard's model overestimated the yield strength by approximately 55%. Field and Swain's procedure overestimated the tensile flow curve by roughly 40% which precluded obtaining a meaningful estimate of the yield strength. Among the most likely explanations for these surprisingly poor results are the effects of roughness and contaminants on the surface and an indentation size effect.