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Microstructure and strength of graded structures produced by shot peening

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Fengxiang Lin, Yubin Zhang, Wolfgang Pantleon, Dorte Juul Jensen, Supercube grains leading to a strong recrystallized cube texture (17')

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13:30 – 15:15	Session 6, Applications – chaired by Niels Hansen and Qing Liu

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Xiaodan Zhang, Niels Hansen, Yukui Gao, Xiaoxu Huang, Microstructure and strength of graded structures produced by shot peening (30')

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15:15 – 15:30	Closing – by Ke Lu
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Microstructure and strength of graded structures produced by shot peening

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The structure and strength of low carbon steel samples have been analyzed after plastic deformation by shot-peening and cold-rolling. The fine scale surface microstructure caused by shot-peening extends to ~50 µm below the surface. The structure is graded and subdivided by dislocation boundaries and high angle boundaries showing a clear resemblance to the lamellar structure, which evolves during conventional rolling of bulk metallic materials from medium to high strain. As the surface is approached, the boundary spacing decreases to ~50 nm at the surface. In parallel, the misorientation angle across boundaries increases to ~65% of high angle boundaries. The cold-rolled steel shows a low hardening rate at high strain and by assuming additive strength contributions from Hall–Petch and dislocation strengthening, the flow stress has been expressed by the relationship $\sigma - \sigma_0 = k_2 D_{av}^{-0.5}$, where D_{av} is the average spacing between the low and high angle boundaries which subdivide the microstructure, σ_0 is the friction stress and k_2 is a number which is expressed in terms of structural parameters which have been determined by electron backscattered diffraction. It is found that calculated k_2 values are in accord with an experimental value of 310 MPa $\mu m^{0.5}$. In the shot-peened steel the increase in D_{av} with increasing distance from the surface is transformed into a stress profile based on the σ - D_{av} relationship established for cold-rolled bulk samples. The calculated stress profile is validated by comparison with the experimental profile based on hardness measurements, and good agreement is found. This result points to a wider application of the suggested method to derive the local flow stress in a deformed microstructure based on a measurement of the local boundary spacing and the stress–structure relationship for the bulk material in the deformed state.

Reference:

[1] Hall–Petch and dislocation strengthening in graded nanostructured steel. Xiaodan Zhang, Niels Hansen, Yukui Gao, Xiaoxu Huang. Acta Materialia 2012; 60: 5933-5943.