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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')

Zhenbo Zhang, Dorte Juul Jensen, Yubin Zhang, Oleg Mishin, Nairong Tao, Wolfgang Pantleon, On the orientation dependent recrystallization in a nanostructured modified 9Cr-1Mo steel (17')

Dorte Juul Jensen, Conclusion (10')

12:30 – 13:30 Lunch

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

Qing Liu, Introduction (5')

Krishnendu Mukherjee, Søren Fæster, Study of fatigue fracture of ductile cast iron (15')

Renlong Xin, Dejie Liu, Bo Li, Zheng Zhou, Qing Liu, Inhomogeneous deformation and failure of friction-stir-processed magnesium alloys (20')

Yan Chong, Andy Godfrey, Wei Liu, Zhengdong Liu, The application of grain boundary engineering in a Ni-base superalloy Inconel 740H (20')

Søren Fæster Nielsen, Microstructural investigation of HH rails (10')

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

Niels Hansen, Conclusion (5')

15:15 – 15:30 Closing – by Ke Lu

18:00 – 20:00 Dinner

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 $\sim 50 \mu\text{m}$ 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 $\sim 50 \text{ nm}$ at the surface. In parallel, the misorientation angle across boundaries increases to $\sim 65\%$ 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 $310 \text{ MPa } \mu\text{m}^{0.5}$. 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 $\sigma - D_{av}$ 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.