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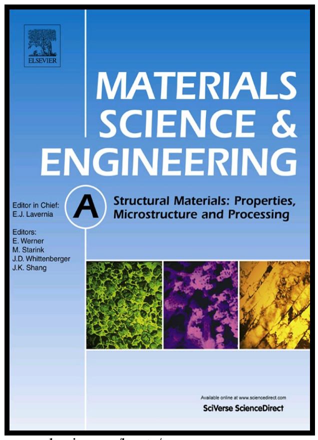

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Multiple strengthening sources and adiabatic shear banding during high strain-rate deformation of AISI 321 austenitic stainless steel: effects of grain size and strain rate

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Abstract

The dynamic impact response of AISI 321 steel at strain rate of 4000, 5500, 6500 and 7500 s^{-1} was investigated using the split Hopkinson pressure bar system. The alloy samples processed to have grain size of 0.24, 3, 13 and 34 μm were studied. While the yield strength and hardness increases with decrease in grain size, strain hardening rate is comparable for all grain sizes. Microstructural evaluation of the impacted specimens using high-resolution electron backscattered diffraction (HR-EBSD) technique showed grain boundary strengthening, deformation twinning, deformation-induced martensitic transformation, dislocation multiplication during slip and precipitation of carbides that act as barriers to dislocation motion as additional source of strengthening. Slip and twinning were the dominant deformation mechanisms observed in the steel. Twinning, dislocation multiplication during slip and carbide precipitation contributed more strongly to strain-hardening in coarse-grained (CG) specimen while stain-induced martensite and grain boundary strengthening are the most beneficial to strengthening in the ultra-fine-grained (UFG) specimens. The temperature rise in the specimens during impact increases with strain rate. This slowed the kinetics of twinning, phase transformation and dislocation interaction especially in CG structure. Both XRD and HR-EBSD texture results confirmed the development of {110}||CD (CD: compression direction) texture in the austenite phase at the expense of {100}||CD and {111}||CD fibres. Thermomechanical instability leading to the formation of adiabatic shear band (ASB) occurred in the test specimens as they deformed at high strain rates. While the amount of deformation twinning and α′-martensite decreases towards the ASB, only the carbides and small fraction of α′-martensite are observed inside the ASB. Grain refinement via rotational dynamic recrystallization occurred within the ASB. The extent of grain refinement increased with increase in initial grain size of the test specimen.

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