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THE EFFECT OF GRAIN SIZE ON THE SHOCK-HARDENING RESPONSE OF TYPE 304 STAINLESS STEEL

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If one assumes that a plastic shock wave produces - upon traversing a metal - a high density of defects that are homogeneously distributed and that the shock front is planar, then one would expect similar responses from a same metal with different initial grain sizes. In order to verify this hypothesis a series of shock-loading experiments were conducted with AISI 304 stainless steel; the residual mechanical properties and structure were analysed.

Sheet samples of 3.2 mm thickness were annealed (and subsequently quenched in order to prevent sensitization) to produce a large variation of grain size consistent with specimen dimensions; the average grain diameters, as measured by the linear intercept method, were 23, 55, 85 and 187 μm.

Shock loading was conducted by the flyer-plate method, producing a normally incident plane wave. The specimens were protected by a cover plate (having, in each case, the same grain size), side bars, anvil and spall plate. The explosive (Pentolite) was detonated by a plane-wave generator. Further details are given elsewhere (1,2). The calculated peak pressure at the sample was 10 GPa (100 Kbar) and the pulse duration 2 μsec. Cold-rolled material was compared to shock-loaded one on the basis of equal maximum shear strains (3). The 10 GPa pressure corresponded to 5.2 pct. reduction in thickness.

The results of the tensile tests conducted at room temperature are shown in the Table. It can be

Table - 1% Offset Stresses for Different Conditions

Grain Size (μm)	1% Offset Stresses (kg/mm^2)		
	Undeformed	Rolled	Shocked
23	22.9	40.6	48.0
55	26.6	41.1	54.2
85	27.3	41.0	57.5
187	31.3	45.2	64.1

clearly seen that the efficiency of shock loading decreased as the grain size increased. This is in contrast with cold rolling, which resulted in similar yield point increasis for the four grain sizes. While the results for the undeformed and cold-rolled conditions conform to a Hall-Petch plot, such is not the case for the shocked ones.

The microstructure of the shocked conditions was characterized by mechanical twinning and planar dislocation arrays, as well as α and ε martensite. Incidentally, the occurrence of ε martensite was not homogeneous throughout the sample section (4). In conjuction with the variation in mechanical response, the amounts of ε and α martensite increased with decreasing grain size.

It can be concluded that the shock wave produces different effects for different grain sizes. A detailled version of this investigation is being submitted elsewhere (5). This work is supported by the I.M.E. Materials Research Center.

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