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INHOMOGENEITIES OF TRANSFORMATION IN SHOCK-LOADED TYPE 304 STAINLESS STEEL

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There is a certain disagreement regarding the structures of shock-loaded stainless steels(1,2). Some authors report the occurrence α or α and ε martensites, while others did not find these transformations, simply reporting deformation twins.

It is the purpose of this note to show that the geometry of the shocked samples might be important in determining the residual structure. A sheet sample (3.2 mm thickness) of 304 stainless steel was shocked to a pressure of 10 GPa and pulse duration of 2 μsec by explosive means. The system dimensions were calculated according to Orava and Wittman(3). The experimental details are provided elsewhere(4). A protective cover plate of the same alloy having the same thickness was used. Both the sample and cover plates had a mean grain diameter of 23 μm (as determined by the linear intercept method).

The presence of martensite was monitored in a diffractometer, using a Mo tube operated at 40 KV and 20 mA and a zinc filter. Diffraction traces were made at four positions: lower surface and interior of cover plate, and upper surface and interior of sample plate. For the traces of the plate interiors, cuts were made parallel to the outer surfaces by spark erosion. The inside surfaces were subsequently spark planed and electrolytically polished. Both α and ε martensite were detected in the plates. In order to ascertain that the sample preparation did not induce phase transformation, an undeformed sample was prepared by the same technique. Transmission electron microscopy (4) confirmed the presence of α and ε martensite in addition to deformation twins. Figs. 1 and 2 show portions of the diffractometer traces for the sample and cover plates, respectively; Figs. 1(a) and 2(a) refer to the surfaces while Figs. 1(b) and 2(b) are traces of the interior. The peaks at around 20° and 23° are the austenite (110) and (200) reflections, respectively. The peak at around 21.5° is the (10.1) reflection from the ε phase. It is clearly evident that ε occurs preferentially at the interior of the cover and sample plates.

Among the possible reasons for preferential ε martensite formation at regions away from the surface, the most noteworthy are:

a) Temperature deposition effect. Urtiew and Grover(5,6) show that significant temperature rises can occur at interfaces between two materials, due to the presence of gaps. If the temperature rise at the cover plate-sample plate interface is much higher than the one predicted by the adiabatic compression and isentropic release(7) and characteristic of the bulk metal, then one could expect a different residual structure.

b) Relaxation of the stress conditions. The stress system imposed by the

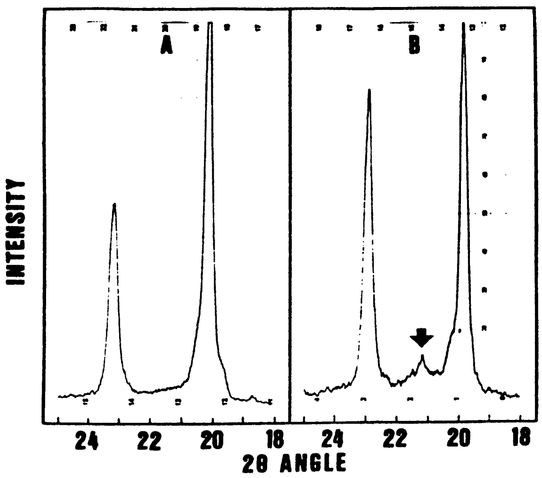

FIG. 1

Diffractograms of sample plate; (a) upper surface of plate; (b) interior of plate evidencing (10.1) reflection of ε martensite.

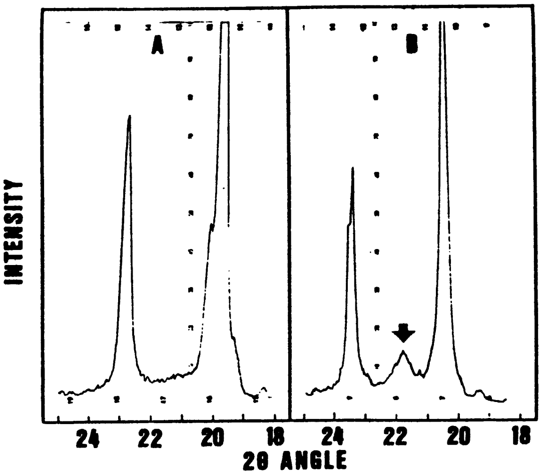

FIG. 2

Diffractograms of cover plate; (a) lower surface of plate; (b) interior of plate evidencing (10.1) reflection of ε martensite.

shock wave is necessarily relaxed at the surface of the cover and sample plates. The stress component perpendicular to a free surface is zero, independent of the other components. And martensite nucleation is strongly dependent upon the stress system.

In summary, it was shown that ε martensite nucleation is less likely to occur at the surface than in the bulk of 304 stainless steel sheets; this inhomogeneity of transformation might partially explain some of the contradictory results reported in the literature (1,2).

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