Notes on the Plastic Critical Temperature In Strain-Induced Martensite Reactions

by C. Dean Starr

IT is well known that the martensite reaction can be induced to occur isothermally above the M_s temperature by plastic deformation of an alloy in its austenitic state, and also that as the test temperature is increased above the M_s temperature, plastic deformation under a given set of conditions merely causes additional slip with a corresponding tendency toward the formation of less martensite per unit of strain. Thus it appears that a maximum temperature exists above which martensite cannot be formed isothermally by plastic deformation. This temperature is commonly designated as the equilibrium temperature T_E .

Attempts to determine experimentally the equilibrium temperature have indicated that a critical temperature is observed, under a given set of conditions, above which martensite cannot be formed isothermally by plastic deformation. But the observation of a "so called" critical temperature, T_D , should not be confused with the equilibrium temperature, T_E .

In order to clarify this anomaly, true stress-strain curves were obtained for a series of type 304 stainless steel specimens (manufacturer's analysis, 0.08 pct C, 18 to 20 pct Cr, 8 to 10 pct Ni, balance Fe) over the temperature range 67° to 300°K.¹ Since martensite is magnetic, a quantitative measure of the amount of martensite that was produced by plastic deformation was obtained by determining the magnetic permeability as a function of strain. The results of these tests are given in Fig. 1. They appear to indicate that a plastic critical point does exist at about 240°K for the stainless steel under investigation here. But that 240°K is not the equilibrium temperature nor even a true plastic critical temperature can be seen from Fig. 2 wherein the permeability of the same material is shown to increase with cold rolling at 293°K.

Consequently the observation of a "so called" plastic critical temperature is dependent on the mode of deformation and has no theoretical significance.

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Fig. 1—An apparent plastic critical point as determined by simple tension testing.

Fig. 2—Formation of martensite during cold rolling of 18-8 stainless steel at 293°K.

¹ C. Dean Starr, M. Reporter, J. E. Dorn: Investigations on the Mechanism of the Strain Induced Martensitic Reaction in 18-8 Stainless Steel. Univ. Calif. Inst. of Engineering Report, Series No. 22, Issue No. 15, June 1951.