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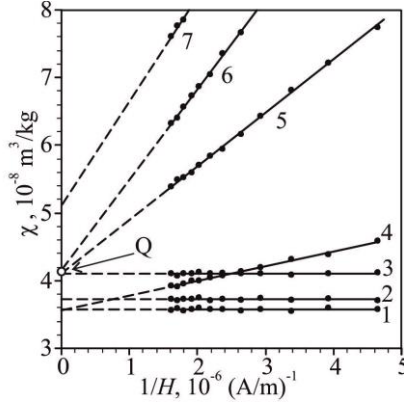
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THERMODYNAMIC ASPECTS OF FORMATION MARTENSITE PHASES AT DEFORMATION OF AUSTENITIC STEELS

In austenitic steels during deformation is possible to the formation of two types of martensitic phases (ε and α'). Austenitic steel X10CrNi1613 before uniaxial compressive plastic deformation were completely austenized, and the initial value of the paramagnetic susceptibility χ was $3.58 \cdot 10^{-8}$ m³/kg (Fig. 1, line 1). Further deformation (lines 2 and 3) led to an increase the paramagnetic susceptibility χ to value $4.11 \cdot 10^{-8}$ m³/kg. With further increase deformation of austenite appears slope of the lines $\chi(1/H)$ (lines 4...7). This indicates the occurrence of ferromagnetic α' -martensite. The value χ in this case depends on the total quantity of phases present in the steel (austenite and martensite). Since the line 5 coincides with the start point of the highest horizontal line that allows you to find the starting point of reference for the ever-increasing number of α' -phase (with increasing deformation).



Deformation: 1 – 0; 2 – 8.9; 3 – 22.7; 4 – 29.3; 5 – 44.2; 6 – 50.5; 7 – 54.7 %.

Figure 1 – Dependence of $\chi(1/H)$ for various values of deformation by uniaxial compression samples steel X10CrNi1613.

Fe-Cr-Ni system is a phase mixture of austenite and α' -martensite, then because of the coincidence of lines at the point Q (see Fig. 1) have the expression:

$$\frac{\chi_{\alpha'+\gamma}}{\chi_{\gamma}} = \frac{\chi_{\alpha'} + \chi_{\gamma}}{\chi_{\gamma}} = 1, \quad (1)$$

Martensitic phase is absent at $\chi_{\alpha'} = 0$. This result also follows from thermodynamics. The point Q there is a phase equilibrium between the martensite and austenite and their partial chemical potentials equal. The point Q corresponds to the equality $dG_{\alpha'} = dG_{\gamma}$. The α' -phases can be found from the relations:

$$dG = dG_{\alpha'} + dG_{\gamma} = 0, \quad (2)$$

$$\begin{aligned} (-M_{\alpha'} + M_{\gamma})dH \Big|_{T,P=\text{const}} &= 0 \Rightarrow \\ -[\chi_{\gamma} + (\chi_{\alpha'} + \chi_{\gamma})] \cdot dH &= 0 \quad \text{and} \quad \chi_{\alpha'} \cdot dH = 0. \end{aligned} \quad (3)$$

In this case $\chi_{\alpha'} = 0$ indicating the absence of α' -martensite. Considering the coincidence of the numerical values corresponding to the Q point (Fig. 1), the ratio proposed below makes it possible to detect small amounts of martensite, which is formed when pressure change.

$$\chi' = \frac{\chi_{\Sigma}}{\chi_{\alpha'}} = \frac{V_{\alpha'} \cdot J_{\alpha'} + V_{\gamma} \cdot J_{\gamma}}{V_{\alpha'} \cdot J_{\alpha'}} = 1 + \frac{V_{\gamma}}{V_{\alpha'}} \cdot \frac{J_{\gamma}}{J_{\alpha'}}, \quad (4)$$

where $J_{\alpha'(\gamma)}$ and $V_{\alpha'(\gamma)}$ – the specific phases of the magnetization and the volume of the alloy phases, respectively.

Let $\frac{J_{\gamma}}{J_{\alpha'}} = m$ and $V_{\alpha} \ll V$, then from (4) obtain the relation

$$\frac{V_{\alpha'}}{V - V_{\alpha'}} = \frac{m}{\chi' - 1} \cong \frac{V_{\gamma}}{V}, \quad (5)$$

It follows from (4) that as $\chi_{\alpha'}$ increases, value χ' decreases $\frac{J_{\gamma}}{J_{\alpha'}} \cdot \frac{1}{\chi' - 1} = \frac{V_{\alpha}}{V - V_{\alpha'}} \cong \frac{V_{\alpha'}}{V_{\gamma}}$. Then, on the basis $\chi' > 1$ and $V_{\gamma} \gg V_{\alpha'}$, with decreasing value $(\chi' - 1) < 1$ increases $\frac{V_{\alpha'}}{V - V_{\alpha'}}$, and provided small quantity V_{γ} of α -phase approaches the total phase volume.