V. D. Sadovskiĭ. *Structural heredity in steel.* Small-crystal (fine-grained) structure in metals and alloys is distinguished by a better combination of strength and plasticity as compared to coarse-grained structure. Among other alloys, steel exhibits what may be a unique property: that of correcting its coarse-grained structure in response to heat treatment alone, without the use of plastic deformation. This possibility, which is highly important for engineering and was discovered by D. K. Chernov, is related to the polymorphism of iron and, in particular, to the alpha (bcc)-to-gamma (fcc) transformation that occurs when the steel is heated above the critical points (Ac_1-Ac_3). It is generally as a result of this transformation that the fine-grained γ-phase structure is formed and the desired fine-grained structure is obtained in steel after cooling.

In some cases, however, the polymorphic α–γ transition is not accompanied by recrystallization, and the grain of the steel remains as coarse as it was initially. Here we have a manifestation of structural heredity. The nature of the initial structure and the heating rate are decisive in this respect. In the initial crystallographically ordered structure (martensite, bainite), very rapid or, conversely, very slow heating of steel above the critical points is not accompanied by structural refinement despite the polymorphic α–γ transition that occurs. The latter is brought about by a crystallographically organized mechanism, crystallization in the sense of crystallite-size reduction does not occur, the original coarse grain is restored, inheriting its sizes and orientations, and the steel's inherent capacity for structural refinement is lost. Strictly speaking, it is still possible for recrystallization to occur in this case, but not immediately upon the α–γ phase transition; it occurs at higher temperatures in the single-phase γ region and as a result of another process—spontaneous recrystallization of the γ phase due to internal (phase) strain-hardening. Recrystallization follows a two-stage scheme: first the α–γ transition occurs with no accompanying change in grain size, and then the γ phase recrystallizes. The two-stage nature of recrystallization is also manifested in alloy steels, but it can be detected quite reliably even in simple carbon steels, for example on ultrafast laser heating.[1]

Thus, the α–γ polymorphic transformation is not or is accompanied by recrystallization, depending on its structural mechanism—cooperative or recrystallization (the "normal" mechanism in G. V. Kurdyumov's terminology), respectively. However, the cooperative mechanism may result in a degree of saturation with structural imperfection such that spontaneous recrystallization becomes possible at higher temperatures. In other polymorphic metals (for example, in cobalt and titanium and its alloys), this second stage may be absent, and structural refinement may become impossible despite the presence of polymorphism. On the other hand, crystal-structure refinement is sometimes found to be possible without polymorphism. An example is found in alloys with cellular decay during aging, in which the growth of supersaturated solid solution decay product cells is accompanied by reorientation in microscopic volumes.

[1] V. D. Sadovskiǐ, T. I. Tabatchikova, A. V. Salokhin, and M. M. Malysh, Fiz. Met. Metalloved. 53, 88 (1982).