Studies of the kinetics of the transformation of austenite worked at temperatures above $A_c_3$ are of interest to determine the best conditions for heat treatment combined with plastic deformation of stable austenite (quenching from the rolling heat, HTTMT [high-temperature thermomechanical treatment], and HTTMT with austempering), and therefore C-C-T and T-T-T diagrams were plotted [1].

Here we present results from a study of the effect of hot rolling on the kinetics of the isothermal transformation of austenite in steels 40 (0.37% C) and U8 (0.78% C).

The experiments were made with chrome-plated samples $2 \times 2 \times 25$ mm. The samples were austenitized at 900 and 1200°C in argon for 3 min and cooled to rolling temperature in a furnace heated to the given temperature. The samples were rolled with preheated rolls. The samples of steel 40 were rolled at 800°C, and steel U8 at 750°C, with 50% reduction. The rolled samples were transferred to an isothermal bath with an alternating current magnetometer [2], by means of which the kinetics of the transformation was determined. The time for transfer of the samples was 1 sec. A study showed that no recrystallization of austenite occurred in this period.

The T-T-T diagrams for undeformed and deformed austenite are shown in Fig. 1. In plotting the diagrams we took the beginning of austenite decomposition as the time corresponding to 5% decomposition and the end of decomposition as 95%. The difference in the rate of decomposition of undeformed and deformed austenite increases with the austenitizing temperature. It is probable that increasing the

![Fig. 1. T-T-T diagrams for steels 40 (a) and U8 (b). I) Heating to 900°C; II) 1200°C. —— No deformation; —— 50% deformation of steel 40 at 800°C, 50% deformation of steel U8 at 750°C.](image-url)
austenitizing temperature has a larger effect on the kinetics of the transformation of undeformed austenite than the deformed austenite.

Hot deformation has the greatest effect on the decomposition of austenite at elevated isothermal temperatures. With decreasing temperatures the effect of deformation gradually decreases. For example, deformation shortens the initial decomposition of austenite in steel U8 (after heating to 1200°C) by a factor of 4.8 at 650°C, 4 at 600°C, 3.3 at 500°C, and 1.7 at 400°C. These results agree with data in [3] for steel ShKh15 obtained by chemical carbide analysis.

For steel U8 at 300°C and lower, i.e., in the bainitic region, the decomposition rate of deformed austenite is somewhat lower than for undeformed austenite. Thus, the same deformed condition of austenite may be activated with regard to the pearlitic transformation and stabilized with regard to the bainitic transformation. It should be noted that the retarding influence of prior deformation on the bainitic transformation of steel U8 opposes the influence of deformation at the transformation temperature. According to [4], such deformation greatly accelerates the bainitic transformation.

It is interesting to note that deformation has the same qualitative effect on the kinetics of the transformation of austenite as lowering the austenitizing temperature. When the austenitizing temperature is lowered from 1200 to 900°C, as during deformation but to a lesser extent, the transformation is accelerated in the upper range of temperatures and slowed down in the lower range.

Metallographic analysis showed that prior deformation of steel 40 increases the amount of excess ferrite after decomposition at elevated temperatures (500-650°C). The amount of pearlite (pseudoeutectoid) decreases correspondingly. In hot rolled samples the ferrite is in the form of fine grains regardless of the austenitizing temperature (Fig. 2a), while undeformed samples austenitized at 1200°C have Widmanstätten ferrite along with granular ferrite (Fig. 2b). Thus, prior deformation prevents formation of Widmanstätten ferrite. This agrees with data in [5], where similar results were obtained for commercial iron. Hot deformation of steel U8 reduces the pearlite grain size. However, as was shown by electron microscopic analysis, the dispersity of the ferrite remains unchanged. The acicular form of the bainitic transformation products in the deformed samples is less distinct than in undeformed samples. The difference in the microstructure of the deformed and undeformed samples of both steels was proportional to the difference in the kinetics of the transformation of the deformed and undeformed austenite at a given isothermal temperature.

The acceleration of phase transformations as the result of prior deformation can be explained by the increase of the thermodynamic motive force of the transformation, which is the difference in the free energies of the original and new phases. The difference increases because of the fact that plastic deformation, inducing defects in the original phase (dislocations, vacancies), increases the free energy. The free energy of the new phase formed from original deformed samples does not change, since the defects of the original phase are not passed on to the new phase. This holds true only for the diffusion (normal) transformation mechanism.

With decreasing transformation temperatures the motive force increases and the addition to the motive force due to deformation becomes smaller, and therefore with decreasing transformation temperature the effect of prior deformation on the kinetics of the transformation decreases.