THERMAL STABILITY OF HARDENING OF STEEL Kh18N10T RESULTING FROM MECHANICOTHERMAL TREATMENT

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Mechanicothermal treatment (MTT) permits a substantial increase of the strength characteristics of austenitic steels at room and elevated temperatures [1]. The thermal stability is one of the factors determining the operating temperature threshold resulting from hardening. The thermal stability of cold hardening after different mechanicothermal treatments is of definite interest.

We investigated the thermal stability of hardening in steel Kh18N10T resulting from high-temperature mechanicothermal treatment (HTMTT).

The chemical composition of the steel was 0.08% C, 1.18% Mn, 0.47% Si, 0.026% P, 0.005% S, 10.5% Ni, 17.3% Cr, 0.48% Ti, 0.04% Al. The bars were 20 mm in diameter and 300 mm long.

The high-temperature mechanicothermal treatment consisted of rolling at 900-1100°C with reductions of 12-15 and 25-28%. The bars were previously heated to 1100°C for 30 min and cooled in air to 1050, 1000, 950, and 900°C. The samples were held 5 min at these temperatures and then rolled in a manual laboratory mill at the rate of 4.3 m/min and cooled rapidly in a water spray.

All the high-temperature mechanicothermal treatments investigated increased the strength characteristics by comparison with the standard treatment, consisting of quenching from 1100°C (Fig. 1). The higher the degree of deformation and the lower the deformation temperature the greater the strengthening. The greatest increase of the yield strength results from rolling at 900°C with 25-28% reduction (42 kg/mm^2 as compared with 21 kg/mm^2 after quenching). HTMTT has less effect on the ultimate strength, which increases to 64.5 kg/mm^2 after rolling at 900-1000°C with 25-28% reduction as compared with 57 kg/mm^2 after quenching, i.e., increases 13%.

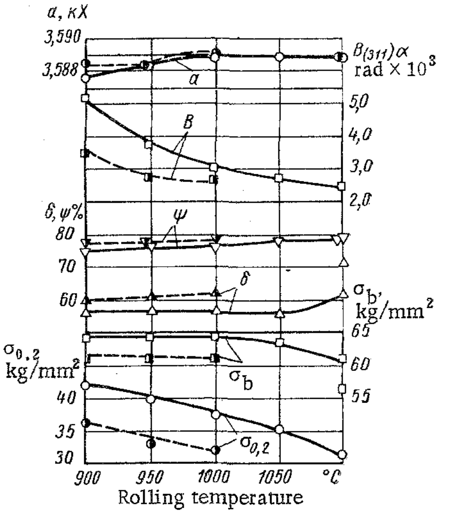

Fig. 1. Variation of mechanical properties, line broadening (311)$_\alpha$, and austenite lattice parameter of steel Kh18N10T with rolling temperature. ----) Standard treatment; ——) HTMTT.

It should be noted that the increase in the strength characteristics resulting from HTMTT is accompanied by a slight reduction of plasticity. The specific elongation drops from 72 (after quenching) to 62-57% and the reduction in section from 80 (after quenching) to 75%.

The increase in the strength characteristics after HTMTT is matched by broadening of the (311)$_\alpha$ line, which indicates considerable refining of the mosaic blocks and an increase of the microdistortion of the crystal lattice. After rolling at 900 and 950°C the austenite lattice parameter decreases somewhat, which is evidence of the precipitation of carbide phases from the solid solution. The strengthening after rolling at 900 and 950°C is probably due to refining of the fine structure as well as precipitation of carbides.

The change in the hardness of the mechanicothermally strengthened steel in relation to the annealing temperature is shown in Fig. 2. The increase of hardness at 750-780°C must be

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Chelyabinsk Polytechnical Institute; Zlatoust Metallurgical Plant. Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 3, pp. 52-55, March, 1969.

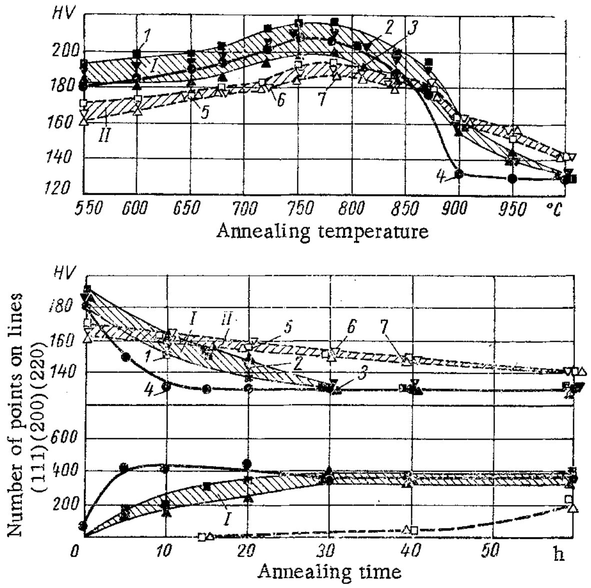

Fig. 2. Effect of annealing temperature and time on the hardness and number of point reflections on the x-ray patterns of steel Kh18N10T after HTMTT at 900°C (1, 5) 950°C (2, 6), 1000°C (3, 8), and 1100°C (4). I) 25-28% reduction. II) 12-15% reduction.

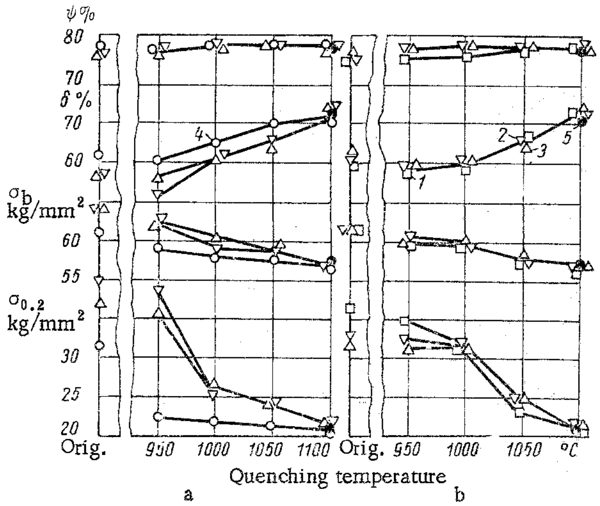

Fig. 3. Mechanical properties of Kh18N10T steel after HTMTT at 900°C (1), 950°C (2), 1000°C (3), and 1100°C (4) with reduction of 25-28% (a) and 12-15% (b) and repeated quenching. Curve 5 is for samples not subjected to HTMTT.

due to precipitation hardening. Rapid softening begins above 870°C. Cold hardening is most easily removed after rolling at 1100°C with 25-28% reduction. In this case the hardening is completely removed at 900°C. The samples rolled at 1000-900°C soften less readily. The extent of softening is almost independent of the rolling temperature and is determined mainly by the reduction during rolling. The thermal stability of cold hardening increases when the rolling reduction decreases from 25-28 to 12-15%. In the samples reduced 25-28% the cold hardening is completely removed in heating at 1000°C; in samples reduced 12-15% the cold hardening is only partially removed at this temperature.

X-ray structural and microscopic studies showed that the difference in the character of softening is due to the difference in the rates of recrystallization processes. Recrystallization is most intense in the samples rolled at 1100°C with 25-28% reduction. The number of recrystallized grains increased noticeably even at 780°C. In the samples rolled at 1000-900°C with 25-28% reduction noticeable recrystallization occurred only in annealing at 870°C. At 12-15% reduction the initial recrystallization temperature shifts to 900°C. In the given range the rolling temperature has no effect on recrystallization during subsequent heating.

The slower development of recrystallization at lower degrees of deformation is due to the lower level of cold working, which reduces the driving force of recrystallization. The low thermal stability of the cold working resulting from rolling at 1100°C depends on the characteristics of the original structure. Partial recrystallization of the austenite occurs during HTMTT at this temperature, while no recrystallization occurs in HTMTT at 900-1000°C. Evidently the formation of recrystallized areas with high-angle boundaries in the original structure facilitates the development of recrystallization during subsequent heating.

It was of interest to study the kinetics of high-temperature softening of steel Kh18N10T. Figure 2 shows the variation of hardness with the holding time at 1000°C. Softening was greatest for the samples rolled at 1100°C with 25-28% reduction. In samples rolled at 1000-900°C with the same reduction the thermal stability of cold hardening increased notably. The hardening was completely removed in 10 min in the first case, but only after 30 min in the second case. At a reduction of 12-15% softening slowed down. The rapid development of cold hardening corresponds to the intensive development of recrystallization processes, which is indicated by the variation in the number of reflections on the x-ray patterns with the annealing time.

In annealing at 950°C or lower the cold hardening is removed considerably more slowly. Evidently it is aging processes that determine the character of softening in these cases. Firstly, the precipitation of carbides can promote hardening of the steel, thus compensating the partial removal of the cold hardening of the austenitic matrix. Secondly, the precipitating particles can slow down recrystallization processes. At an annealing temperature of 1050°C the removal of cold hardening is sharply accelerated – cold hardening is completely removed in 5 min regardless of the previous deformation conditions.

The variation of the mechanical properties after HTMTT and after repeated quenching from 950-1100°C is shown in Fig. 3. Heating at 950°C has little effect on the yield or ultimate strength of the samples rolled at 950-1100°C with 25-28% reduction. However, both the yield and ultimate strengths decrease sharply on heating at 1000°C, which must be due to intensive development of recrystallization processes. In this case the yield strength is 4-5 kg/mm^2 higher than that of samples quenched from 1100°C. At a heating temperature of 1050°C the strength characteristics decrease as the result of complete recrystallization of the austenite. Heating at 1100°C leads to collecting recrystallization and further drop of the strength. In this case the strength of the samples rolled at 1100°C drops sharply even on heating to 950°C, which is due to the low thermal stability of the structure.

After HTMTT at 900-1000°C with 12-15% reduction the yield and ultimate strength change negligibly on heating up to 1000°C (see Fig. 3b), which is due to the slow development of recrystallization processes. After quenching from 1000°C the yield strength increases 10 kg/mm^2 and depends very little on the rolling temperature. The strength drops sharply only on heating to 1050°C.

CONCLUSIONS

1. High-temperature mechanicothermal treatment at 900-1100°C with 12-15 and 25-28% reduction notably increases the strength characteristics of steel Kh18N10T but reduces the plasticity only slightly. The strength increases as the rolling temperature decreases and the degree of deformation increases.

2. The thermal stability of the hardening resulting from HTMTT under conditions completely preventing recrystallization depends very little on the rolling temperature but mainly on the degree of reduction.

The thermal stability is highest after 12-15% reduction at 900-1000°C.

3. The partial development of recrystallization during high-temperature deformation sharply reduces the thermal stability of the cold hardening resulting from HTMTT.

LITERATURE CITED

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