EFFECT OF TEMPERING REGIMES ON THE STRUCTURE AND MECHANICAL PROPERTIES OF INTERMEDIATE-ALLOYED STEEL

Z. Yanushevich,1 Z. Gulishiya,1 V. Diordievich,1 R. Gulishiya,1 and Z. Karastoikovich1


The high-strength intermediate-alloyed steel HSLA is widely used in the industry but the literature presents little data on the structural state of this steel after high-temperature tempering. The article concerns the microstructure and the mechanical properties of steel after tempering in a wide range of temperatures and holds.

Steel HSLA belongs to the group of high-strength intermediate-alloyed steels and acquires the best qualities after tempering. This steel is widely used preferentially after a low-temperature tempering. There are virtually no data on its behavior after a high-temperature tempering though in some cases this is important, for example, for welded joints.

We investigated cold-rolled strips from steel HSLA (0.30% C, 0.90% Mn, 0.90% Si, 1.0% Cr, 0.016% S, and 0.018% P). The strips were quenched in oil from 870°C (30 min) and tempered at 400, 450, 500, 550, 600, 650, and 680°C for 15 min, 1, 3, 6, and 24 h. One of the tempering parameters was changed and the other was kept constant. Three specimens were investigated for each tempering variant.

In order to eliminate oxidation and decarburization the steel was heated for quenching in vacuum.

Fig. 1. Structure of steel HSLA (× 500). a) After quenching from 870°C (30 min); b, c, d) after quenching and tempering for 24 h at 500, 650, and 680°C, respectively.

1 Institute of Technology of Nuclear Raw Materials, Polytechnical Academy, Belgrade, Yugoslavia.
The structure of the HSLA steel is a combination of a massive and a plate martensite in the presence of a certain amount of retained austenite (see Fig. 1a). The retained austenite could not be identified precisely by metallographic methods.

Figures 1b–1d present the structure of the steel after quenching and tempering at 500, 650, and 680°C for 24 h.

It can be seen that the martensitic structure formed during quenching is transformed during tempering into a ferrite-carbide mixture with a selectively preserved martensite morphology. This has been observed even after a 24-h tempering at low temperatures. With increase in temperature and tempering time, the content carbon in the α-phase decreases; this is accompanied by the formation and growth of carbide particles. The carbide particles are detectable in metallographic analysis only after tempering at quite high temperatures, when the diffusion mobility of the atoms of carbon, iron, and the alloying elements increases. The rather high diffusion mobility of the elements promotes a uniform distribution of coagulated carbide particles that become more noticeable in the ferrite matrix (Figs. 1b–1d).

We could not detect any changes in the ferrite matrix by the investigation techniques used. It seems that in tempering