When steel 18Kh2N4VA is heated to high temperatures the grains become larger, although the mechanical properties are not impaired. However, heating should not exceed the temperature at which lithoidal fracture occurs.* Figure 1 shows the variation of the fracture toughness with the heating temperature for holding times of 30 and 90 min. At temperatures up to 1250° no crystalline or lithoidal fracture occurs and the fracture toughness remains high. After heating to 1300-1350° the fracture becomes lithoidal. In this case the fracture toughness decreases sharply also after cooling in air and subsequent heat treatment (normalizing at 950°, tempering at 650°, quenching from 850°, and tempering at 180°).

Preliminary tests of several heats of steel 18Kh2N4VA showed that after heating to 1300-1350° and subsequent cooling in air the fractures differ in different heats. In most heats the fracture is crystalline. Two heats were selected for investigation (Table 1) – a heat with crystalline fracture (heat 1, Fig. 2a) and a heat with lithoidal fracture (heat 2, Fig. 2b). After normalization at 900° the crystalline fracture changed to lithoidal (Fig. 2c).

To correct the fractures the overheated samples from both heats were heated at 900-1150°, with holding 2 h, and then cooled in air. In samples with a crystalline fracture it was almost completely eliminated by heating to 1050°, while in samples with lithoidal fracture it was not eliminated even at 1150°.

Thus, crystalline fracture, although it is characterized by larger grains, is easily corrected. With lithoidal fracture the grains are finer, but very stable.

The samples of both heats were heated to 1000° and forged with a reduction of 2-2.5%. Heat 1 retained only slight traces of overheating (small matte spots in the fracture); in heat 2 the grains became finer but the structure from overheating was retained.

To determine the influence of carburizing and subsequent heat treatment on the structure of the core and the case, the overheated samples from both heats were pack carburized at 910° and cooled slowly.

The carbide network obtained was characterized by the size of former austenite grains. The carburized samples were subjected to double high-temperature tempering at 620°, quenching from 810°, and tempering at 180°.

* T. F. Sekacheva and R. I. Levokhina participated in this work.

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Fig. 2. Fractures after overheating at 1350°C: a) heat 1 after overheating and cooling in air; b) heat 2 after overheating and cooling in air; c) heat 1 after normalizing at 900°C.

Fig. 3. Macrostructure of steel overheated at 1350°C: a) after overheating and cooling in air, heat 1; b) after overheating and cooling in air, heat 2; c) after overheating, carburizing, and heat treatment, heat 1; d) after overheating, carburizing, and heat treatment, heat 2.

In both heats the lithoidal fracture was retained after carburizing and high-temperature tempering, and also after subsequent quenching and low-temperature tempering. The lithoidal structure was more distinct in the core, in the form of large protruding crystals. The fracture of the case was even, with no distinct relief—there were lithoidal crystals only in separate areas. At a depth of 0.2-0.3 mm from the edge of the fracture there was a thin border of shiny crystals.

The macrostructure of the samples after overheating had distinct light and dark areas differing in luster that corresponded to the original austenite grains in size and shape. In samples of heat 1 with coarse crystalline and lithoidal fractures the grains were very large (12 mm² in section—see Fig. 3a), while in samples with fine lithoidal fracture (heat 2) the grains had a section of 2 mm² (Fig. 3b).

After carburizing and heat treatment the coarse-grained structure remained, but the areas differing in luster in the core and the case were less distinct and smaller (Fig. 3c, d).

Figure 4 shows the microstructure of the case after high-temperature tempering. In the steel not previously overheated the carbide network is very fine (grade 8) and even, occurring in a homogeneous troostite—sorbite matrix (Fig. 4a). In the steel subjected to preliminary overheating a relatively fine carbide network (grade 5-6) is observed only to a depth of 0.1 mm, followed by a network of very coarse carbides, particularly in samples of heat 2 (Fig. 4b, c). In some places the coarse carbide network

Fig. 4. Microstructure of case after high-temperature tempering (× 100): a) without preliminary overheating, heat 1; b) with preliminary overheating, heat 1; c) with preliminary overheating, heat 2.