TREATMENT OF ALLOYED STRUCTURAL STEELS
TO PREVENT THE FORMATION OF FLOCCULES

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The heat treatment of forgings to prevent the formation of floccules in highly alloyed steels (in which the austenite is highly stable in the pearlitic region) is carried out by preliminary transformation of supercooled austenite into the ferrite-carbide mixture (bainite or a mixture of bainite and pearlite). The Ural Machine Construction Plant and many other plants use supercooling of forgings to 280-320°C to transform the austenite [1].

There are essentially two different heat treatment conditions for prevention of floccules in forged highly alloyed steels; these are indicated in Fig. 1. Some authors [2] indicate that the forgings should be supercooled to 200-250°C or even lower to ensure complete transformation of austenite.

To prevent the formation of floccules and ensure complete decomposition of austenite, the authors in [3,4] recommend subjecting forgings to double or even triple supercooling and cooling at the highest rate until quenching in water, oil, or hot media [3], which is difficult to do with large forgings under industrial conditions.

The purpose of our investigation was to study the influence of the austenitization temperature (860 and 1000°C), the cooling rate from this temperature (200 and 50°C/h), the supercooling temperature (480-300°C) and subsequent isothermal heating (650 and 700°C) on the transformation of the supercooled and the residual austenite of highly alloyed 35KhNM and 34KhN3M steels used for manufacturing large critical forged parts.

For our study of the transformation of supercooled and residual austenite, we used the modernized and automated magnetometric Steinberg apparatus. Samples of 35KhNM steel (0.35% C, 1.5% Cr, 1.0% Ni, and 0.25% Mo) and 34KhN3M steel (0.34% C, 1.2% Cr, 3% Ni, and 0.40% Mo) which were 5 mm in diameter and 50 mm long were chromium plated to prevent decarburization and then heated in the furnace of the magnetometer to 860 and 1000°C. After a certain time at these temperatures, they were cooled at the rate of 50°C/h or 200°C/h to the desired supercooling temperature, kept at this temperature for 2 h, and then heated at the rate of 100°C/h to the temperature of isothermal heating (650°C in one case and 700°C in the other), kept at this temperature 2 h, and then cooled in the furnace of the magnetometer to 50°C. In selecting the heating and cooling rates, we took into account the industrial conditions of the heat treatment of forgings to prevent the formation of floccules.

The concentration of the magnetic phase was determined during heating, cooling, and during supercooling and isothermal heating. For these measurements we used a ballistic magnetometer with automatic recording of the temperature in a field of 9000 Oe. In the calculations of the amounts of the magnetic phase, we took into account the dependence of the magnetization of a standard sample on the heating temperature.

Figure 2 shows the curves of thermokinetic transformation of austenite in 35KhNM and 34KhN3M steels as a function of the cooling rate and the austenitization temperature. Since the austenite in 35KhNM steel is transformed into pearlite during cooling at the rate of 50°C/h, the transformation of the austenite in this steel was studied only after cooling at the rate of 200°C/h.

Figure 2 shows that the decrease in the cooling rate of samples of 34KhN3M steel from 200 to 50°C/h considerably increases the temperature of the beginning of the transformation into bainite, slows down its transformation at 480-300°C, and also increases the amount of undecomposed austenite at temperatures below 300°C. When the supercooling of austenite is below 300-320°C, then the transformation of the austenite practically ceases.

An increase in the austenitization temperature from 860 to 1000°C has a similar effect on the kinetics of the transformation of the supercooled austenite in samples of 35KhNM and 34KhN3M steels.

Figure 3 shows the dependence of the rate of transformation of supercooled austenite in 34KhN3M and 35KhNM steels on the austenitization temperature and on the cooling rate. An increase in the austenitzation temperature from...
860 to 1000°C increases the temperature of the beginning of the bainitic transformation by about 25°C. Also, with increasing austenization temperature, the temperature of the end of the transformation of austenite decreases by about 25-50°C. A decrease in the rate of cooling has the same effect as the increase of the austenization temperature on the bainitic transformation of 34KhNM steel.