The effect of boundaries on spheroidization is marked since slip bands disappear in the initial stages of annealing.

Thus, defects in the atomic crystal structure of both ferrite and cementite affect the mechanism and kinetics of pearlite spheroidization. Under the influence of previous cold work during subcritical annealing of steel, the process of cementite separation into pieces is made easier. Duration of spheroidization decreases if the products of pearlite transformation are previously formed into strip or rod-shaped cementite.

LITERATURE CITED

EFFECT OF PRELIMINARY ANNEALING ON TEXTURE FORMATION IN ELECTRICAL STEEL

R. I. Malinina and V. R. Mincheva

UDC 621.785.33:669.14.018.5

It is well known [1, 2] that certain preliminary annealing (PA) schedules have a favorable effect on the amount of cubic component in the texture. However, there is little information in the literature on the effect of PA on texture formation and magnetic properties in silicon electrical steel.

The present work concerns a study of different PA schedules in order to select optimum conditions for facilitating an increase in the cubic component in the texture formed after final annealing.

Sheets of steel (0.045% C; 2.2% Si; 0.15% Mn; 0.05% P; 0.04% S; 0.008% Al; 0.01% N; 0.004% O) 2.5 mm thick after hot rolling were decarburized in moist hydrogen at 800°C for 2 h. In this way the carbon content was reduced from 0.045 to 0.018%. Then the steel was subjected to two-stage treatment: cold rolling with a compression of 10% followed by annealing at 1100°C for 12 h in a vacuum of \(10^{-1} - 10^{-2}\) Pa, then cold rolled with a compression of 77% to a thickness of 0.5 mm followed by preliminary and final annealing. The change in microhardness at a load of 1 N due to PA duration at 500, 550, and 600°C is given in Fig. 1. It can be seen that maximum hardness with increasing PA temperature is observed with the shortest soaking time. Appearance of a maximum in the kinetic microhardness curves, as shown by electron-microscope studies, was connected with aging-precipitation during PA of...
Fig. 1. Kinetic curves for microhardness after preliminary annealing at 500 (●), 550 (×), and 600°C (△).

Fig. 2. Effect of preliminary annealing duration at 500°C (a) and 600°C (b) (final annealing at 900°C for 2 h) on grain size \( D_m \) (5) and proportion \( P \) of texture components with different orientations: 1) \((100)[011] \pm 17°\); 2) \((100)[011] \pm 10°\); 3) \((110)[011] \pm 10°\); 4) \((111)[112]\).

**finely dispersed aluminum nitrides.** The sharp reduction in microhardness after PA for >1 h was caused by recovery and primary recrystallization.

Primary recrystallization starts after 1 h for annealing at 500°C, and in 30 min at 550 and 600°C. However, complete recrystallization is not observed after PA for 10 h. Grains orientated at \((100) [011] \), \((310) \), \((410) \), \((111) \) after PA at 500°C and at \((100) [011] \), \((310) \) after PA at 550 and 600°C remain unrecrystallized.

Specimens subjected to PA were annealed at 900°C for 2 h. The change in specimen texture showed that PA for a particular duration corresponds to the maximum proportion of plane cubic component (Fig. 2). With an increase in PA temperature from 500 to 600°C the maximum for the plane cubic component moves in the direction of shorter soaking times (from 1.5 to 0.5 h, respectively). Schedules for PA corresponding to the maximum for component \((100)[011]\) are optimum for obtaining high magnetic properties in electric steels. In specimens treated by the optimum PA schedule the \((100)[011]\) component increases by ~30% in comparison with specimens annealed without PA.

The shift in texture maximum and minimum microhardness with increasing PA temperature in the direction of shorter soaking times makes it possible to assume that the appearance of maxima is caused by the same reason, i.e., aging. The mechanism of the effect of PA on texture formation is not yet clear. There are two hypotheses. According to one \([3, 4]\) PA affects nucleus formation during primary recrystallization, and according to the other \([1, 2]\) it affects grain growth. It is considered that PA affects the mobility of grain nuclei having different orientations in different ways.

In order to explain the reasons for the effect of PA on texture the microstructure of specimens after PA and final annealing at 900°C for 2 h was studied in detail. After final annealing the microstructure of specimens previously annealed at 500°C by the optimum schedule consists of recrystallized and unrecrystallized grains, whereas complete recrystallization occurs in specimens without PA and with PA at 500°C for 5 h during final annealing. Unrecrystallized grains occupied 10-15% of the whole specimen and had a \((100)[011]\) orientation. Retarded recrystallization for \((100)[011]\) grains is probably connected with the effect of a second phase, and this agrees with the data in \([4]\).

It can be seen that PA carried out by the optimum schedule increases resistance to recrystallization during subsequent annealing of deformed grains with \((100)[011]\) orientation. About 40% of the grains had a \((100)[011]\) orientation in test steel in the worked condition. It is of interest to follow the recrystallization kinetics for these grains, and also to study the orientation of grains formed as a result of recrystallization.

*In determining the \((100)[011]\) component, grains were considered whose \((100)\) plane deviated from the rolling plane around \([100]\) and \([110]\) from 0 to 10°, and for the \([100]\) direction those which deviated from 0 to 45° from the rolling direction.*