Shown in Fig. 4b is the effect of aging temperature on the hardness of Nb–N alloys quenched from 1600°C. The nature of the dependence of hardness on aging temperature is similar to the change in hardness observed after aging at 1300°C, which is due to generation and precipitation of dispersed stable NbN phase particles uniformly distributed throughout the volume of grains. A reduction in hardness for the test alloys after aging at 1400°C is connected with coalescence of particles of this phase.

**CONCLUSION**

Maximum strengthening for alloys of the Nb–N system is observed after quenching from 1600°C and subsequent aging at 1300°C, which is due to formation of highly dispersed precipitates of stable NbN nitride phase uniformly distributed in the matrix. Generation of nitride phase particles during aging is accompanied by occurrence of elastic fields due to distortion of the crystal lattice of the matrix.

**LITERATURE CITED**


**MICROSTRUCTURAL FEATURES OF PLASTIC DEFORMATION UNDER SUPERPLASTICITY CONDITIONS FOR STEEL Kh18AGN**

G. Zlateva and N. Petkov

Results are given in this article for a study of the possibilities of performing plastic deformation for austenitic steel Kh18AGN containing 0.9% N in two directions:

1) preparation of a superfine grain size required for occurrence of structural super-plasticity;

2) determination of deformation mechanisms controlling the process of superplastic flow in different rate ranges.

Our previous studies showed that a superfine grain size in austenitic steel Kh18AGN may be obtained as a result of treatment by the following schedule [1]:

a) plastic deformation at 1100°C with ε = 95%;

b) cold plastic deformation with ε = 50%;

c) isothermal annealing at a temperature somewhat above 750°C (temperature for the start of recrystallization).
Fig. 1. Microstructure of steel Kh18AGN: a) dislocation structure after deformation with $\varepsilon = 95\%$ at 1100°C and with $\varepsilon = 50\%$ at 20°C; b) after isothermal annealing at 750°C for 60 min; c) after deformation ($\delta = 100\%$) at 800°C at a rate of $2 \times 10^{-4}$ sec$^{-1}$; d) coherent twinned boundaries in the first deformation rate range at 800°C; e) after deformation at 800°C at the optimum rate $\dot{\varepsilon} = 1 \times 10^{-3}$ sec$^{-1}$ and with $\dot{\varepsilon} = 1 \times 10^{-2}$ sec$^{-1}$ respectively; a) $\times 20,000$; b-f) $\times 10,000$.

The main factor governing the structural state of steel Kh18AGN after the treatment indicated above is alloying of austenite with nitrogen. Nitrogen reduces the defect packing energy [2] as a result of which cold plastic deformation is accomplished as a result of broadly extended dislocations connected with strips of packing defects. An increase in the density of them with an increase in the degree of deformation leads to formation of plane accumulations of dislocations, strips of packing defects, and $\varepsilon$-martensite. Reaction of dislocations with mutually intersecting sets of densely packed planes leads to formation of sessile barriers, a reduction of the distance between separate plane elements and after deformation with $\varepsilon > 50\%$ to occurrence of a three-dimensional grid of exceptionally high density of defects, i.e., a so-called 'network structure' [3] (Fig. 1a).

With isothermal annealing above the temperature for the start of recrystallization there is simultaneous precipitation of nitride phase and growth of new grains. Throughout the whole volume of solid solution supersaturated with nitrogen, rounded particles of Cr$_2$N with a size from 0.01-0.1 $\mu$m precipitate. They operate as recrystallization centers around which new austenite grains grow. The high density and homogeneous distribution of defects in the deformed crystal lattice govern the high density of nitride particles (up to $5 \times 10^9$ cm$^{-2}$), the large number of austenite nuclei, and the limited possibility for growth of new grains. Thus, grain size after the thermomechanical treatment indicated above does not exceed 2-3 $\mu$m (Fig. 1b).

Our subsequent studies showed that the maximum ductility properties for the steel are achieved after deformation at 800°C. Precipitation of nitride phase and recrystallization occur also without prior isothermal annealing, i.e., during heat for deformation. The grain size obtained under these conditions is 3-4 $\mu$m.

It can be seen from Fig. 2 that the maximum ductility ($\delta = 320\%$) is achieved with a deformation rate of $\dot{\varepsilon} = 10^{-3}$ sec$^{-1}$. The high ductility, lack of mechanical strengthening