DEPOSITION KINETICS OF THE $\gamma'$ PHASE IN N36T2Yu2 STEEL

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Electron microscopy is reported for the deposition in this steel; quantitative results are given on the particle size of the $\gamma'$ phase deposited during a continuous and uninterrupted decomposition. The deposition of the $\gamma'$ phase occurs in one stage, while the two stages in the variation in the mechanical properties arise from features of the interaction of dislocations with the $\gamma'$ phase particles. There appears to be only a small energy barrier to the generation of $\gamma'$ phase particles. Spherulites are formed in regions of interrupted decomposition. The effects of quenching temperature on the deposition mechanism are discussed.

It has been shown [1-5] that the deposition of the $\gamma'$ phase can be either continuous or discontinuous; there is a marked effect from the quenching temperature on the extent of the discontinuous decomposition. The discontinuous deposition is a constant of difficulty in continuous deposition of the $\gamma'$ phase; this agrees with the data of [6], in which it was concluded that there is a substantial energy barrier to the nucleation of the $\gamma'$ phase. It has also been concluded [6] that deposition of the $\gamma'$ phase is preceded by barrier-free formation of zones. From this viewpoint, the effects of temperature on the $\gamma'$ phase deposition mechanism can be explained in terms of grain-boundary segregations, which reduce the barrier height [2, 3]. For this reason, we have made quantitative studies on the discontinuous and continuous deposition of the $\gamma'$ phase. We consider that evidence on this question may decide whether it is realistic to assume that there is a zone stage and an energy of activation for $\gamma'$ phase nucleation. Evidence on these topics should provide some explanation of the interrupted deposition of $\gamma'$ phase. It was also proposed to examine the coagulation processes that occur in regions of discontinuous deposition.

MATERIALS AND METHOD

As the material we used austenitic steel type N36T2Yu2 (Ni 36.1; Ti 2.5; Al 2.1 wt.%).

The structural studies were performed in transmission with a UЭMV-100K electron microscope; the particle sizes were measured on light-field figures. Check measurements of particle size were made with dark-field photographs, which were obtained in superlattice reflections from the particles of the $\gamma'$ phase, which gave similar results. The particle sizes were averaged over 20-50 measurements.

Fig. 1. Decomposition structure in N36T2Yu2 steel after ageing at 700° C for: a) 2 h; b) 1380 h. ×40,000.
The microhardness was measured with a PMT-3.

The specimens were aged at 700 and 800° after quenching from 950 and 1150° (time spent 1 h). The ageing and quenching from 950° were performed at $10^{-2}$ mm Hg. In the case of quenching from 1150°C, a pressure of $10^{-4}$ mm Hg was used to prevent interaction with oxygen [4].

In all cases the specimens were quenched in water.

**RESULTS AND DISCUSSION**

Quenching from 1150° with subsequent ageing produced [4] only continuous deposition of the γ' phase; but in material quenched from 950° there was rapid discontinuous deposition as well.

Observations on the continuous decomposition structures showed that the γ' phase was deposited as spherical particles (Fig. 1). These particles remain spherical in spite of very long ageing times, which shows that there was only a small difference in lattice parameters between the γ' phase and the matrix [7]. This was confirmed also by the absence of deformation contrast from the particles.

The following equation [8] describes the particle coagulation at the stage where the matrix supersaturation is very small:

$$d^3 - d_0^3 = kt,$$

where $d$ and $d_0$ are the current and initial dimensions of the particles respectively, $t$ is time, and $k$ is a constant. If the times are sufficiently long, when $d >> d_0$, (1) may be put as

$$d^3 = kt.$$

Then we plotted the mean particle diameter as a function of $t^{1/3}$ for specimens aged at 700 and 800° after quenching from 950 and 1150° (Figs. 2 and 3). We can see that the kinetics of γ' particle growth in continuous decomposition are closely described by the above equation, and the results for quenching temperatures of 950 and 1150° lie on the same straight line.

The results of Fig. 2 show that coagulation during ageing at 700° begins not later than 20 min after the start of ageing, so this is the time involved in γ' phase nucleation and initial coagulation at high matrix supersaturation at 700°. In the case of ageing at 800°, Fig. 3 indicates that the relevant time does not exceed 1 min.

As for many other alloys [9-11], the improvement in the mechanical properties of ageing occurs in two stages (Fig. 4). A characteristic feature of the second stage is that the microhardness becomes dependent on the load, which indicates a substantial increase in the