MARTENSITIC PLATE DIMENSIONS IN Fe-Ni ALLOYS

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CERTIFICATE

This is to certify that the thesis entitled "Martensitic Plate Dimensions in Fe-Ni Alloys" by R. Datta submitted to the Indian Institute of Technology, New Delhi (India) for the award of the degree of Doctor of Philosophy in Applied Mechanics is a record of bonafide research work carried out by him under our joint supervision and guidance. The thesis work, in our opinion has reached the standard fulfilling the requirements for the Doctor of Philosophy Degree. The research report and results presented in this thesis have not been submitted in part or in full to any other University/ Institute for the award of any degree or diploma.

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ABSTRACT

The mean dimensions of martensitic plates are influenced by geometrical and fundamental factors. The objective of this thesis has been to study, the basic factors at play (keeping the geometrical factors constant) and systematically determine their influence on the following:

(a) The overall dimensions of martensitic plates.

(b) Variation of the twinned thickness in partially twinned martensitic plates.

(c) Effect of prestrain at room temperature on the overall and twinned plate dimensions.

The experimental techniques used in the investigation include argon arc melting of Fe-Ni alloys in the composition range of 30 to 34.5 wt % Ni, homogenization, rolling, austenitization, doping and plastic deformation of some heat-treated austenitic samples on a Hounsfield Tensometer. The austenitic specimens are cooled in a liquid bath till the burst temperature M_b is attained. As soon as the burst is detected, the specimens are upquenched to room temperature. Some of the unstrained samples are cooled to various temperatures above M_b (upto M_b + 25 K) and the protrusion provided at the end of the sample is 'tweaked'. This resulted in different M_b's and different fractions of martensite (f) for the same alloy. The dimensions of martensitic plates are determined by quantitative metallography, using Fullman's equations.

The overall plate dimensions have been determined for ten unstrained Fe-Ni alloys. The mean radius ($\bar{r}$) and the mean semithickness ($\bar{c}$) of the plates are found to be independent of f. This is because the transformation progresses predominantly by the formation of clusters of plates in some grains and the spreading of these clusters to neighbouring grains by autocatalytic stimulation. The mean semithickness-to-radius ratio ($\overline{c/r}$) decreases linearly with decreasing temperature from 0.11 at 250 K to 0.04 at 80 K. The ratio of the mean semithickness to the mean radius ($\bar{c}/\bar{r}$) decreases in a similar fashion, though the values of $\bar{c}/\bar{r}$ appear to be slightly larger than the corresponding values of $\overline{c/r}$ at lower transformation temperatures. So, to a first approximation, the c/r ratio is independent of plate lengths. The flow strength of the austenite, which increases by a factor of 2-3 in the temperature range (250-80 K) can possibly account for this decrease in $\overline{c/r}$.

The same ten Fe-Ni alloys described above, have been used for the evaluation of the twinned dimensions of partially twinned martensitic plates. In these new measurements, the variation of the overall $\overline{c/r}$ ratio with M_b is also linear, agreeing well with the results described above. The variation of $(\overline{c/r})_T$ with M_b is non-linear, increasing initially with decreasing temperature, reaching a maximum value at an intermediate temperature and then decreasing with a further decrease in temperature. Extrapolation of this curve to the high temperatures yields the result that $(\overline{c/r})_T = 0$ at 285 K.

This approximately coincides with the transition in the morphology from plate to lath martensite. At the lower end of the temperature range, it is found that $(\overline{c/r})_T \simeq (\overline{c/r})$. This indicates that plates formed at low temperatures are fully twinned. The $(\bar{c}/\bar{r})_T$ versus M_b plot follows closely the variation of $(\bar{c}/\bar{r})_T$.

Metallographic studies revealed that plates become thinner with a more irregular austenite-martensite interface with increasing prestrain. The twinned thickness also decreases with increasing strain but the twinned-untwinned interface remains smooth in both strained and unstrained samples. The overall and twinned plate dimensions have been determined in nine prestrained Fe-Ni alloys. Plots of $\overline{c/r}$ against prestrain is linear and shows the plates to thin down progressively with increasing prestrain. The plots of $\bar{c}/\bar{r}$ against prestrain shows a linear variation similar to the above plot. Cross-plots of $\overline{c/r}$ and $\bar{c}/\bar{r}$ against M_b at 0, 10, 20 and 30% strains, show straight line fits. The fractional decrease in $\overline{c/r}$ between 0 and 30% prestrain is 0.52 at 250 K and 0.35 at 100 K. The c/r ratios become progressively insensitive to strain with decreasing M_b and remain constant near 0 K, irrespective of the amount of strain. It is also found from a limited number of measurements in the range of 230-115 K, that $(\overline{c/r})_T$ decreases as a function of strain at a constant temperature.

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