Effect of Stress on the Martensitic Transformation in the Cu-Zn System

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THE martensitic transformation in the β -phase of the Cu-Zn system has been the subject of several investigations.¹⁻⁴ The transformation is known to be reversible and to be affected by stress. Its temperature range has been determined as a function of composition. In the investigation reported here, the effect of tensile stresses on the transformation was investigated quantitatively. Some information was also obtained on the thermoelastic behavior of the martensite formed in the first stages of the transformation.

Most of the experiments were done with alloy E of an earlier investigation;⁴ this alloy analyzed 60.49 pct Cu and 39.51 pct Zn by weight. The methods of shaping and heat treatment were also essentially the same as those previously used. The stress was applied to the specimen immersed in a cooling liquid. The transformation was followed by measuring the electrical resistance with a Kelvin bridge and the elongation with a cathetometer.

Fig. 1 shows the M_s temperature as a function of stress. Resistance and strain measurements gave essentially identical values. The results suggest a roughly linear relation between M_s and σ in the range investigated, up to 12 kg mm⁻². At higher stresses, plastic deformation begins to interfere seriously with this relationship.

The increase of M_s with stress is consistent with published work on the effect of stress on the martensitic transformation.^{5,6} The slope of the curve, 4°C per kg mm⁻², is of the same order of magnitude as the corresponding value calculated for steel.⁷

Fig. 1 also shows the difference, ΔM , between the temperature of 50 pct transformation on cooling, as measured by changes in length, and that of 50 pct reverse transformation on heating. This difference, which may be considered a measure of the hysteresis, increases with stress; the decrease at highest stresses is probably associated with plastic deformation.

Preliminary work using only resistance measurements was done with an alloy containing 60.15 pct Cu and 39.79 pct Zn by weight. The results indicated higher values of M_s in agreement with the known variation of M_s with composition.⁴ The effect of stress on M_s (2°C per kg mm⁻²) was of the same order of magnitude as that shown in Fig. 1 for composition E. An increase in hysteresis with stress was also found.

The following experiment was made in order to investigate a partially transformed structure. A specimen of alloy E was cooled to -85°C under a stress of 4.7 kg mm⁻². Under these conditions, the martensitic transformation started but did not go to completion. The stress was then released and the

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Fig. 1—The starting temperature M_s and the temperature hysteresis ΔM of the martensitic transformation are shown as functions of stress in an alloy containing 60.49 pct Cu and 39.51 pct Zn by weight.

Fig. 2—The elongation of a specimen containing 60.49 pct Cu and 39.51 pct Zn by weight is shown as a function of temperature and stress in the region of incipient transformation.

specimen cooled to -105°C. Fig. 2 shows the measured elongation ϵ . The first change in the slope of the curve indicates the beginning of the transformation under stress. Removing the load at -85°C caused a decrease in length to the value corresponding to the elastic elongation of the parent phase resulting from the applied stress. Hence, the martensite formed in the first part of the experiment apparently disappears completely and without hysteresis upon the release of the stress. The increase in length on further cooling indicates renewed formation of martensite. These conclusions are consistent with the concept of "thermoelastic" martensite,⁸ which has been confirmed by test.⁹

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