Textures and Microstructures, 1991, Vols 14–18, pp. 531–536
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TEXTURE DEVELOPMENT AND INHOMOGENEITY OF LOW C STEEL WIRES MADE FOR COLD HEADING

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INTRODUCTION

Nuts, rivets, bolts and screws are used in the automobile,construction and general utilities industries. Any improvement in cold headability, more accurately called upsettablitiy of cold heading requires a more accurate control of texture development and extensive control of microstructure. The mechanical properties of the product are influenced by the alloy composition, the forming schedule,and the heat treatment schedules - consequently by the resulting texture and microstructure. In a recent publication we [1] have analysed the compound influence of texture and microstructure on low C steel wires in a more general manner. Here we discuss texture inhomogeneity and the effects due to texture on mechanical properties.

MATERIALS

SAE 1018 (C=0.18%) and SAE 1033 (C=0.33%), 5.53 mm diamater hot deformed rods were drawn to a total of 78% area reduction in altogether 5 passes. Cold drawn wires were than heat treated (i) at 850°C for 2 hours followed by a (spheroidization) heat treatment at 690°C for 3-15 hours (ii) at 690°C for 3-15 hours ; and (iii) at 710 °C for 20 hours .

TEXTURE MEASURMENTS AND ANALYSIS

Since mid-section texture measurements were presented earlier (Gangli et al.[1]), here we present only the textures of 32%RA cold drawn specimens sectioned at the surface, 1mm and 2mm from the surface, and also at the mid-section (the

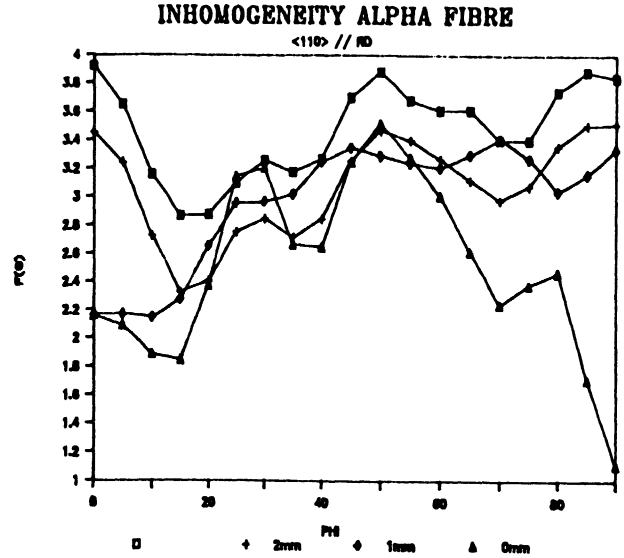


Fig. 1 Radial through thickness variation of texture in 32% RA cold drawn low C wires. (1) (□)at the surface, (2) (+) 1mm, (3) (◊) 2mm from the surface and (4) (Δ) at the mid section.

Fig. 1a <110>// FA α-fibres

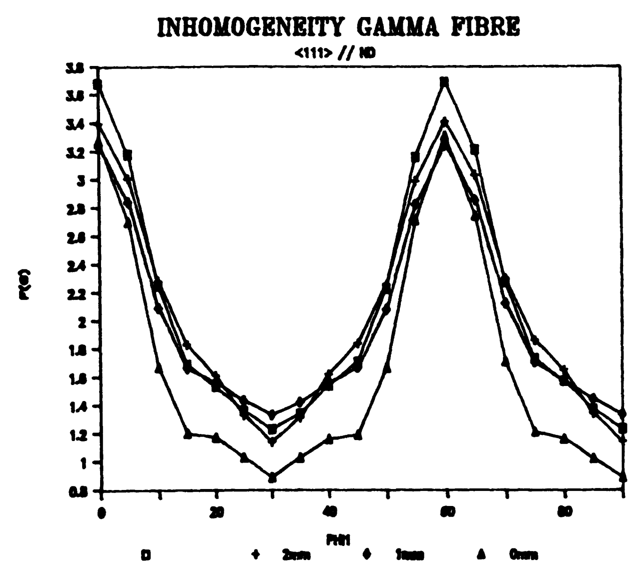


Fig. 1b <111> ⊥ FA γ-fibres.

Fig 2 Texture buildup (ODFMAX, {111}<110>) as a function of the cold drawing reduction.

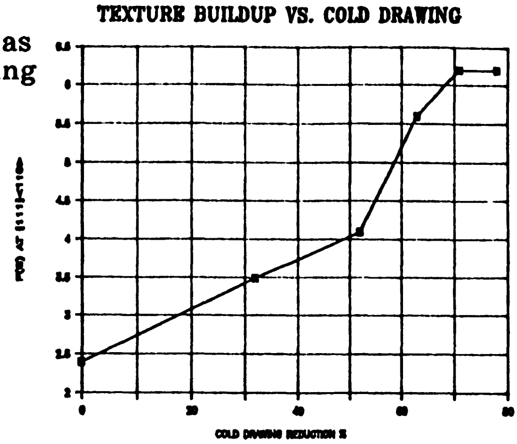


Fig. 3 Taylor factors as functions of the cold drawing reduction.

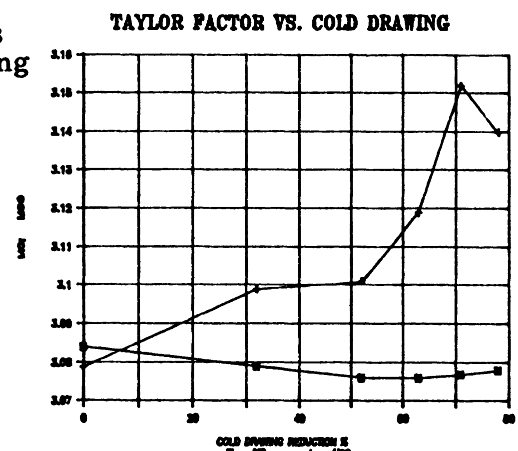
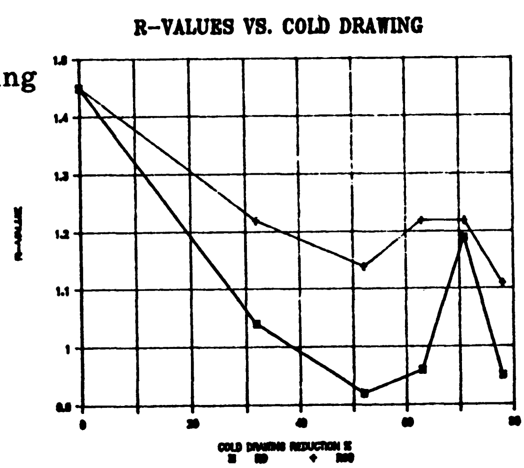


Fig. 4 R-values as functions of the cold drawing reduction.



radius was 2.28 mm). Composite specimens were used to measure (110), (200), 112) pole figures by X-ray diffraction.

ODFs were calculated using the series expansion method [2]. Results are shown in the form of <110> parallel to the fibre axis (α-fibre), and <111> normal to the fibre axis (γ-fibre). These fibres are presented in Figs 1a and b. the fibres respectively at the surface, 1mm, 2mm below the surface, and at mid sections. We note that in both fibres the surface and subsurface texture display a strong asymmetry in the <110> //FA fibre and a better symmetry on approacing mid sections. The γ fibres appear to be similar, all displaying the {111}<110> (0°,54.5°,45°) orientation as the major component. The surface has no {111}<112> (0°,54,5°,45°) component at all. These texture are basically similar to those shown and analyzed in Ref. 1. The only major difference is the stronger asymmetry of the <111>//FA fibres near the surface.

TEXTURE RELATED PROPERTIES

Clearly texture alone cannot fully determine mechanical properties, as we have shown earlier [1] in these materials the texture effect is comparable to that of the microstructure. We have used the texture data for the cold drawn and for the annealed series to calculate relevant texture of mechanical properties data. Taylor factors and R-values were calculated assuming {111}<110> glide, and the strain constrains were relaxed [3]. Fig. 2. shows the texture buildup w.r.p. to cold drawing. Texture is characterized by ODFMAX taken at {111}<110>. Three distinct texture development stages are noted: first there is a slow development, followed by a faster rate of texture buildup, which at the end is concluded by a stagnating period. This implies that the rate of rotation accompanying a unit step of drawing is different in different drawing stages. A similar kind of observation can be made looking at Figures 3 and 4 that present the Taylor factors and the R-values taken at 0° and 90° to the fibre axis. It is remarkable that while M(0) is almost invariant, M(90) is extremely sensitive to cold drawing reduction (Fig. 3). R-values R(0) and R(90) both decrease as functions of the cold drawing (Fig. 4). Here the three stages of texure development are again well reflected:first slow,then rapid texture buildup, followed by stagnation. This observation is also in agreement with calculations of the rotation field given by Tóth et al.[4] during cold deformation.

Annealed specimens were analized in a similar manner. Again we refer to [1] for the ODFs and fibres. Here we show the

Fig. 5 Texture buildup (ODFMAX at {111}<110>) versus the time of heat treatment in hours.. (1) A 890°C, 2 hours pretreatment. followed by a 690°C anneal, (2) anneal at 690°C and (3) anneal at 710°C.

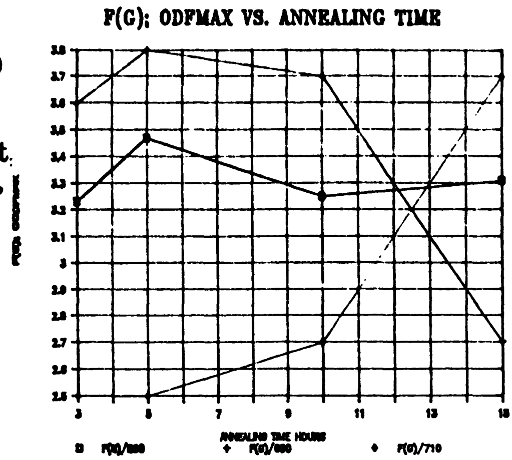


Fig. 6. Taylor factors versus the time of heat treatment in hours. (1) A 890°C, 2hours pretreatment, followed by a 690°C anneal, (2) anneal at 690°C and (3) anneal at 710°C.

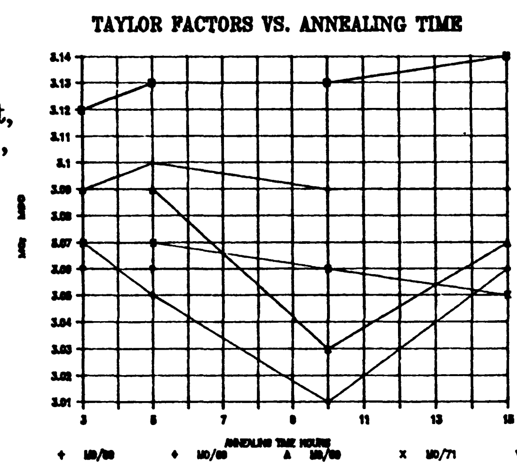
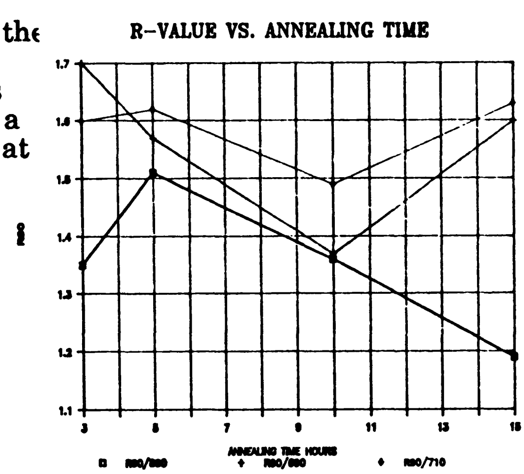


Fig. 7. R-values versus the time of heat treatment in hours. (1) A 890°C, 2hours pretreatment, followed by a 690°C anneal, (2) anneal at 690°C and (3) anneal at 710°C.



texture buildup, the Taylor factors and R-values, as functions of the spheroidizing, anealing time. Fig. 5 shows the texture buildup (ODFMAX). Fig. 6 presents Taylor-factors, M(0) and M(90), while R-values are shown in Fig 7. All three figures show the same varied behaviour. The sole common feature is the up and down turn of these functions in terms of annealing time. One exception is found in the case of the Taylor factors obtained from specimens spheroidized at 690^{o}C, where values first decrease to 10 hours of heat treatment, followed by a consistent increase to 15 hours.

CONCLUDING REMARKS

A consistent texture buildup is observed in the cold drawing process. The heat treatments seem to influence texture develoment in a more complicated way. Here recrystallization is accompanied by second phase diffusion. Mechanical properties reflect the texture. The Taylor-factor, and R-value calculations, both for the cold drawn, as well as for the annealed wires reflect major tendencies of the texure development.

As a significant observation we note the three-stage texture development, reflected in the texture buildup, as well as in the Taylor-factor and R-value calculations. This observation is in agreement with calculations of the rotation field [4] during cold deformation.

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