Materials Science Forum Vols. 467-470 (2004) pp. 235-240
online at http://www.scientific.net

Study of Texture and Recrystallization in Wire Steel

Z. BOUMERZOUG, N . LAHRAKI and M. ZIDANI
Mechanical engineering department, Biskra University, Algeria
B.P: 145 – Biskra - 07000 - Algeria

Keywords: wire drawing – steel - texture – recrystallization.

Abstract. The operation which allows reducing wire diameter is called wiredrawing. The wiredrawing principle is that of using the metal plasticity to reduce the wire diameter. Our study is based on wire steel containing 0.05 % carbon. The regular orientation of the grains (texture) caused by external stresses during the drawing process is observed. This texture causes a phenomenon of material consolidation. Two annealing temperatures were applied on deformed wires for modifying the structure and mechanical properties. The effects of drawing and thermal treatment on our material were studied by, scanning electron microscope, hardness measurements and X – ray diffraction.

Introduction.

Wiredrawing is one of the most frequently applied techniques in the wire manufacturing industry[1]. This process is one of the oldest metal forming processes. The regular orientation of the grains caused by external stresses during the drawing process is referred to as 'deformed texture'. Formation of texture favors the anisotropy of mechanical and physical properties[2]. However, the state of hard-drawn metals is unstable from a thermo-dynamic point of view. Heating of this type of material brings about a process of regeneration and recrystallization that restores all the properties featured by the metal before deformation. In this paper, we would like to present the results concerning microstructural and mechanical evolutions of low carbon steel after cold drawing operation and the effect of annealing treatment on drawn wires.

Experimental Procedures.

The material used in this study is a commercial low carbon steel wire containing approximately 0.05 wt % of carbon (initial section S_0= 6.20 mm). Different techniques have been used for this investigation: Scanning electron microscopy (SEM) observations of the wire were made along a longitudinal view after etching with Nital. In order to evaluate the mechanical properties of the wire, hardness Vickers measurements were applied. On the other hand, X – ray diffraction (XRD) experiments were used. This analysis has been applied in the longitudinal section of the wire by using CoKα radiation. The rate of wire drawing (Eq.1) is:

$$\varepsilon = \frac{S_0 - S}{S_0} . \qquad (1)$$

with, *S*: is final section.

Results and discussion.

Characteristic of the drawn wires:

Figure 1 shows different SEM micrographs of the as–deformed microstructure on longitudinal section of the wire. The drawing processes leads to the alignment of colonies of pearlite and grains of ferrite with the wire axis (texture).

On the other hand, (Fig. 1) show reductions of the pearlitic lamellar distance with drawing strain. The effect of cold wiredrawing on the hardness of drawn wires is presented in Fig. (2). This process induces a strong hardening of material. Probably, the interactions between cementite particles and dislocations involved by deformation are thought to be responsible for observed increase in hardness. It assumes that in a given pearlite colony, the deformation is equal in the ferrite and the cementite phase. In pearlite, the dislocation accumulation process in the ferrite is the most dominant during forming. It is generally accepted that the cementite interfaces act as barriers to slip propagation in the ferrite [3].

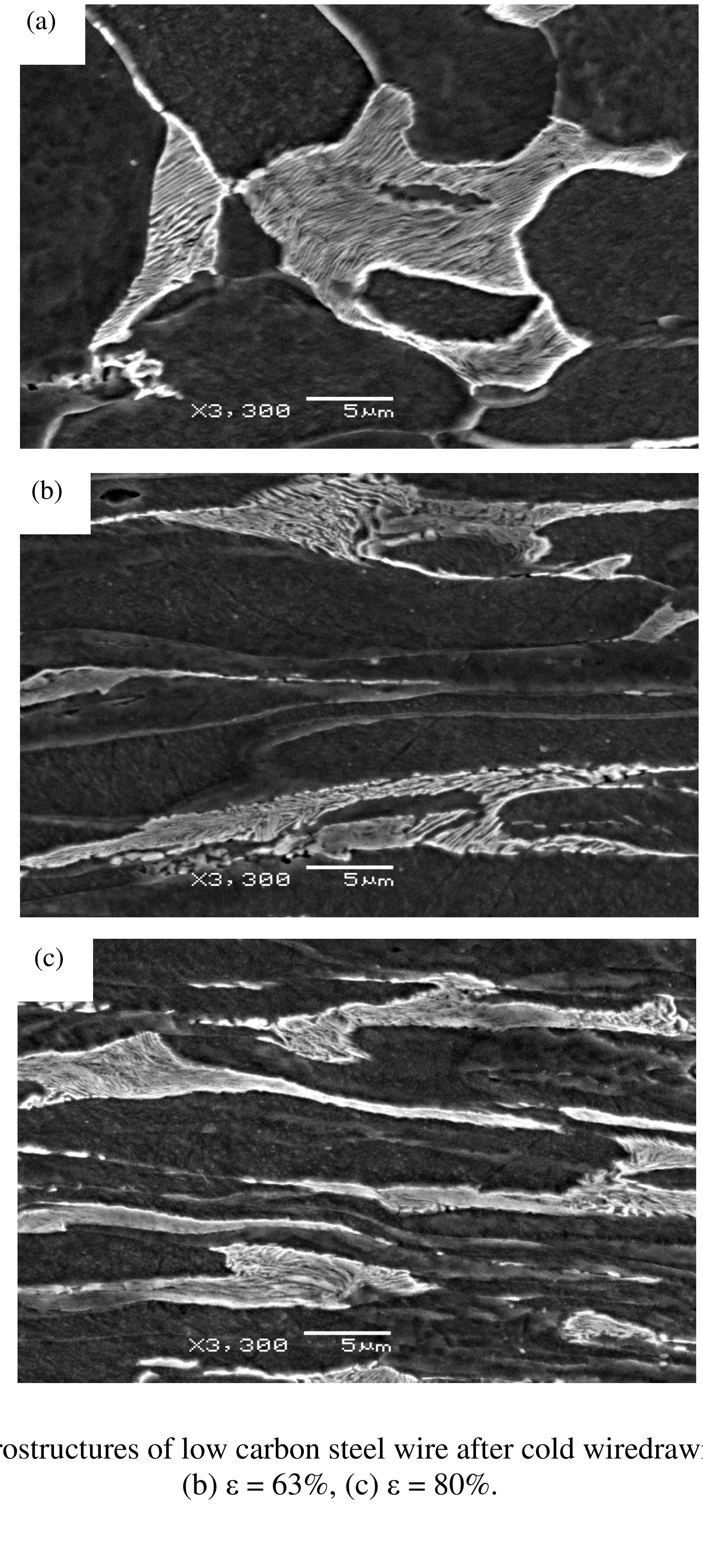

Fig.1 SEM microstructures of low carbon steel wire after cold wiredrawing: (a) $\varepsilon = 34\%$, (b) $\varepsilon = 63\%$, (c) $\varepsilon = 80\%$.

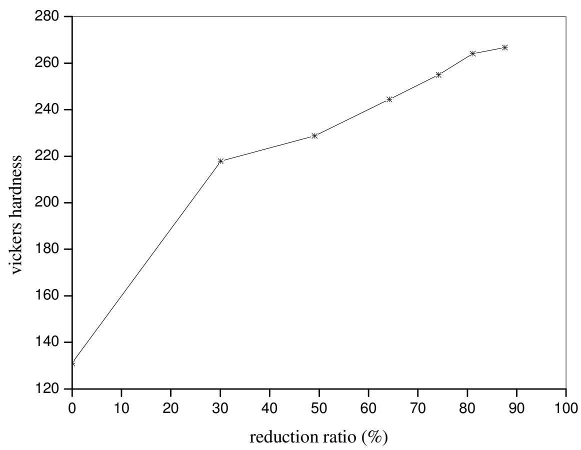

Fig.2 Vickers hardness curve of low carbon steel wire after cold wire drawing

The effect of cold drawing on structure of wire is confirmed by X – ray diffraction. Figure 3 of XRD results obtained from wires with three reduction ε = 34% (Fig. 3a), ε = 63% (Fig. 3b) and ε = 80% (Fig. 3c) shows the <110> fiber texture in the ferrite phase during wire drawing. We notice that some results have confirmed the presence of pronounced <110> fiber texture in ferrite [4,5]. It must be a characteristic of the drawing process.

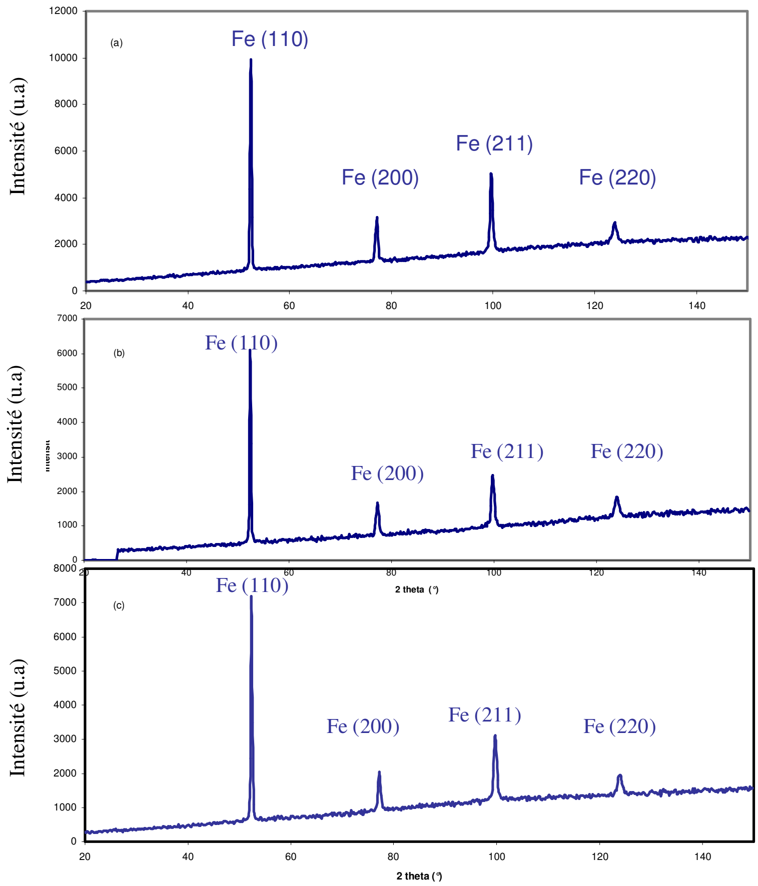

Fig.3 XRD spectrums of the low carbon steel wire after cold wire drawing to rate of:
(a) ε = 34%, (b) ε = 63%, (c) ε = 80%.

Characteristics of the annealed drawn wires.

It is known that when a deformed metal is annealed, recovery or recrystallization occurs, depending on the annealing temperature.

In this work, two annealing temperatures were applied on drawn wires (200°C and 620°C): Annealing at 200°C, it is noteworthy to say that changes only the mechanical properties, where the ductility of the wire is restored (Fig. 4).

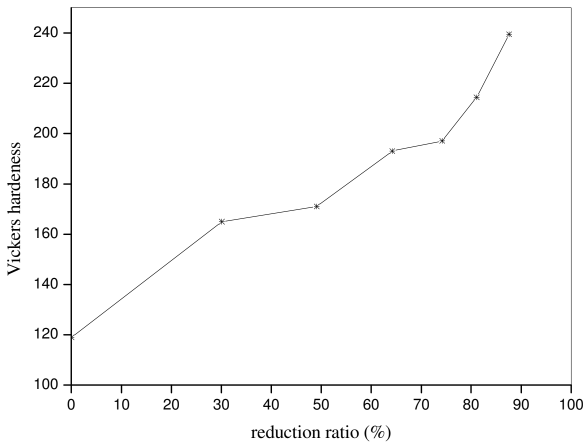

Fig.4 Vickers hardness curve of low carbon steel wire after cold wire drawing and followed by an isothermal annealing at 200 °C during 80 min.

Generally, annealing at low temperatures results in recovery with little change in texture. However, annealing at 620°C leads to mechanism of recrystallization of the ferrite domain followed by restoration of ductility (Fig. 5). It is known that at higher annealing temperatures, primary recrystallization occurs (Fig. 6). The texture of the recrystallized structure (Fig. 7) is generally different from the deformation texture.

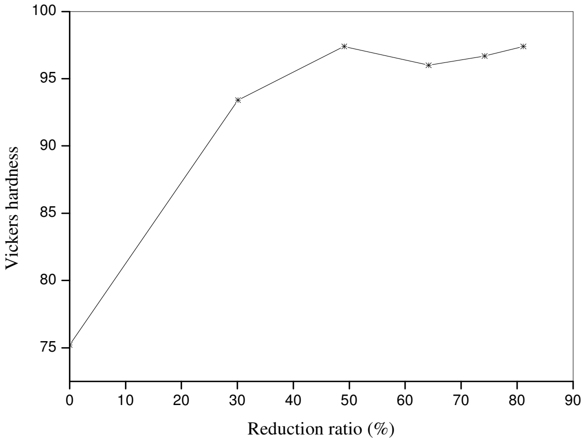

Fig.5 Vickers hardness curve of low carbon steel wire after cold wire drawing and followed by an isothermal annealing at 620 °C during 80 min.

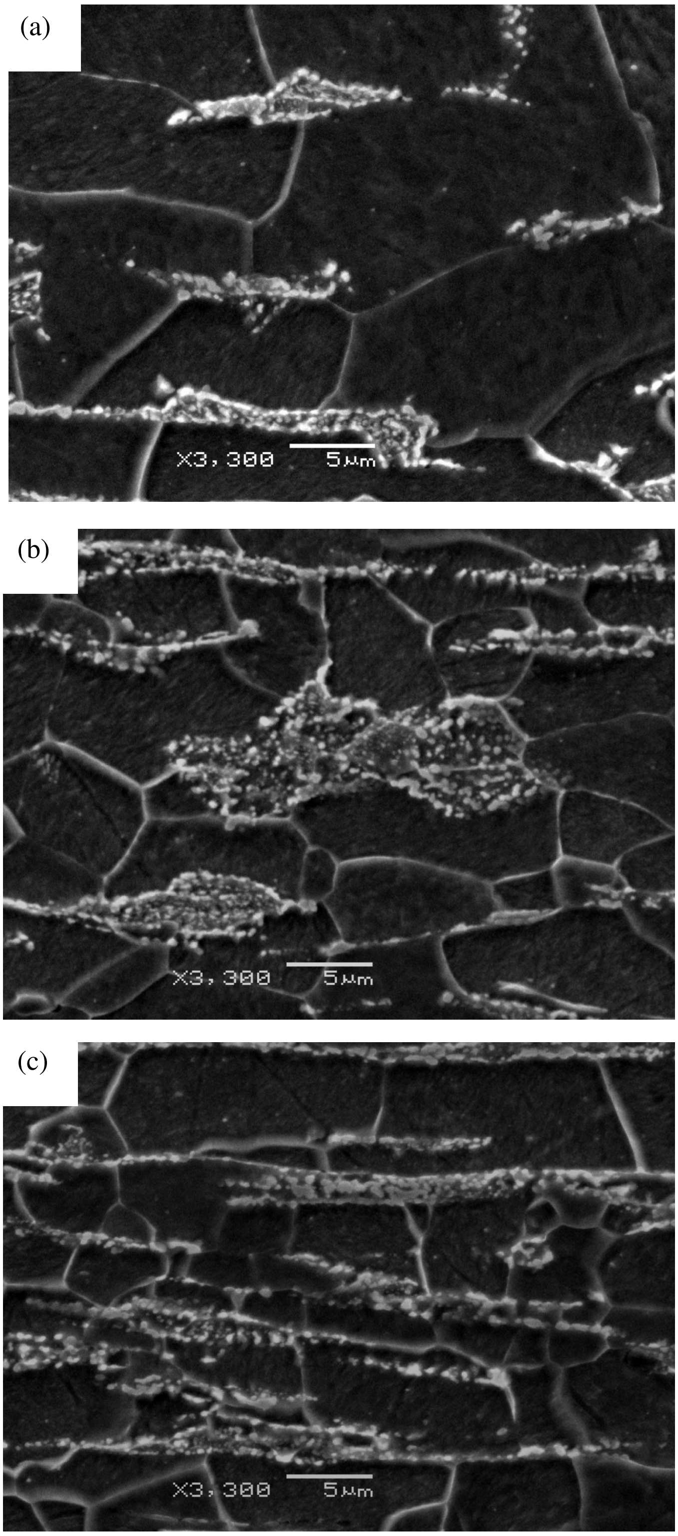

Fig. 6 SEM microstructures of low carbon steel wire annealed at 620°C during 80 min after cold wiredrawing: (a) ε = 34%, (b) ε = 63%, (c) ε = 80%.

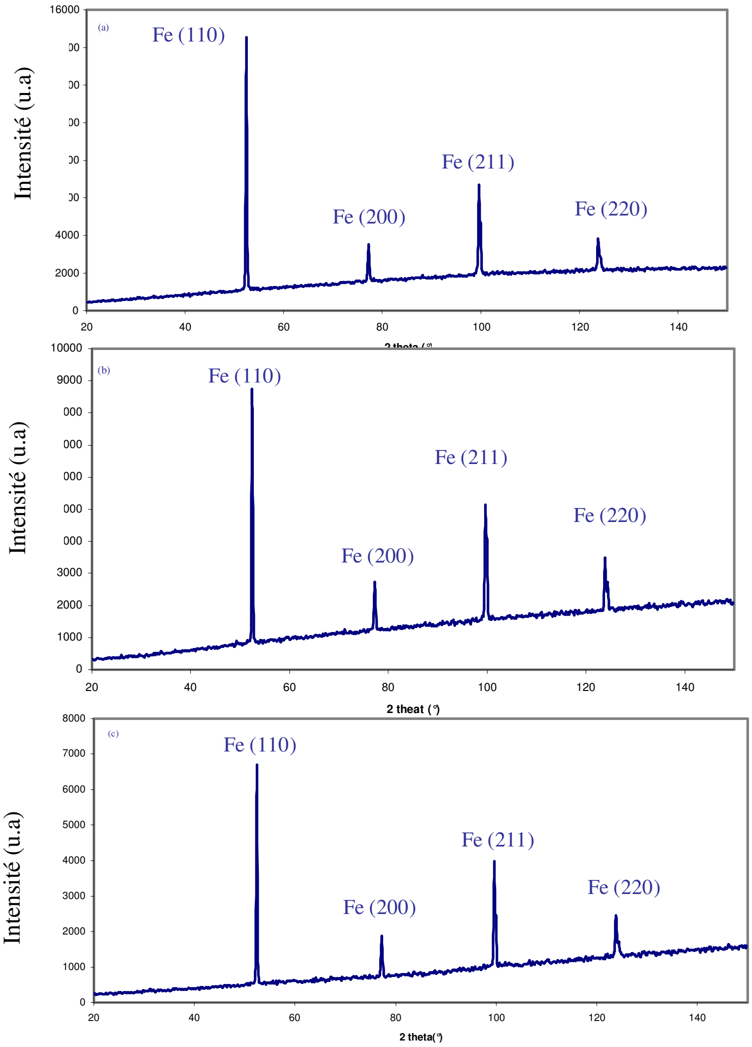

Fig.7 XRD spectrums of the low carbon steel wire after cold wire drawing and isothermal annealing at 620°C during 80 minute: (a) ε = 34%, (b) ε = 63%, (c) ε = 80%.

Conclusion.

Our investigation represents a contribution to the study of the effect of cold drawing on low carbon steel wire. The drawn wires are characterized by texture and hardening mechanisms. For annealing at 620°C, a recrystallization event occurs in the microstructure and leads to a decreasing of hardness.

References.

[1] S.He, A.Van Bael, S.Y.Li, P.Van Houtte, F.Mei and A.Sarban: Mater.Sci and engineering A 346 (2003), p. 101-107

[2] I. Lakhtine: *Métallurgie et traitements thermiques des métaux*, 4éme éd (1986), p. 76-77

[3] P.Watte, P.Van Houtte, E.Aernouldt, J.Gil Sevillano, W.Van Raemdonck and I. Lefer: Mater. Sci. Forum Vol 157-162 (1994), p. 1689-1694

[4] J. Languillame: Pb. s. Thesis, Institut National Polytechnique de Grenoble (1995)

[5] W. F Hosford, Trans. AIME 23912 (1966)