ESTIMATING THE STACKING FAULTS OF HIGH ALLOYED STEELS

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Abstract. *In cadrul analizelor prin difractie de raze X asupra structurii materialelor metalice, un loc important il are determinarea defectelor de impachetare care apar in planele de impachetare compacta din reteau cristalina de tip cub cu fete centrate (CFC) sau in reteaua cristalina de tip hexagonal compacta. Prelucrarea la rece a metalelor cu retea cristalina de tip CFC, dar si transformarile de faza, cum ar fi transformarea martensitica din oteluri, poate induce astfel de defecte de impachetare pe planele (111). In cadrul acestei lucrari se prezinta o metoda de determinare a concentratiei defectelor de impachetare din austenita reziduala pentru oteluri inalt aliate marca M42.*

Keywords: *Defecte de impachetare, retea de tip CFC, oteluri inalt aliate, raze X.*

Abstract. *In the X-ray diffraction analysis on the structure of metallic materials, an important place is determining packaging defects occurring in the planes of the face-centered cubic (CFC) crystal lattice or compact hexagonal lattice type. Cold working of metals with CFC crystal lattice type, and phase transformations such as martensitic transformation in steels, can induce such stacking faults on planes (111). In this paper we present a method for determining the concentration of residual austenite stacking failts for high alloyed steels M42 brand.*

Keywords: *Stacking fault, crystal lattice type CFC, high alloyed steels, X-ray*

1. INTRODUCTION

Cold working of CFC metals crystalline network, and phase transformations such as martensitic transformation in steels, can induce such stacking faults on planes (111), which are flat compact stacking in the crystal lattice type CFC or hexagonal. On a microscopic level, the martensitic transformation is characterized by:

1.- The appearance of platiform-lenticular martensite with two typical morphologies: (i) in strips (massive or internal defects), with dimensions of the order of 200 x 4 x 0.4 • 10^{-6} m and high density of dislocations, that occurs between 0.2-0.6% C and (ii) plate with a central ridge and the more internal twin crystal that contains as much carbon.

2. - The existence of a relationship orientation - between austenite γ with face-centered cubic structure (cfc) and quenching martensite α' with volume centered tetragonal structure (tvc) - associated with the occurrence of undeformed and unturned plan (invariant habitat plan) which provides for a mechanism to rapid growth of martensite. The appearance of habitat plan was explained by the so-called *phenomenological theories* that aim to describe the martensitic transformation without specifying any physical mechanisms of transformation and no order of their occurrence. Crystallographic theory of martensite who explaining invariance habitat plan by minimizing the interfacial free energy considered microstructural mechanism involves the production of four elementary deformations. These are: (i) a simple homogeneous deformation (distortion Bain) invariant inhomogeneous shear slip or macling (iii) rotation transformed network and (iv) uniform dilation of austenite-martensite interface (A / M) [1]. The arrangement of atoms in a compact stacking can be seen according to Figure 1a), 1b) and 1c).

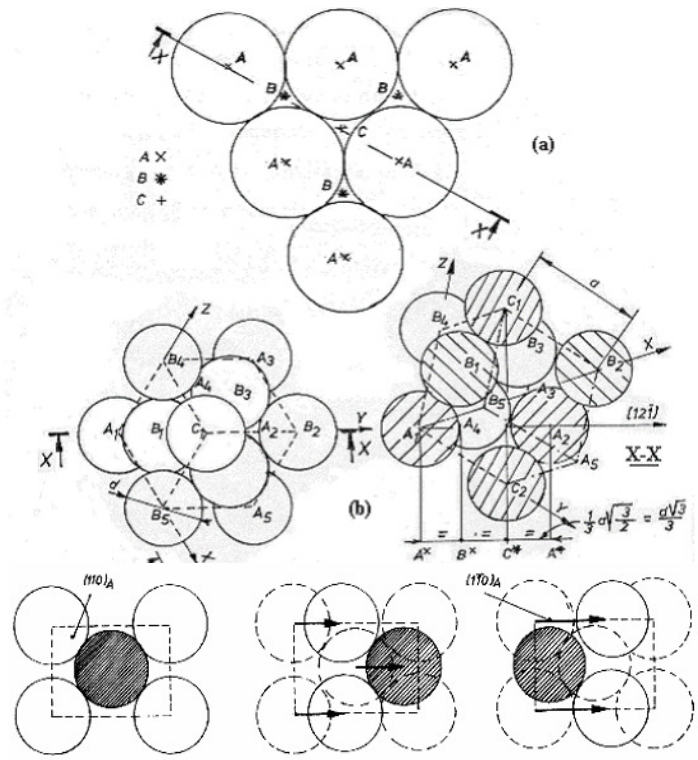

Figure 1. Compact stacking atomic layers: (a) scheme of possible positions of arrangement for compact atomic planes (b) unit cell packing CFC and order ABC (3R), c) the three possible ways of stacking of atoms in martensitele obtained from austenite.

Can observe that the first model packaging in Figure 1c) is the plane (110) of austenite. The other two models of stacking are derived from it, after the atomic displacements in the direction [1 1 0] A.

2. DESCRIPTION PROBLEM.

If we relate to one of the layers of atoms compact stacking (layer A), then the following layer atoms can occupy either position B or C. Both arrangements positions, B and C, give a compact stacking structure. CFC structure is obtained from the sequence ABC, ABC .... (Figure 2a) while the fourth layer is disposed over the first and compact hexagonal structure, while the third layer is disposed over the first, that appropriate succession ABA, BAB ..... (figure 2b).

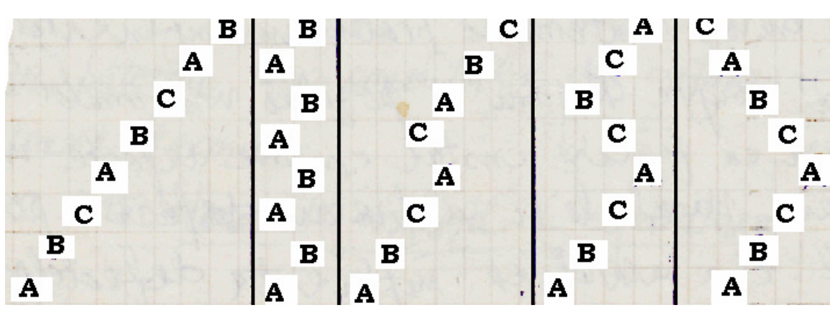

Figure 2. a) Sequence arrangement of atoms in stacking compact planes: a) CFC correct network, b) HC network correctly, c) simple fault deformation, d), e) twinning fault.

The deviation from the normal order of succession into atomic planes is a stacking fault of them. In a CFC network disruption is produced by three atomic layers of planes (111) not order ABC or CBA. Examples of developing stacking faults are given in Figure 2. If layer B that follows the layer A is fixed in place denoted by C, then we have a new fault ABCACABC……….. sequence containing four layers of compact hexagonal crystal lattice (Figure 2c). Such a defect is called reduction defects that form if the correct sequence is extracted layer planes (in this case, B).

If each layer following the first fault, will move by the same law, we obtain the sequence ABC (A) CBA ..... which is a macle into CFC structure (Figure 2e). Two sequences ABC and CBA describe CFC network as well, that there exists only a disturbance CAC, which is called growth defect or twinning defects. The twin crystal which is the least likely contains two layers in notation with letters it is ABCACBCA ……..where the BCACB layer forming the twin crystal. Such a defect is called extrinsic stacking fault, he formed if in the correct sequence is inserted another plane (in this case is C). Intrinsic defects (reduction) and extrinsic defects are obtained as a result of plastic deformation called, therefore fault deformation. Patterson [2] treated the mathematical problem of stacking faults influence on the bandwidth and the diffraction peak positions, making the assumption that each crystal contains defects only in a series of parallel planes and that each defect propagates throughout the crystal. It showed that the influence of the defects depends on the indexes of the plan, and if h + k + l = 3N (where N-integer) the reflection diffraction peak broadens nor not moving. If, however, h + k + l = 3N ± 1, then get a broad and shifted reflex to higher angles (for the sign +) and for small angles (for the - sign). The planes (111) and $(\overline{111})$ give nonbroadens and unbiased components, rest {111} family planes broadened and moving reflex toward higher angles. Examining this way all the family {hkl} can get a complete picture about the influence of stacking fault on the diffraction image. Schematically, this is depicted by Figure 3 where the vertical lines show the nonbroadens components and shaded area shows the extended components. The arrows indicate the direction of displacement (numbers above the peaks indicating the number of components).

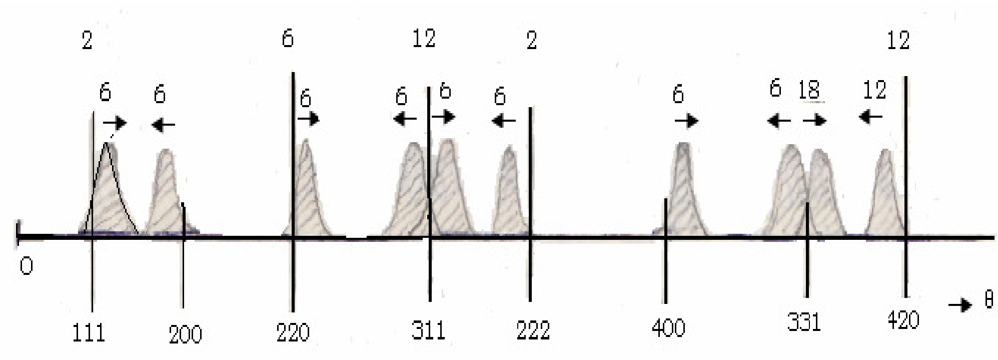

Figure 3.The influence of stacking fault on the diffraction image.

We denote by α the probability of finding a stacking fault of deformation, in a certain layer (ie a fault is at α^{-1} plane). According to the theory of Patterson between α and (111) and (200) displacement peaks of CFC crystalline structure, damaged by packaging defects, there is relation below [2]:

$$\Delta(2\theta_{200} - 2\theta_{111} = -45\sqrt{3}\,(2\mathrm{tg}\theta_{200} + \mathrm{tg}\theta_{111})\frac{\alpha}{2\pi^2} \quad \textbf{(1)}$$

where θ is the diffraction angle.

Size Δ, angular displacement, and α, as demonstrated experimentally varies greatly with the conditions of plastic deformation and / or heat treatment.

3. EXPERIMENTAL METHOD

To determine the concentration of stacking faults in metals and alloys with CFC crystalline network is indicated to be used the variation "distance" angle of the peaks (111) and (200) because the peak (111) is shifted to higher angles while peak (200) is shifted to lower angles. This makes as two displacement to be merged, and the total displacement increase, leading to increased accuracy in the determination and measurement of Δ. Also, to increase the accuracy of measurements, recording the two peaks should be carried out in one continuous recording. The apparatus with which measurements have been carried out consist of a type Philips diffractometer PW 1130/90 equipped with a vertical goniometer. For monochromated radiation using a curved crystal monochromator graphite diffracted beam mounted. So it could work very well with copper radiation for tests on iron (steel). Registering peaks (111) and (200) was done without interruption, from the small angle reflection (111), until the fund reaches large angles of reflection (220). To use formula (1) to calculate the value of α (the probability of finding a stacking fault of deformation), we mention that its determination in a material subjected to processing, relate to a reference condition of the material (such as condition obtained by annealing treatment). In that case, the left side of equation (1) becomes:

$$\Delta = \Delta_1 - \Delta_0 = (2\theta^1_{200} - 2\theta^1_{111}) - (2\theta^0_{200} - 2\theta^0_{111}) \quad \textbf{(2)}$$

where the notation higher indices 1 and 2, of the term 2θ refers to the distorted sample, reference sample, respectively.

The final formula becomes:

$$\Delta = \Delta_1 - \Delta_0 = -45\sqrt{3}(2tg\,\theta_{200} + tg\,\theta_{111})\frac{\alpha}{2\pi^2} \quad \textbf{(3)}$$

4. EXPERIMENTAL RESULTS

This method of calculating the concentration of residual austenite packaging defects of steel applied for high alloy steel samples M42 brand. As standard γ-Fe phase austenitic steel using a 10TiNiCr180 brand that has a high alloy steel similar to that of M42 type. For metal materials previously mentioned determinations were made of the diffraction pattern in the range of angle 2θ $\in [42^0\text{-}52^0]$, in continuous mode. For each sample were carried out two records and records media carried. Experimental data and calculated according to the formulas above (Eq. 3) has been shown in Table 1.

Table 1

Experimental data	**Samples material**	
	10TiNiCr180	M42
$2\theta^1_{111}$	**-**	**43.27**
$2\theta^1_{2000}$	**-**	**50.28**
Δ_1	**-**	**7.01**
$\mathbf{2}\theta^0_{111}$	**43.56**	**-**
$2\theta^0_{111}$	**50.72**	**-**
Δ_0	**7.16**	**-**
Δ	**0.15**	**-**

2tgθ_{200}	**0.94390**	**-**
tgθ_{111}	**0.39795**	**-**
α	**-**	**1.57x10^{-4}**

5. CONCLUSIONS

Processing by cold plastic deformation (and phase transformations) metallic materials such as stainless steel and high alloy steel type 10TiNiCr180 and M42 is accompanied by changes in the mechanical characteristics, namely that occurs increase in mechanical strength but a decrease in plasticity properties. Changing the appearance of these features is induced by distortions, displacements and stacking faults in the crystal lattice planes specific to these types of austenitic steels. If the stacking faults concentration is high may occur phase transformation from austenite phase into martensitic phase. The method presented in this paper for determining the value of stacking fault concentration is usual and accessible in accordance with literaturep [4-10]. Examination of the diffraction image confirming a presence minimal stacking faults in the studied samples. This is confirmed by a change reduced bandwidth and diffraction peak positions. This is confirmed mathematically lower value obtained for the factor α. For steel samples studied, we can estimate that are in accordance with austenitic steels class that includes.

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