The recrystallization process in steel 08kp

V. Ya. Gol'dshein and D. E. Verbovetskaya

UDC 669.14:620.186.5

The crystallographic texture has a substantial effect on the mechanical and technological properties of materials. It determines, for example, the active slip system during deformation [1] and the angular parameters of the structure (misorientation between grains, type of boundary) [2-4]. It was found in [5-8] that the presence of component (111)[UVW] in the texture of automobile sheet facilitates deep drawing.

The final texture of a material develops in the process of recrystallization annealing of cold-rolled strip, and thus to determine the possibility of controlling the texture we investigated the recrystallization process in automobile sheet from the standpoint of the crystallographic changes accompanying this process.

Metallographic analysis of samples annealed to different stages of recrystallization showed that new grains that are formed during annealing of the deformed metal are localized in certain sections of the matrix (Fig. 1). These characteristic sections include: 1) the boundaries of the original grains; 2) regions adjoining large particles of second phase (D > 3 μ); 3) microbands in deformed grains.

To determine the orientation of grains formed during recrystallization in different sections of the deformed material we investigated the recrystallization texture in three groups of samples of steel 08kp with different original structures (the same heat).

The first group of samples was prepared from fine-grained steel (dav ≈ 0.02 mm). The second group of samples was coarse-grained steel (dav ≈ 0.3 mm), obtained by high-temperature vacuum annealing (10⁻² mm Hg) at 1100°C of samples from the first group. The third group of samples had the same grain size (dav ≈ 0.3 mm) but differed from samples of the second group in the size and number of particles of second phase, as a result of a high cooling rate.

![Fig. 1. Formation of new grains during recrystallization of steel 08kp.](image)

![Fig. 2. Pole figures (110) of steel 08kp after recrystallization.](image)

All three groups of samples were rolled with 50\% reduction and annealed at 700°C for 2 h. It was assumed that the recrystallization nuclei formed mainly in the grain boundaries in the first group of samples, around particles of second phase in the second group of samples, and in microbands in the third group of samples. The experiments confirmed this assumption.

Pole figures (110) were made by Schultz's method [9] from the central layers of the samples, where the possibility of changes in chemical composition is minimal. The deformation texture of the samples proved to be almost identical for the three groups: the typical texture of rolled bcc metals with characteristic components (111)[112], (111) [110], (001) [110], and (112) [110].

With an original fine-grained structure, the recrystallization texture is similar to the deformation texture (Fig. 2). The nuclei formed in the grain boundaries have the orientation of one of the grains in whose boundary they are formed. This is confirmed by the pole figures (Fig. 3a, b); the diffractometric curve was obtained with slow (0.86 rev/h) rotation of the sample around the normal to the surface; interference lines from new recrystallized grains appear preferentially at texture peaks.

The texture of recrystallized coarse-grained samples differs noticeably from the deformation texture. Components develop during annealing that are in the texture before deformation — (110) [001]. This indicates that recrystallization nuclei formed in microbands have an orientation close to that of the original grains before deformation. On the diffractometric curves (diffraction line profiles) the interference lines of individual crystals are concentrated in sections corresponding to the texture of minimum deformation (Fig. 3c, d).

It can be seen from comparison of the pole figures (Fig. 2b, c) that the recrystallization texture of samples from the second group is more scattered, and the nuclei formed around large particles of second phase have an orientation differing from that of nuclei formed in grain boundaries and in microbands.

Thus, to ensure a texture suitable for drawing, recrystallization in automobile sheet must occur in a fine-grained matrix not containing large particles of second phase, and characterized by texture (111) [UVW] after cold deformation.

In automobile sheet from commercial heats, in which particles of second phase are unavoidable, the scattering of the recrystallization texture can be reduced by "rocker" annealing (Fig. 4).

As the result of this cyclic heat treatment the lattice of grains formed near large particles of second phase during recrystallization is distorted due to the difference in the expansion coefficients of the particle and the matrix.

Furthermore, phase transformations localized around carbide particles at T_{high} somewhat above A_C may also cause distortion of the lattice in surrounding grains and fragmentation of them. Thus, the energy of these grains increases and they are absorbed in the boundaries of original grains during recrystallization annealing.

<table>
<thead>
<tr>
<th>Steel</th>
<th>Intensity of (111) [UVW]</th>
<th>Average grain size, μ</th>
<th>Number of particles per cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>06kp</td>
<td>9.0</td>
<td>12</td>
<td>2.3·10⁶</td>
</tr>
<tr>
<td></td>
<td>12.5</td>
<td>28</td>
<td>9.8·10⁶</td>
</tr>
<tr>
<td>08Fkp</td>
<td>6.0</td>
<td>15</td>
<td>2.6·10⁶</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>33</td>
<td>1.0·10⁷</td>
</tr>
<tr>
<td>08Yu</td>
<td>10.2</td>
<td>9</td>
<td>3.1·10⁶</td>
</tr>
<tr>
<td></td>
<td>13.2</td>
<td>17</td>
<td>1.9·10⁷</td>
</tr>
</tbody>
</table>

Note: Data in numerators refer to annealing at 700°C for 2 h, denominators to rocker annealing for 100 cycles.