Texture of submicrocrystalline magnesium alloy after equal channel angular pressing

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Deformed magnesium alloys find wide application in various branches of mechanical engineering and, first of all, in air, automobile and electronic industry. Though they have high specific strength, plasticity of semifinished products from these alloys, is especial at temperatures of deformation below 250˚C, is not rather high. It in many respects is connected to features of the structure and texture formation at plastic deformation of the given alloys. The situation can considerably be improved if to find ways of deformation of magnesium products allowing to generate in these materials during deformation the equiaxed fine-grained structure and diffuse or tilted basal texture. One of the promising ways of this problem decision is application of the severe plastic deformations with help of equal channel angular pressing (ECAP)[1].

Material and Experimental Procedures

In this paper we investigated the texture formation after ECAP for Mg-0,49%Al-0,47% Ca alloy.The initial condition before ECAP of alloy was extruded bar, obtained by pressing at the 340ºC with the total drawing ~ 4,4. ECAP was carried out (see Fig.1) on the samples with dimensions 10x10x70 mm at the 220 and 300ºC with 6 passes (it corresponds to the strain $\varepsilon \approx$ 6,8) on the route BC (after each pass the sample rotates around its longitudinal axis by 90º clockwise). X is an extrusion direction. Textures of the magnesium alloy were measured by X-ray diffraction using a Texture Goniometer "DRON-7" (CuK_{alpha} radiation). Pole figures were recorded on the plane of the sample normal to extrusion (X) direction. There were measured six incomplete pole figures {20.0}, {00.2}, {10.1}, {10.2}, {10.3},{11.0} by the "on reflection" method. The range of tilt angles α (0÷70º) and azimuth angles β (0÷360º) with step on α =5 and β =5º. Fall of intensity on a peripheral part of a pole figure owing to defocusing effect were corrected with the help of correction factors calculated on the basis of conditions of the X-ray recording of the pole figures. Microstructure was obtained for the same plane of the sample using the a light optical microscope "Neophot" and a transmission electron microscope "JEM-1000".

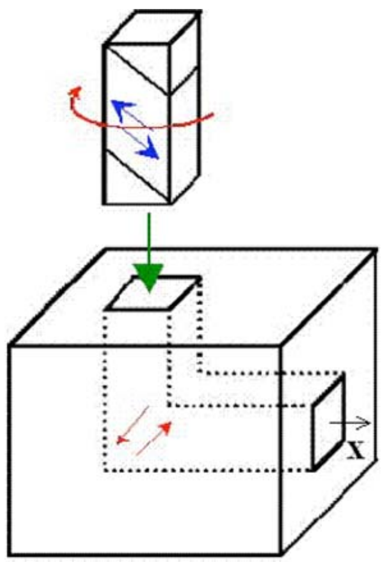

Fig.1. Scheme of the ECAP.

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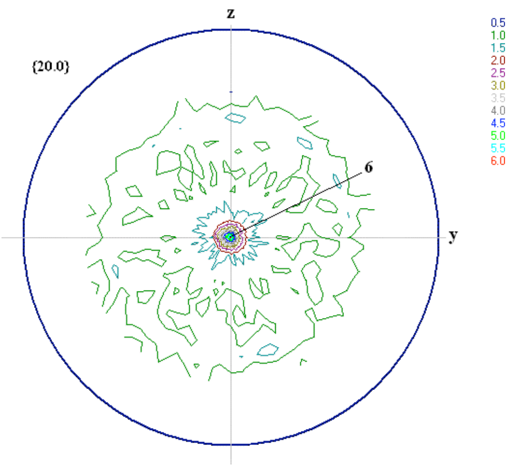
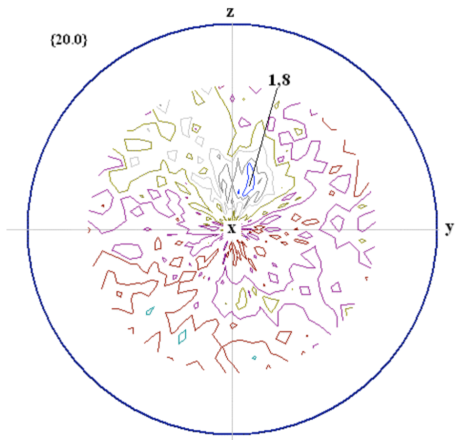
Results and Discussion

Texture of the extruded bar is presented in Fig 2a. The initial texture of the alloy is characterized by a sharp orientation<1010>.The microstructure has the uniform and equiaxed grains of size about 9μm. The selected route of ECAP ensures the ultrafine-grained structure in the investigated alloy. ECAP reduces to the grain size about 1÷3 μm at the 300^0C.The structure changes at the decrease of the deformation temperature up to 220ºC: the grain size decreases up to 500 nm and the dislocation density increases. The pole figure {20.0} of the alloy after ECAP at the temperature 220°C is presented in Fig.2b. It is visible, that texture sharply has changed both for a type, and on an sharpness. The texture is characterized by primary orientations



a



b

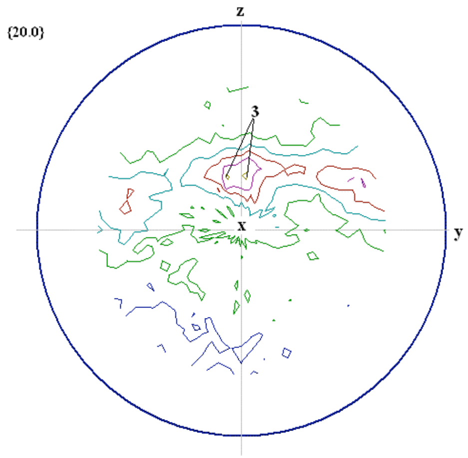


Fig.2. Pole figures {20.0}before (a) and after ECAP at 220ºC (b) and at 300ºC (c)

c

located near to orientation $(10\bar{1}2)[\bar{1}\bar{2}32]$. The pole figure{20.0} of the alloy after ECAP at the temperature 300°C is presented in Fig.2c. The texture is characterized by primary orientation $(11\bar{2}3)[\bar{1}\bar{1}22]$. The type and sharpness of the texture have changed in comparison with the temperature 220°C of ECAP, and the sharpness has increased in 1,5 times at that. The similar texture changes were also revealed in AZ61 alloy after ECAP[2]. The revealed changes in the

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texture are the consequence of the ECAP features and depend on the chosen route of pressing and total amount of passes. Besides in the ECAP process in planes located under a corner 45° to a direction of pressing there are intensive shear deformations, which result in formation of shear textures. It is necessary also to underscore, that the intensive shear deformations stimulate process of a dynamic recrystallization with formation of the submicroscopic recrystallized grains. All these processes result in change of a situation of maxima and their sharpness on the pole figures. Thus, after ECAP there is a significant change of the texture. It is accompanied by the significant refinement of structure, which has deformative character and corresponds to grain-subgrain type of the structure. A such change of the texture and microstructure can improve the mechanical properties of this material. Let consider the texture contribution to this possible improvement of the properties with accent on the ductility. For that we calculated Schmid factors for the main deformation systems for the textures before and after ECAP at 220ºC and 300ºC. The average Schmid factors for these cases are presented in Table 1.

Table 1

Texture type	Average Schmid factors		
	{0001}<1120>	{1010}<1120>	{1122}<1123>
$[10\bar{1}0]$//ED	0	0,29	0,22
$(10\bar{1}2)[\bar{1}\bar{2}32]$	0,31	0,24	0,15
$(11\bar{2}\bar{3})[\bar{1}\bar{1}22]$	0,33	0,13	0,18

It is seen that after 6 ECAP passes the textures formed in which the basal planes were more favorably oriented for slip (Schmid factors are increased). The in spite of sufficiently simplified evaluation of the influence of texture on the ductility of alloy, one should expect that in conjunction with the considerable refinement of the structure a change in the texture can ensure a improvement in the ductility of alloy. However, it is necessary to confirm these assumptions by the direct mechanical testing.

Conclusion

- After 6 ECAP passes in Mg-Al-Ca alloy the texture with main orientations $(10\bar{1}2)[\bar{1}\bar{2}32]$ $(11\bar{2}\bar{3})[\bar{1}\bar{1}22]$ and ultrafine-grained structure with average size of grain in the range from 500 nm to 3μm are formed.
- Using Schmid factor evaluation the texture contribution to the possible improvement of the ductility of the alloy was determined.

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