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TEXTURE STUDY OF ROLLING CONDITIONS FOR ZINC-BASED ALLOYS

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INTRODUCTION

Zinc alloys with low contents of Pb and Cd (up to 0.5% each) are important in metallurgical practice, for example, as material for dry-battery cans.

The plastic deformation of a given technological process produces a characteristic texture that:

1) introduces or changes the orientation dependence of the macroscopical properties of the material[1,2], and

2) reflects in its intensity and symmetry the main features of the deformation process[3,4].

The present paper is mainly related with the second of these questions. The influence of rolling conditions on the resulting texture is studied for the mentioned zinc alloys and pertinent technological recommendations are therefore given.

EXPERIMENTS

Three commercial samples were delivered by the Cuban manufacturer YARA. Samples were two-phase polycrystals. The overwhelming majority of the material (~99%) was built up of zinc crystals with Cd atoms in solid solution. The second minorarity phase was practically Pb in the form of small crystals dispersed in the Zn matrix. These Pb crystallites act as an internal lubricant during the plastic deformation.

Samples were cold-rolled to a final 70% degree of deformation. In sample 1 the process was done in three steps, while in samples 2 and 3 the reduction was obtained in a single pass. Furthermore, in all but the first sample a small asymmetry of the rolling process was introduced by breaking in 1% the parallelism of the driving cylinders.

The so-deformed samples were subjected to semiquantitative X-ray and quantitative neutron texture analyses to determine the effect of the introduced perturbations.

Neutron experiments were performed by angle dispersive diffraction at the RFR reactor of CINR Rossendorf. Full pole figures (triclinic sample_symmetry) were measured for the Bragg reflections (0002), (10$\bar{1}$0), and (10$\bar{1}$1). The neutron wave-length was 0.14516 nm. The scan of the considered hemisphere was done with constant polar and azimuthal steps of 6°. The elaboration of experimental data was performed on the PDP 11/70 computer

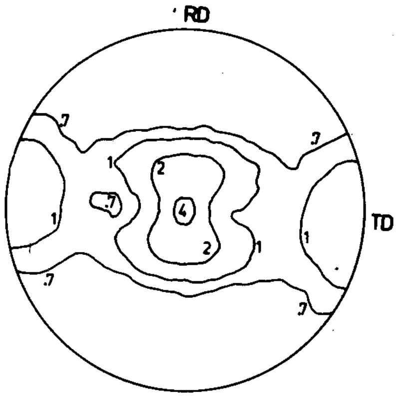


Fig.1. (0002) pole figure for sample 1 (neutrons).

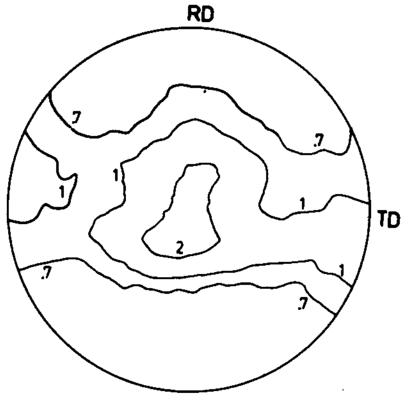


Fig.2. (0002) pole figure for sample 2 (neutrons).

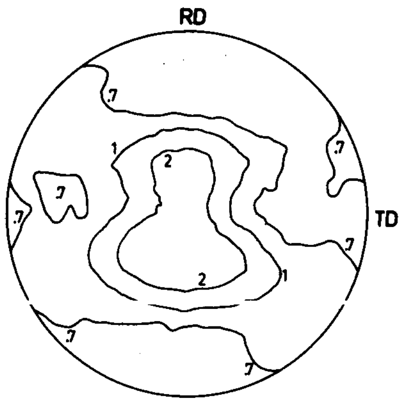


Fig.3. (0002) pole figure for sample 3 (neutrons).

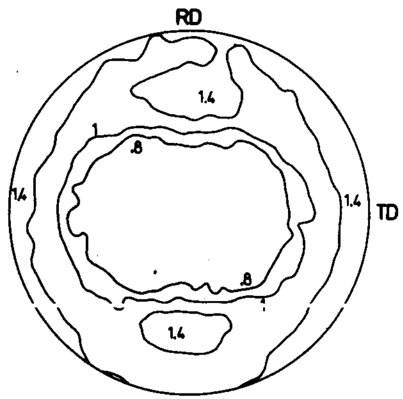


Fig.4. $(10\bar{1}0)$ pole figure for sample 1 (neutrons).

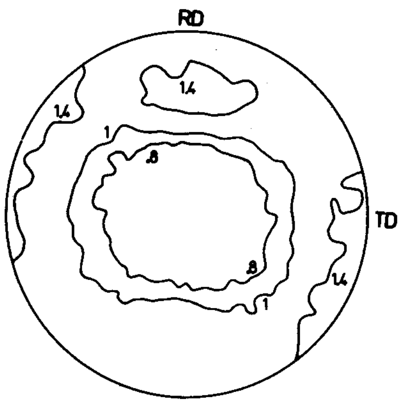


Fig.5. $(10\bar{1}0)$ pole figure for sample 2 (neutrons).

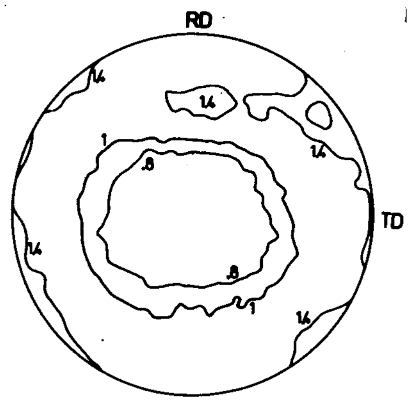


Fig.6. $(10\bar{1}0)$ pole figure for sample 3 (neutrons).

of the Neutron Physics Laboratory, JINR, Dubna. By means of the program STEREO rough data were corrected for absorption, irradiated volume, scale and transmission-reflection calibration according to the prescriptions described in/3/. Normalized pole figures so-obtained are presented in Figs.1-9. In these RD and TD are, respectively, the so-called rolling and transverse directions. The intensity value 1 corresponds to random distribution of crystal orientations.

X-ray measurements were done on the TZ26 texture goniometer installed on the HZG-4/A (VEB Freiberger Präzionsmechanik) diffractometer at TU Dresden. The purpose of the X-ray study was to detect possible inhomogeneities of the texture, so only relative intensities were of interest. Due to the high absorption of X-rays by condensed matter, only the reflection configuration was adopted, thus giving the central peak of the pole figures. Figures 10-12 show the $(10\bar{1}1)$ pole figures of the studied samples. These drawings are representative of the effect that is discussed below.

DISCUSSION AND RECOMMENDATIONS

Plastic deformation of hcp alloys (with axial ratio c/a larger than $\sqrt{3}$, as is the case for Zn) goes through the following fundamental glide and twinning systems/3,5/.

basal glide	(0001)	$[11\bar{2}0]$
twinning	$(10\bar{1}2)$	$[\bar{1}011]$
prismatic glide	$(10\bar{1}1)$	$[11\bar{2}0]$
pyramidal glide	$(10\bar{1}1)$	$[11\bar{2}0]$

For cold rolling the combination of basal glide and twinning systems plays the fundamental role. In compression any glide plane tends to become parallel to the compression plane. If a crystallite is unfavourably oriented for slip on its basal plane, then twinning occurs, as described in/6/, thus allowing basal glide to operate in the twinned part. For hot rolling the prismatic and pyramidal glide systems become more active, thus increasing the plasticity and correspondingly changing the texture.

The experimental pole figures with highest intensities are in the (0002). This corresponds to the preferent slip on the basal planes.

From the drawings it is apparent that the crystal orientation of sample 1 is the most intense and has a differentiating tendency to possess orthorhombic symmetry. This means that the formation of texture in sample 1 was progressive and symmetric. Each new rolling pass further sharpened the developing orthorhombic texture, till the final result of Figs.1,4 and 7.

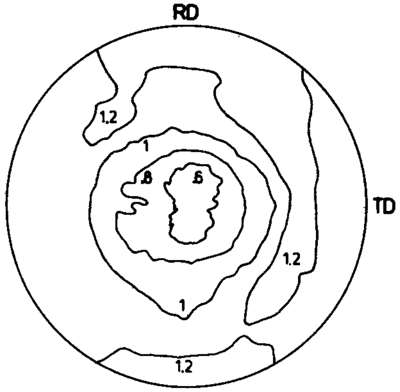


Fig.7. $(10\bar{1}1)$ pole figure for sample 1 (neutrons).

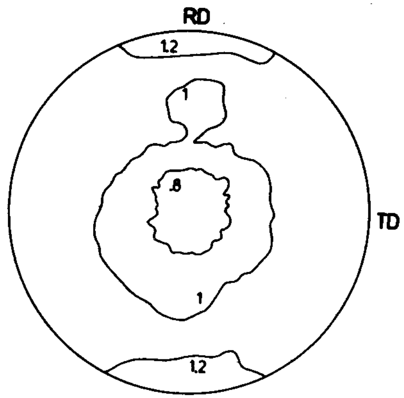


Fig.8. $(10\bar{1}1)$ pole figure for sample 2 (neutrons).

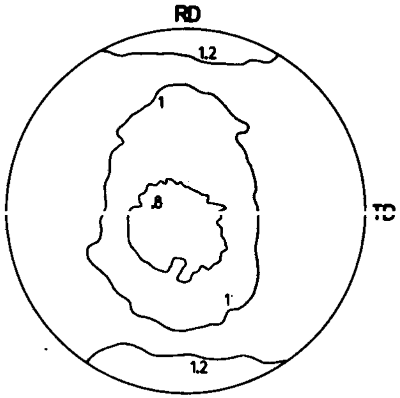
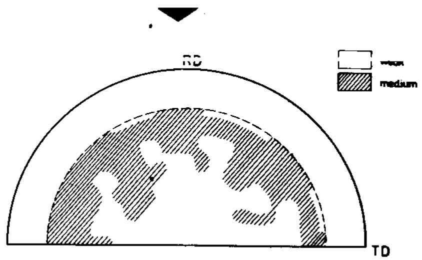


Fig.9. $(10\bar{1}1)$ pole figure for sample 3 (neutrons).

Fig.10. $(10\bar{1}1)$ pole figure for sample 1 (X-rays).



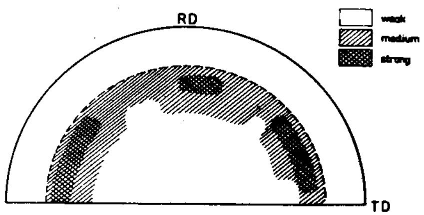


Fig.11. $(10\bar{1}1)$ pole figure for sample 2 (X-rays).

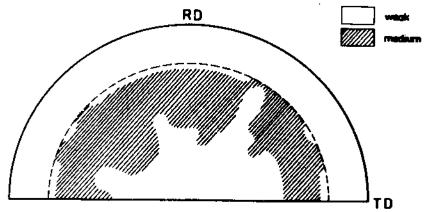


Fig.12. $(10\bar{1}1)$ pole figure for sample 3 (X-rays).

On the other hand the textures of samples 2 and 3 grew abruptly and dispersely, as due to their characteristic rolling processes.

The mechanical treatment of samples 2 and 3 seems to produce an additional effect of non-uniformity between surface and volume textures. This is seen by comparison of the volume texture obtained by neutron diffraction and the surface texture measured by X-rays (Figs.10-12). In samples 1 and 3 the surface texture is practically the same as the volume texture, but in sample 2 the surface texture is the strongest among the considered ones. This is an interesting result, that is worth further investigate, as it may in principle give the possibility to control the relation between surface and volume properties by means of a suitable texture gradient.

As to the selection of a deformation process for standard technological applications, where symmetry and reproducibility of the polycrystal structure and properties is demanded, the results of the present work recommend that of sample 1.

ACKNOWLEDGEMENTS

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Текстурное исследование условий прокатки цинковых сплавов

Исследуется влияние условий прокатки на текстуру цинковых сплавов с низким содержанием Pb и Cd. Эксперименты проводились на текстурированных образцах с различной степенью обжатия с помощью нейтронов и рентгеновских лучей. При этом получены полные полюсные фигуры /триклинная симметрия/ для объемной текстуры с помощью нейтронов и неполные полюсные фигуры /моноклинная симметрия/ для поверхностной текстуры с помощью рентгеновских лучей. Физическая интерпретация полученных результатов проводится на основе механизмов скольжения и двойникования, а также особенностей изучаемых процессов прокатки. Установлены наиболее подходящие способы механической обработки для технологических целей.

Работа выполнена в Лаборатории нейтронной физики ОИЯИ.

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Texture Study of Rolling Conditions for Zinc-Based Alloys

The influence of rolling conditions on the texture of zinc alloys with low contents of Pb and Cd is studied. The texture of samples with different rolling reductions and symmetries are measured with neutrons and X-rays. Complete (triclinic symmetry) pole figures are obtained by neutrons for volume texture and incomplete (monoclinic symmetry) pole figures with X-rays for surface texture. The physical interpretation of the obtained data is given on the basis of the activity of glide and twinning systems and the peculiarities of the considered rolling processes. The suitability of the studied mechanical treatments for technological purposes is clarified.

The investigation has been performed at the Laboratory of Neutron Physics, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1985