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# Anisotropic Superplasticity*

- by -

H. Naziri and R. Pearce

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*Subsequently, SP will be used for superplastic(s) and superplasticity.

Anisotropy has already been mentioned in connexion with SP. Johnson et al (1) have shown that specimens of circular cross-section, machined from hot-rolled SP Zn/Al eutectic and eutectoid plate, become elliptical on straining in the rolling direction, while the fine-grain Zn/Al eutectoid produced by the quench → spinoidal decomposition method did not.

In this work the anisotropic behaviour of a SP Zn/0.4% Al alloy in sheet form is examined at angles of 0°, 45°, and 90° to the rolling direction. This alloy, processed to give a grain-size of $<1\mu$, can show ~ 550% elongation at a crosshead speed 0.1 in/min at room temperature ($0.43T_m$) (2).

The strain-rate sensitivity of the flow stress (m) is a common parameter indicating the degree of SP and this was determined from specimens cut at 0°, 45° and 90° by the method proposed by Backofen et al (3). The results are shown in Figure 1.

To determine the effect of SP deformation on crystallographic texture, basal-plane pole-figures were determined on the starting material, and on specimens cut at 0°, 45° and 90° to the rolling direction and then deformed 300% in uniaxial tension (Figure 2a, b, c and d).

The strain-rate sensitivity m varies in the plane of the sheet, due to preferred orientation produced by rolling and controlled by crystallographic slip. (0001) pole figures show, firstly, in figure 2a, the characteristic pole-figure for unidirectionally rolled zinc, with the basal planes tilted at ~ 22° from the sheet plane towards the rolling direction. Figures 2b, c and d show the marked change in texture after 300% tensile elongation. Figures 2a and 2b show that at 0°, the initial strong texture (18x random at peak) weakens (6x random at peak) with basal planes becoming parallel to the plane of the sheet. Figure 2c shows that at 45° the behaviour is quite different. The basal plane normals are compressed into the rolling direction and a rotation of ~ 30° occurs away from the tensile axis, the basal planes tilt slightly (22° → 15°) and the texture weakens. At 90° (Figure 2d) the basal-plane normals are only compressed along the rolling direction and again the texture weakens. The reason for these changes must be that while slip occurs on the appropriate system and rotation also occurs, tending to align the basal planes parallel to the direction of applied tension, dynamic recovery is also taking place, enabling slip and rotation to continue, but to different degrees in different directions in the sheet plane. At 0° the texture is ideal for slip and basal-plane rotation, while at 45° the process is more difficult and at 90° scarcely possible. The behaviour is illustrated in Figure 3. Recovery, rather than recrystallization, is suggested as part of this model, as dynamic recovery was put forward by these authors as the predominant deformation mechanism in the extended plasticity found in fine-grained commercial-purity zinc (2).

Packer et al (4) determined basal-plane pole-figures for a rolled Zn/Al eutectic alloy, both in the as-rolled condition and after 300% extension in the rolling direction. Their results are similar to Figure 2a and 2b in the present work, and they proposed slip and continuous grain-boundary migration/recrystallization as the important mechanisms in their alloy.

The total elongations of the tensile specimens pulled are as follows:

| 0° | 45° | 90° |
|---|---|---|
| 520% | 490% | 420% |

whereas from the m values, it would be expected that the 90° specimen would have given the greatest elongation. However, as m was determined at elongations less than 30%, and Morrison (5) has reported decreasing m with increasing elongation, it is supposed that this also occurs in the present instance, but in some complex fashion in the sheet plane. This matter is being further investigated.

## Acknowledgements

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## References

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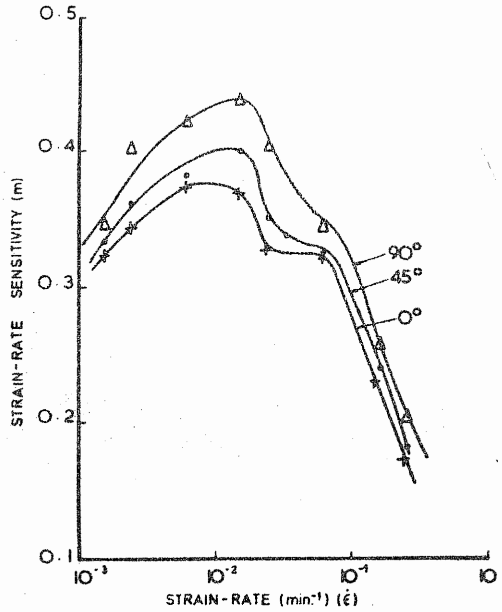

FIG. 1 - Variation of m with strain-rate and with direction of straining.

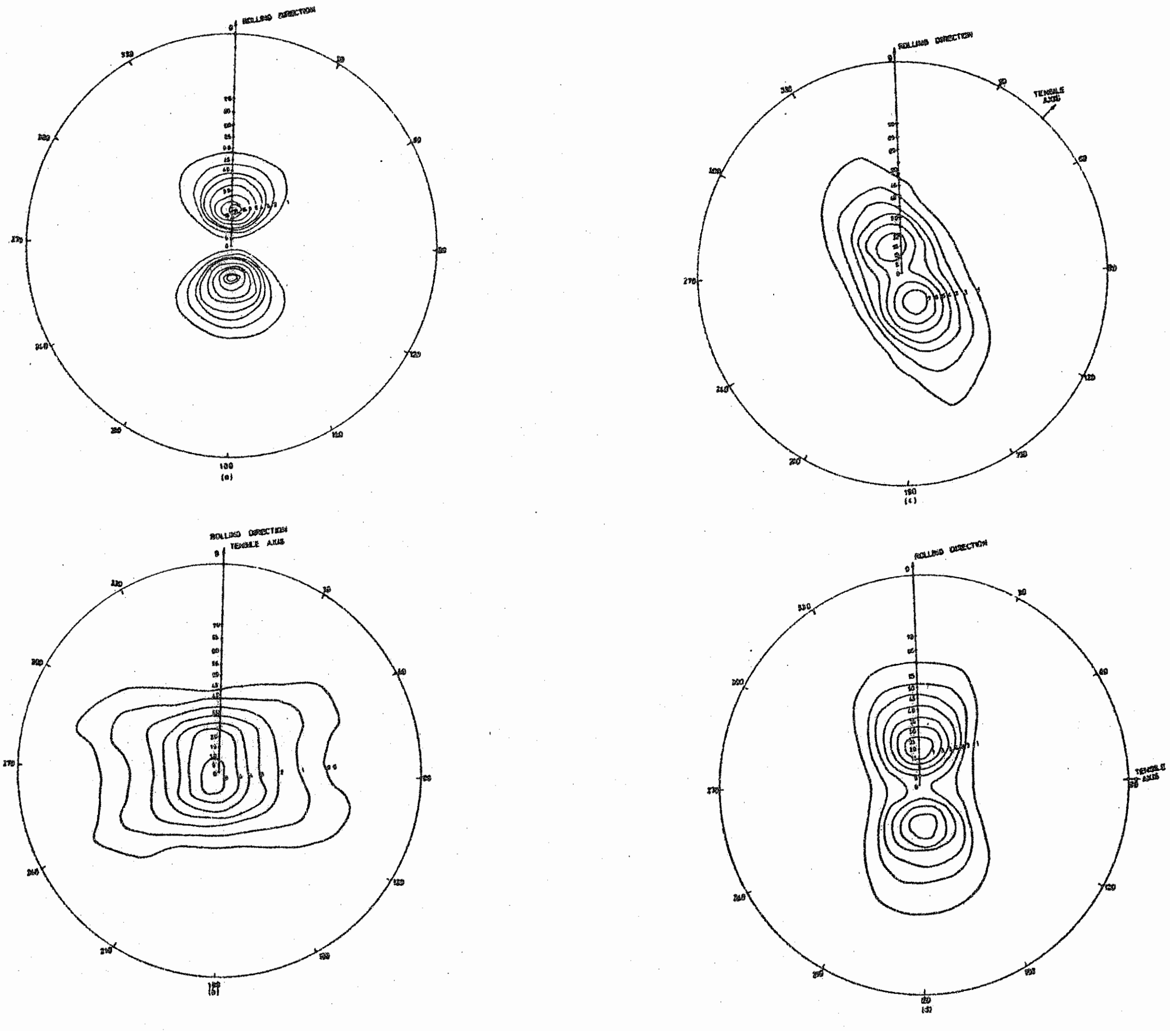

Fig. 2 - Basal-plane pole figures for the as-rolled sheet (a) and for specimens strained 300% at 0°, 45° and 90° to the rolling direction (b, c and d). Intensities are in units times random.

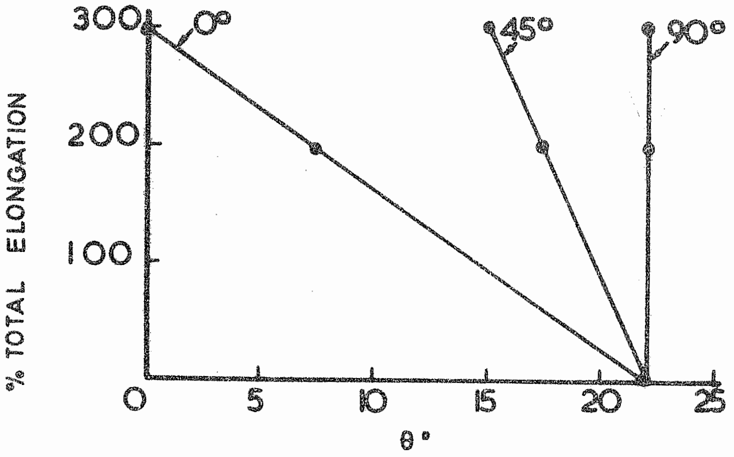

FIG 3 - Variation in basal plane rotation with the direction of straining.