ARC Centre of Excellence Design in Light Metals

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Novel Solid State Processing Route for the Development of Nanostructured Magnesium Alloys

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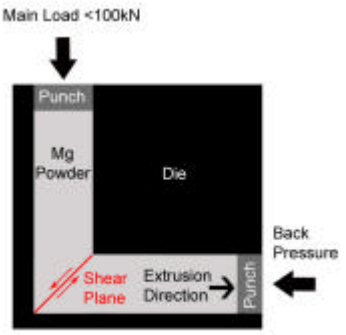
PhD Project Overview

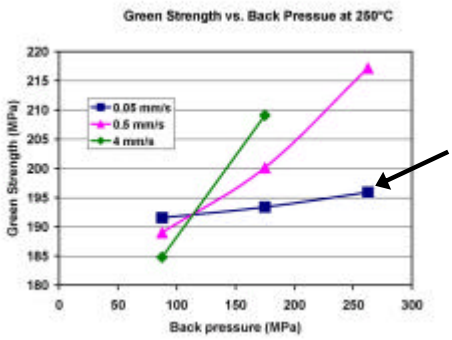
The production of solid billet from powder can be successfully carried out by means of equal channel angular pressing (ECAP) with the use of back pressure. A severe shear deformation with imposed hydrostatic pressure has advantages over conventional extrusion in terms of compaction and pore closure. Alternative methods, such as the molten route, restrict the creation of non-equilibrium phases which may be beneficial to the mechanical properties. It is hoped that incorporating the powder route with a Mg -Al-Nd alloy will result in a fine grained extrusion with precipitates of Al4RE and Mg12RE in the matrix and grain boundaries. The material will exhibit much higher strength and creep resistance than results from conventional routes.

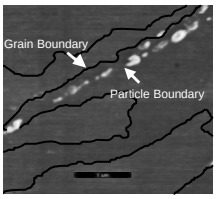
Basics of ECAP with Back Pressure

- ECAP with back pressure induces severe shear deformation with imposed hydrostatic pressure whilst retaining original specimen dimensions.
- Powder particles (~100µm) will undergo compaction followed by shear deformation in the consolidation process.
- Oxides on particle boundaries are broken.
- Main punch speed can be adjusted <4mm/s.



Effect of Strain Rate on Green Strength





- Green strength quantifies inter-particle adhesion.
- Increasing back pressure improves green strength.
- Increasing strain rate leads to higher gradient of curve.
- SEM image of particle boundary in a billet processed with 260 MPa back pressure, 0.05 mm/s strain rate, at 250°C clearly shows that the grain boundary has migrated across the particle boundary.
- It is postulated that this is a diffusion mechanism and would lead to increased green strength.

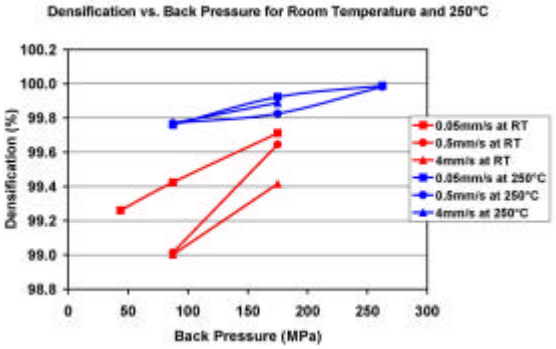
Further Work

- Investigate the shear band regions, where very high deformation takes place, and their influence on the properties of the samples. Control of the shear band spacing will also be investigated as homogeneous spacing would be optimal.
- After the basic principles of the ECAP process are understood and the optimal parameters found, the investigation of alloying effects will begin.

Current Status

The information presented in this poster reviews the work carried out up until the present time. As this is a new processing route it was deemed necessary to optimise the processing parameters. For this purpose, as well as to recognise some basic principles of the ECAP route, pure Magnesium powder has been processed under various temperatures, strain rates and back pressures. Interesting findings have been presented here.

Effect of Temperature and Back Pressure on Densification

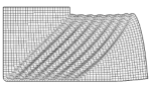


- Compaction achieves relative density of 100% when 260 MPa back pressure is used at 250°C.
- Increasing back pressure improves compaction.
- Increasing temperature improves compaction.

Note. 1vol.% MgO (derived from SEM image) included for 100% density estimate.

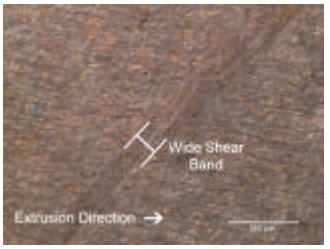
High Energy Regions of Severe Localised Deformation

One of the most noticeable phenomena associated with the ECAP process is the production of several severe deformation bands that form in the shear direction. Several models exist illustrating this effect.



(ref. *R.B. Figueiredo et al. / Materials Science and Engineering A 430 (2006) 179–184)*

Light micrograph of typical shear band in a sample made at room temperature, with 260 MPa back pressure at a strain rate of 0.5 mm/s, showing a highly localised region of shear deformation. Shear band size and spacing are similar to that predicted by models of the ECAP process from several research groups.



Under slightly different conditions the shear bands are seen to separate and disperse homogeneously throughout the sample. Understanding and controlling this effect would result in improved properties.